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Assessing the value of cultural ecosystem services in urban landscapes: evidence from Tai'an City, China

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Cultural ecosystem services (CES) refer to the intangible benefits provided by ecosystems to enhance the quality of human life. As cultural services are an important part of ecosystem services, how to account for the value of cultural ecosystem services CES has become an important research topic in the sustainable development of ecosystems. The establishment of a system of indicators and methodologies for cultural ecosystem services CES both improves comprehensive ecosystem assessments and facilitates scientific decision-making, and is essential for realizing synergies between ecological protection and economic and social development. Based on the existing accounting framework of cultural service value at home and abroad, this study constructs a more scientific and perfect indicator system of cultural service value, including four indicators: tourism and recuperation, leisure and recreation, landscape value-added and scientific research and education. research and education. Based on the four ecological and economic evaluation methods of travel costs act, time-cost method, market value approach and results-based approach, the cultural service value accounting model is optimized, and a new set of scientific research and education index value accounting model is established. Applying the indicator system and accounting model constructed in this paper study, the quantity of value of cultural services in Tai'an City in 2022 totaled 5.306 billion yuan CNY, which verified the feasibility of the indicator system and accounting model. Based on the accounting results, the study proposes a path to realize the value of cultural services in Tai'an. The results of this paper study can provide research references for the accounting and realization of ecological product value in different cities.

KEYWORDS

cultural ecosystem services, cultural services indicator system, accounting model, accounting boundary, scientific research and education, value realization path, Tai'an City

1 Introduction

Gross ecosystem product accounting is an important tool for quantifying the value of ecosystem services and conducting assessments of the effectiveness of ecosystem protection (Wei et al., 2017; Chen et al., 2022). For example, through payment for ecosystem services (PES), which is based on the quantification of ecosystem services, economic incentives are

used to create ecological protection (Braat and de Groot, 2012; Brathwaite et al., 2021). Of the three main categories of services accounted for in the gross ecosystem product (material provisioning, regulating services, and cultural services), cultural ecosystem services (CES) have a direct impact on human well-being and sustainable development. CES refers to the intangible benefits that people obtain from ecosystems through spiritual satisfaction, cognitive development, contemplation, recreation, and aesthetic experiences. However, in terms of current research, studies on the evaluation and management of cultural services lag far behind provisioning and regulatory services (Vihervaara et al., 2010). This is because their intangible impact or direct contribution is difficult to measure monetarily, and there are few indicators to monitor them (Atkinson et al., 2012). However, the construction of culture as a class of ecosystem services is a major test of ecosystem decision-making approaches (Fish et al., 2016). It has been shown that defining cultural services based on accounting models can clearly link ecological structures and functions to cultural values and benefits, facilitating communication between scientists and stakeholders (Daniel et al., 2012). The importance of cultural services has been consistently recognized (Ferreira et al., 2020; Thompson and Friess, 2019; Kosanic and Petzold, 2020; Daniel et al., 2012). Sipesihle Booi and colleagues conducted 61 studies that demonstrated the important value of CES (Booi et al., 2022). At present, CES research also plays an important role in the ecosystem assessment process carried out in the United Kingdom and Spain (Fish et al., 2016). However, due to issues such as the "intangible" nature of CES, the lack of readily available data, and the inability of existing methods to cover all CES indicators, research on CES remains insufficient. (Cabana et al., 2020; Coscieme, 2015; Tengberg et al., 2012; Hirons et al., 2016).

Due to the importance of cultural services for human well-being, there is a growing body of research on ways to measure the value of cultural services (Yang and Cao, 2022). All methods for quantifying CES are generally summarized as either monetary or non-monetary (Hirons et al., 2016). The market value of cultural services received a lot of attention in early research, and the use of monetary valuation methods to estimate the economic value of cultural services has been a popular topic (Chan et al., 2012). In-depth research on CES has concluded that only cultural services like tourism have significant market value (Chen, 2020). It is difficult to quantify monetary valuation methods for cultural services such as inspiration and religion that do not have a sales path (Chen, 2020). Subsequently, academics have continued to develop many new alternative research methods to scientifically quantify cultural services. Empirical studies using social values for ecosystem services (SolVES), public participation mapping (PPGIS), geospatial analysis, and other research tools are gradually increasing (Bagstad et al., 2016; Ridding et al., 2018). However, these methods only conduct non-monetary quantification of CES, which cannot meet the goal of valuing CES economically. The global valuation of economic substance is being promoted as a solution for effective ecosystem management (Luederitz et al., 2015), and decisions at the policy and management levels need to be based on economic value (Maes et al., 2012). Therefore, this study focuses more on how to quantify CES using monetary methods. By means of ecological economic methods such as benefit-transfer, replacement-cost, and travel-cost, we monetize cultural services whose values are difficult to marketize.

However, the unclear accounting system for the value of cultural services and the difficulty in obtaining basic data (Costanza et al., 2017) not only leads to large errors in the results of accounting for the value of cultural services but also makes it difficult to implement the accounting framework on the ground. These are serious constraints on the process of realizing the value of cultural services. CES are a major category of ecosystem services. In their valuation, not only is it necessary to establish a more comprehensive indicator system but also to explore more diversified estimation methods for converting the quantity of goods produced into value quantities and to carry out interdisciplinary and multi-method integration for the refined assessment of cultural services (Liu et al., 2023; Li, 2019). Therefore, there is an urgent need to establish a complete research system that covers theory, technology, and methodology for the value accounting of cultural services (Zheng et al., 2023; Ouyang et al., 2013) and to make a close connection with practical applications.

The city of Tai'an is famous nationally and internationally for Mount Tai, which contains national scenic, historical, and cultural spots which attract tourists from many countries every year, with the number of tourists reaching 8.94 million in 2022. It provides a place for people to recuperate their body and mind, relax their spirit, and enrich the spiritual world of tourists. Tai 'an City has a long history, and its nature and culture are the precious wealth of all humankind. The Taishan and Dawenkou cultures of Tai'an are open and tolerant, are developing in a diversified way, and are bringing people spiritual enjoyment, inspiration, and other intangible benefits, which contain great value as cultural services (Xu et al., 2025).

In summary, this study takes the cultural service products of Tai'an City in 2022 as the research object and investigates the accounting for the value of CES. Specifically, the current accounting index system of cultural service value is supplemented and improved, a new accounting system is established, and the feasibility of the index system and accounting system is verified through accounting for Tai'an City.

2 Materials and methods

2.1 Source of data

The data for accounting the quantity of goods produced and value of cultural service indicators in Tai'an come from the Shandong Provincial Bureau of Statistics, the Tai'an Culture and Tourism Bureau, the Bureau of Commerce, the City Administration Bureau, the *2022 Statistical Bulletin of Scientific Research Expenditure* in Shandong Province, the Tai'an Seventh Census Bulletin, and questionnaires.

On-site research was conducted for key, missing, or needing to be reviewed data, and tourism development service data. Finally, data preprocessing and parameter localization were carried out.

The research results of this study can help Tai'an City determine the city's cultural service product resource base and improve the accuracy of cultural service value accounting. Moreover, it can provide a reference for other regions to promote the realization of cultural service value paths such as ecological protection

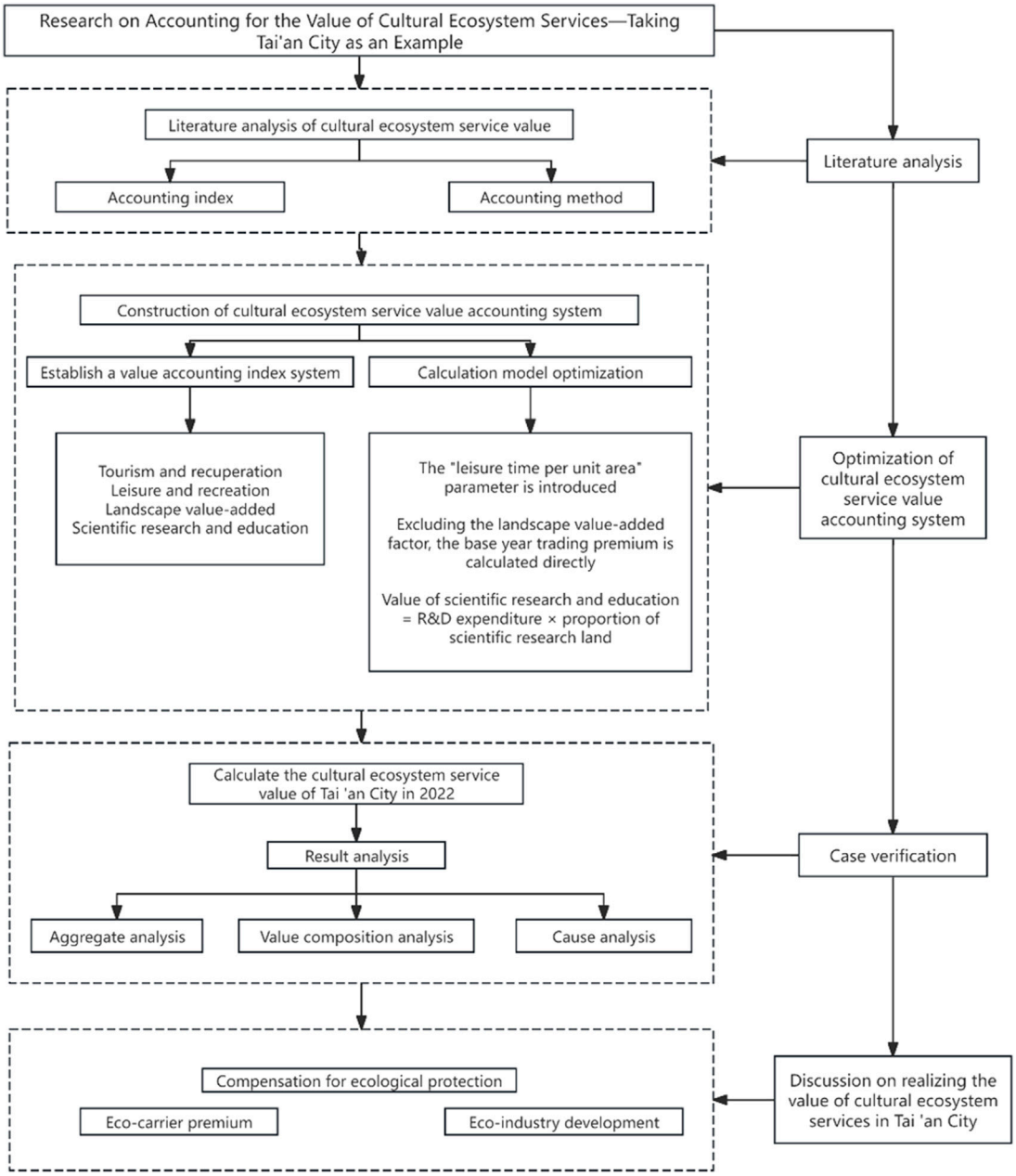

FIGURE 1
Technical roadmap.

compensation and ecological carrier premiums. The technical roadmap is shown in Figure 1.

2.2 Comparison of existing accounting systems

Comprehensively and systematically constructing a new accounting system for the valuation of cultural services with a better indicator system and more feasible accounting methods is the focus of this research. Table 1 collates several widely used indicators and methods for accounting for the value of cultural services.

SAFES employs a substitution approach that utilizes the combined value of tourism revenues and the output generated by other industries directly stimulated by tourism as a proxy for the value of forest healthcare within forest ecosystems. This methodology effectively replaces the need to directly measure the intricate value of forest healthcare by leveraging the quantifiable economic impacts of forest-based tourism and its associated sectors (Ecology and Nature Conservation Institute of China, 2020). Sumarga et al. (2015) calculated recreation and ecotourism on the basis of entrance fees paid to parks and revenues generated by the local ecotourism sector using the market-price method. Christie et al. (2012) used a travel cost approach to calculate cost data associated with destination travel to assess the recreational and ecotourism benefits of the resource.

TABLE 1 Existing indicators and methods for accounting for the value of cultural services.

Indicators	Methods	References
Forest health care	Forestry, tourism, and recreation production value alternatives	Specifications for assessment of forest ecosystem services (SAFES) (Ecology and Nature Conservation Institute of China, 2020)
Leisure and recreation	Alternative costing method	*Norms for Accounting for Gross Ecological Products* (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022)
Recreation and ecotourism	Market price method	Sumarga et al. (2015)
	Travel cost method	Christie et al. (2012)
Partial economic value of changes in ecosystem services and amenities	Hedonic pricing method	Chenxi (2024)
Entertainment	Benefits/value-transfer method	Preece et al. (2016)
	Contingent valuation method	Gandarillas et al. (2016)
Recreation and leisure	Deliberative valuation method	Kenter (2016)
Landscape preference	Hedonic pricing method	Spangenberg and Settele (2010)

Spangenberg and Settele (2010) used hedonic pricing to estimate the partial economic value of changes in ecosystem services and amenities based on the sales price of similar properties. In March 2022, the National Development and Reform Commission (NDRC) of China and China's National Bureau of Statistics (NBS) jointly issued Norms for Accounting for Gross Ecological Products (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022), hereinafter referred to as the *Norms*. In these, the relevant concepts and ecological product classification standards were initially clarified, and the original accounting indicators and methods were optimized. However, there are still some deficiencies in the *Norms*. On the one hand, they are not rigorous enough to define concepts of "tourism" and "recuperation" (Qiu and Shi, 2023). For example, the *Norms* do not clarify whether "contribution of goods and services" means goods and services (in their entirety) or only the part of the ecosystem included in goods and services that contributes to the formation of those goods and services (Qiu and Shi, 2023). This may lead to a significant difference from the concept of "ecosystem services" as defined in the SEEA EA, which includes in the scope of ecosystem services or ecological products as the contribution of human inputs, such as production assets and labor, and thus makes the scope of physical accounting for ecosystem provisioning services or ecological and cultural services too large (Qiu and Shi, 2023). On the other hand, the *Norms* do not strictly follow the accounting principle of *supply* = *use* in SEEA EA (United Nations, 2021). For example, the quantity of goods produced by the landscape value-added indicator in the specification is the number of hotel rooms or the area of self-owned housing with value-added from the ecological landscape, but not all hotel rooms or self-owned housing with value added from the landscape were utilized and traded in the base year. Therefore, the quantity of goods produced by value-added landscape should be in accordance with the principle of *supply* = *use* in SEEA EA (United Nations, 2021), and the number of hotel rooms/housing area with value added by landscape that was traded in the base year should be used. Although SEEA EA provides a statistical framework for preparing accounts, further guidance on the methods of preparing accounts is needed (Edens et al., 2022). Therefore, we need to make some improvements to the accounting method.

This study draws on the experience of constructing the cultural service indicator system in the ecological product value accounting framework in China and abroad, conducts a deep analysis of cultural services to further define the accounting boundaries of each indicator of cultural services, and optimizes and updates its accounting model. The cultural service value accounting system formed in this study covers more comprehensive cultural services, and the accounting boundaries of each indicator are clearer, which makes this accounting more feasible to implement on the ground.

2.3 Optimization of indicator systems and accounting methods

We analyzed above some existing typical indicator systems. In the following, we select some of these indicators to be adjusted (Table 2) and explain the content and basis of the adjustment.

In the system of indicators for accounting for the value of CES, leisure and recreation, ecotourism, and esthetic value are the common categories of CES research (Yang and Cao, 2022; Márquez et al., 2023; Duan et al., 2025). Therefore, in terms of the indicator system for accounting the value of CES, this study retains the three major indicators of tourism and recuperation, leisure and recreation, and landscape value-added. However, knowledge systems and cultural diversity are among the least researched categories (Yang and Cao, 2022; Márquez et al., 2023). The scientific research and education value of ecosystems is even more greatly underestimated (Friess et al., 2020). Luca Coscieme estimated for the first time the value of ecosystems for the digital sector of the music industry. He argued that natural capital is a source of inspiration and that one of the cultural benefits of ecosystems is "inspiration" (Coscieme, 2015). Cabana David and other scholars have found through their research that Dublin Bay can provide services related to scientific knowledge and education through inspiration, aesthetic stimulation, and other factors (Cabana et al., 2020). Mangrove forests, coral reefs and open waters in Singapore have also been found to be of high scientific value (Friess et al., 2020). Analogously, it was found that not only bays, but a forest or a lake, for example, can provide the above services. Therefore, this study incorporates the less studied knowledge system into the indicator system of accounting for the

TABLE 2 Adjustments to the system of indicators and accounting methods.

Indicators of cultural services	Source	Adjustments to the method of accounting	The basis for adjustment
Tourism and recuperation	SAFES (Ecology and Nature Conservation Institute of China, 2020), Christie et al. (2012)	——	——
Leisure and recreation	*Norms for Accounting for Gross Ecological Products* (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022)	Introduction of a new parameter: person-hours per unit area	By counting the person-hours per unit area, one can accurately determine the amount of human labor input per unit area within the research region, which is helpful for precisely calculating the labor cost (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022; Sander and Haight, 2012)
Landscape value, landscape value-added	Ungaro et al. (2016)	Clarifies that value is the landscape value-added portion of the hotel or owner-occupied home affected by the landscape, not the full amount of the hotel or owner-occupied home affected by the landscape	Accounting principle of supply = use in SEEA EA (United Nations, 2021)
Scientific research and education	Friess et al. (2020)	Applying the results-based approach to replace the value of scientific research and education with research funding from scientific institutions and higher education	Friess et al. (2020)

value of CES and terms it "scientific research and education". The value of scientific research and education is defined as a characteristic of an ecosystem that contributes to providing opportunities for scientific investigation, discovery and knowledge (Tempera et al., 2016).

Considerations regarding the methodology for accounting for the value of CES are set out below. The city of Tai'an is located in China. In order to make the accounting method for CES in Tai'an City align more with the geographical characteristics, the accounting methods for tourism and recreation, leisure and recreation, and landscape value-added refer to the Norms for Accounting for Gross Ecological Products in China (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022).

It has been shown that the cultural value of an environment depends on ecosystem services that are susceptible to change over time (Cabana et al., 2020). Therefore, this study eliminates the value-added coefficient in the original model of landscape value-added. Strictly following the accounting principle of *supply = use* (United Nations, 2021) for cultural service products, the value-added portion of the use or transaction amount in the base year of hotels and owner-occupied housing is directly accounted for. Some studies have already suggested that the value of scientific research and education can be replaced with a willingness to pay for research at the research site (de Groot et al., 2010; Tempera et al., 2016). The process of generating the value of scientific research and education services is that by which ecosystems provide inspiration for human activities of scientific innovation and artistic creation and then produce new knowledge through human creativity and labor. Robert Fish and colleagues argue that CES are the result of the co-generation and co-creation of human-ecosystem interactions (Fish et al., 2016). Scientific research institutions and research and experimental development (R&D) funding is the actual expenditure of funds incurred to increase the stock of knowledge and to design new applications of existing knowledge. This part of the funding is a joint input to the inspiration and human labor provided by the ecosystem. Therefore, this study takes the research and experimental development (R&D) expenditure inputs of government-owned research institutes and educational institutions within parcels with science and education value as a measure of the quantity of value of scientific research and education services.

2.4 Construction of the index system

2.4.1 Index system

2.4.1.1 Tourism and recuperation

Tourism rest and recuperation is the service of tourism and physical and mental recuperation provided by the ecosystem for human beings. These services bring a range of non-material benefits to people, such as calming the mind, relieving stress, enhancing experience, and relaxing the spirit.

2.4.1.2 Leisure and recreation

Leisure and recreation are the non-material benefits that ecosystems bring to people's spirits, such as pleasure and relaxation. Ecosystems provide human beings with leisure and recreation areas, such as pocket parks, green spaces, lakes, and other natural spaces where people can engage in recreation and sports.

2.4.1.3 Landscape value-added

"Landscape value-added" is the esthetic enjoyment and spiritual value that ecosystems provide to humans (Park and Kim, 2017). The landscape value-added impact on the capitalization of real estate value is mainly focused on house prices (Su et al., 2021), and ecosystems can bring value-added and premium for hotels and owner-occupied houses (Breunig et al., 2019; Kim et al., 2019; Wen et al., 2015).

2.4.1.4 Scientific research and education

Scientific research and education are the non-commercial use of inspirational stimulation with scientific research value provided by the ecosystem. They include intellectual, educational, and artistic enlightenment that specifically increase the stock of knowledge.

2.4.2 Accounting content

2.4.2.1 Tourism and recuperation

The quantity of goods produced for tourism and recuperation is the annual number of visitors to the ornamental natural attractions in the accounting region. The value of tourism and recuperation is the sum of the time cost of tourists and their average travel cost. The time cost of a tourist includes the cost of time spent on the journey and at the natural attraction.

2.4.2.2 Leisure and recreation

The quantity of goods produced for recreation and leisure is the total number of hours of recreation and leisure in parks, lakes, green spaces, and other recreationally active ecological spaces. The types of leisure and recreation areas should cover comprehensive parks, community parks, specialized parks, street gardens, and pocket parks. The quantity of value is the product of the total number of person-hours of leisure and recreation and the per capita wage per unit of time—that is, the value of leisure and recreation time cost.

2.4.2.3 Landscape value-added

The quantity of goods produced by landscape value-added is the number of hotel room nights or square footage of owner-occupied housing that is able to derive added value from the natural landscape of the ecosystem. The value is the sum of the added value of the hotel landscape and the added value of the owner's home landscape, or the value of the property and the hotel value-added. The value-added component is subject to the requirement that the transaction or use occur during the base year.

2.4.2.4 Scientific research and education

Scientific research and education are intangible ecological product, so their quantity of goods produced is not counted, and the meaning of quantity of goods produced is expressed in the process of calculating the quantity of value. The value of research and education is the total amount of R&D funding invested by government research institutes and higher education institutions within the parcels of land with research and education value.

2.5 Construction of the cultural service value accounting method system

This study follows the method and principle of the value accounting of ecological products, and it selects the accounting index of cultural ecosystem services according to the Specification for Accounting for the Total Value of Ecological Products (National Development and Reform Commission of China and National Bureau of Statistics of China, 2022). Choosing the cultural service products in ecological products as the research object, we established a system of accounting methods for the quantity of goods produced and value of cultural service products including the four indicators of tourism and recuperation, leisure and recreation, landscape value-added, and scientific research and education from the perspectives of both physical quantity and value, as shown in Table 3. For specific calculation models, see Formulas 1–11.

2.5.1 Accounting model for tourism and recuperation

Quantity of goods produced: a list of natural scenic spots is formed by applying the statistical survey method, and the annual tourist trips of each scenic spot are summed and accounted for.

$$N = \sum_{i=1}^{n} N_{ti} \tag{1}$$

In this equation: N is the total number of visitors to the natural scenic area (person·time/a); N_{ti} is the ith natural scenic spot visitor trips (person·time/a); i is the type of natural scenic area, i = 1,2,3, . . . ,n; n is the number of natural scenic spots.

Quantity of value: the value of tourism and recuperation services is derived by applying the travel cost method of accounting.

$$V_r = N \times TC + \sum_{i=1}^{n} C_i \tag{2}$$

$$TC = T \times W \tag{3}$$

In this equation: V_r is the the value of tourism and recuperation services (CNY/a); N is the total number of trips to the natural scenic area (person·time/a); TC is the average time cost of tourists traveling to natural scenic spots (CNY/(person·time)); T is the average time spent by tourists traveling by road and in natural scenic spots (day/time); W is the average wage of tourists (CNY/(person·day)); C_i is the business income of the ith scenic spot (CNY/a), including food and lodging expenses in the scenic spot (CNY/(person·time)), scenic spot entrance fee (CNY/(person·time)), and shopping, entertainment and other related extension expenses driven by coming to the natural scenic spot (CNY/(person·time)); i is the natural scenic spots, i = 1,2,3, . . . ,n; n is the number of natural scenic spots.

2.5.2 Accounting models for leisure and recreation

Quantity of goods produced: the use of statistical surveys to account for the leisure and recreation services' quantity of goods produced.

$$N_{pt} = \sum_{i=1}^{n} N_i \times S_i \tag{4}$$

In this equation: N_{pt} is the total person-hours of leisure and recreation activities (person·hour/a); N_i is the number of person-hours per unit square meter of the ith leisure and recreation area (person-hour/(a·m^2)); S_i is the area of the ith leisure and recreation area (m^2); I is the leisure and recreation area, i = 1,2,3, . . . ,n; n is the number of leisure and recreation areas.

Quantity of value: apply the cost substitution method to account for the quantity of value of leisure and recreation services.

$$E_t = N_{pt} \times E \tag{5}$$

In this equation: E_t is the service value of ecosystem leisure and recreation (CNY/a); N_{pt} is the total person-hours for leisure and recreation activities (person·hour/a); E is the local per capita wage per unit of time (CNY/(person·hour)).

TABLE 3 Methodological system for accounting for cultural service indicators.

Indicator	Quantity of goods produced	Method of accounting for quantity of goods produced	Quantity of value	Methods of accounting for quantity of value
Tourism and recuperation	Total number of visitors to natural attractions	Statistical survey (Ma et al., 2020)	Value of input costs for tourism and recuperation	Travel costs act (Hu et al., 2023)
Leisure and recreation	Total leisure and recreation person hours	Statistical survey (Ma et al., 2020)	Value of leisure and recreation time costs	Time-cost method
Landscape value-added	Owner occupied square footage/hotel room nights affected by landscape value-added	Statistical survey (Ma et al., 2020)	Added value of self-housing and hotels	Market-value approach (Sumarga et al., 2015)
Scientific research and education	—	—	R&D spending by government-owned research and educational institutions	Results-based approach (Block et al., 2024)

2.5.3 Accounting models for landscape value-added

Quantity of goods produced: the application of statistical surveys to account for the physical quantity of goods produced by landscape value-added.

$$H_l = \sum_{i=1}^{n} H_{li} \tag{6}$$

$$R_l = \sum_{i=1}^{n} R_{li} \tag{7}$$

In this equation: H_l is the number of hotel rooms (nights) receiving added value from the ecological landscape (night/a); H_{li} is the number of hotel rooms (nights) in region i that receive added value from the ecological landscape (night/a), i = 1,2,3, . . . ,n; R_l is the area of owner-occupied housing that receives added value from the ecological landscape (m^2/a); R_{li} is the area of owner-occupied housing in region i that receives added value from the ecological landscape (m^2/a), i = 1,2,3, . . . ,n.

Quantity of value: the amount of value added to the landscape is accounted for using the market value approach.

$$VL = VH + VR \tag{8}$$

$$VH = H_l \times (RH - PH) \tag{9}$$

$$VR = R_l \times (RR - PR) \tag{10}$$

In this equation: VL is the ecosystem landscape value-added (CNY/a); VH is the added value of hotel landscape (CNY/a); VR is the value added to the landscape of owned housing (CNY/a); H_l is the number of hotel landscape value-added sold rooms (nights) (night/a); PH is the average unit price of hotel rooms (CNY/night); RH is the average unit rate for landscape value-added hotel rooms (CNY/night); R_l is the area of landscape value-added owner-occupied housing contracted for trading (m^2/a); PR is the value of owner-occupied housing services (CNY/m^2); RR is the landscape value-added owner-occupied housing service value (CNY/m^2).

2.5.4 Accounting model for scientific research and education

Scientific research and education indicators, due to their intangible nature, do not count the number of products produced. The meaning of physical quantities is expressed in the accounting for quantities of value (Gao, 2020). The value of this cultural service product is reflected in the level of funding for scientific research and education in a region. Therefore, the quantity of the value of scientific research and education is expressed in terms of the total amount of research and experimental development (R&D) funding invested in government-owned research and educational institutions in the study area.

$$S_c = RD \times \left(SG_{gov} + SG_{edu}\right) \times A_p \tag{11}$$

In this equation: S_c is the value of services of scientific research and education in ecosystems (CNY/a); RD is the total expenditure of funds actually incurred by the research region for the implementation of research and experimental development (R&D) activities in the base year (CNY/a); SG_{gov} is the share of R&D invested by government-owned research institutions in the study region in the base year; SG_{edu} is the share of R&D by educational institutions in the study area in the base year; A_p *is the* proportion of area of scientific and educational value in the study area.

3 Results

3.1 Accounting list of the quantity of goods produced and value of cultural services in Tai'an, 2022

According to the accounting framework of this study, the accounting list of goods produced and the quantity of the value of cultural service products in Tai'an City in 2022 was developed (Table 4).

3.2 Accounting result

As shown in Table 5 and Figure 2, the quantity of value of cultural service products in Tai'an City in 2022 totaled 5.306 billion CNY. Among these, the highest quantity of value of leisure and recreation is 4.027 billion CNY, accounting for 75.90% of the total value of cultural services; the quantity of value of tourism and

TABLE 4 Accounting list of cultural service products in Tai'an City.

Index of cultural services	Description of index
Tourism and recuperation	Time cost and direct/indirect consumption of tourists within the 69 natural scenic spots in Tai'an in 2022
Leisure and recreation	Time cost consumed by people for leisure and recreation in 240 urban parks in Tai'an in 2022
Landscape value-added	Premium portion of sales of landscape-added homes in Tai'an in 2022; value-added portion of the contracted amount of owner-occupied homes affected by natural landscaping
Scientific research and education	Research and experimental development (R&D) funding inputs from government-owned research institutes and educational institutions within parcels of land with science and education value in Tai'an in 2022

The number of scenic spots and parks in the table comes from local culture and tourism bureaus.

TABLE 5 List of accounting results for Taian, 2022.

Types of cultural ecosystem services		Quantity of goods produced	Quantity of value
Tourism and recuperation		8,939,795 (person-times/a)	9.36 (100 million CNY/a)
Leisure and recreation		141,841,107 (person-hours/a)	40.27 (100 million CNY/a)
Landscape value-added	Landscape value-added in hotels	116,416 (night/a)	1.68 (100 million CNY/a)
	Landscape value-added for owner-occupied homes	799,985.40 (m^2/a)	
Scientific research and education		—	1.75 (100 million CNY/a)
Total value of cultural ecosystem services		—	53.06 (100 million CNY/a)

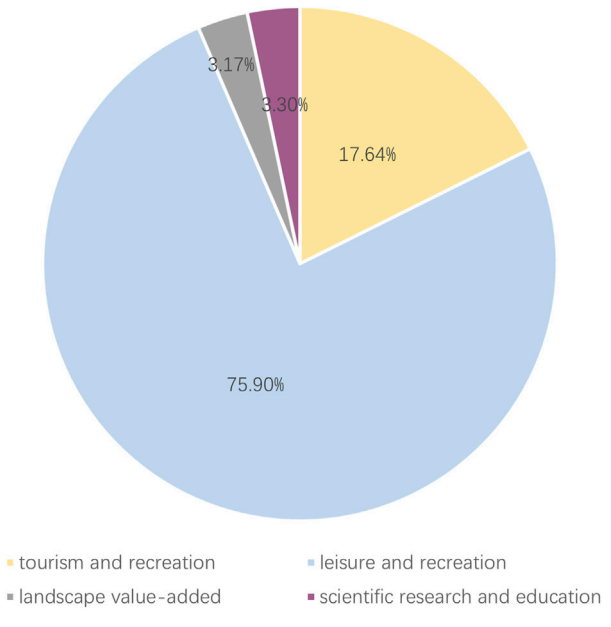

FIGURE 2
Value share of cultural services in Taian, 2022.

recuperation is 936 million CNY, accounting for 17.64% of the total value of cultural services; the quantity of value of scientific research and education is 175 million CNY, accounting for 3.30% of the total value of cultural services; the quantity of value-added of landscape is 168 million CNY, accounting for 3.17% of the total value of cultural services. The quantity of the value of cultural service products is ranked as follows: leisure and recreation > tourism and recuperation > scientific research and education > landscape value-added. Due to the impact of the epidemic in 2022, the tourism industry was hit more seriously. This leads to the low accounting result of the value of cultural service products in Taian City in 2022.

The quantity of the value of cultural service products per capita in Tai'an City has obvious differences in the distribution of administrative/functional areas. As shown in Figure 3, among the nine counties (cities and districts) and functional areas in Tai'an, Taishan Scenic Area has the highest per capita value of cultural service products of 4,338.32 CNY; the Feedback Cuwen scenic area has the lowest per capita value of cultural service products at 33.29 CNY.

The per capita value of cultural service products in nine counties (cities, districts) and functional areas is ranked as follows: Taishan scenic area > Gaoxin district > Dongping county > Daiyue district > Ningyang county > Feicheng city > Taishan district > Xintai city > Cuwen scenic area. From the results of the accounting of the value of ecological products in Tai'an in 2022, it seems that the cultural tourism industry in Tai'an was affected by the epidemic, and the vertical comparison is not very meaningful. From the horizontal comparison analysis, Taishan scenic area occupies obvious advantages, which is sufficient to reflect the cultural tourism brand of "Chinese Taishan—World Taian" in Tai'an City.

4 Discussion

The establishment of a sound mechanism for realizing the value of cultural service products is a powerful impetus for all social forces to actively carry out ecological protection and environmental management and is an important way to improve the

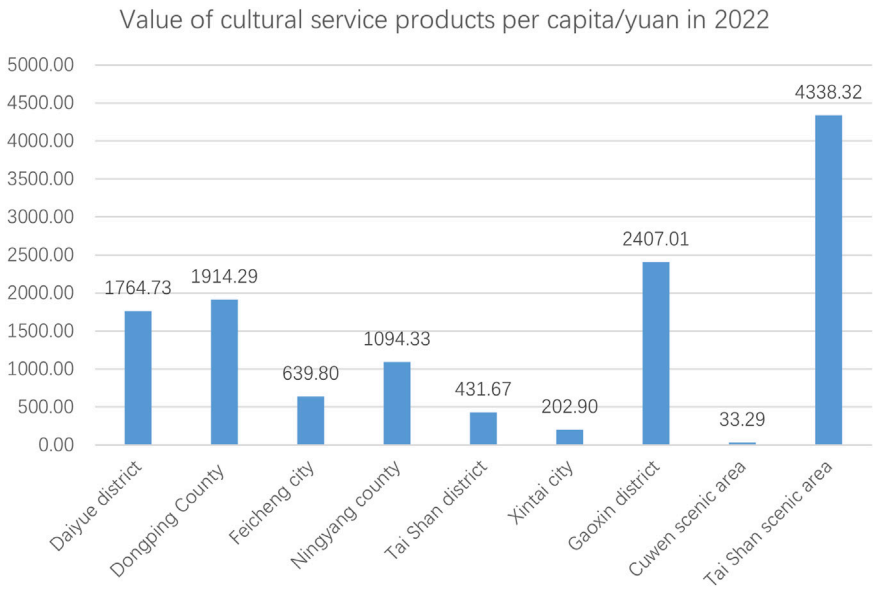

FIGURE 3
Comparative value of cultural services per capita.

effectiveness of ecological protection and the supply capacity of cultural service products. Tai'an city has strong potential for supplying cultural services and should actively explore the realization of the value of its cultural services, creating a "Taishan model" for realizing the value of its cultural services.

4.1 Compensation for ecological protection: "Reward and subsidy model"

When making ecological compensation, it is important to compensate for its totality. It is necessary to not only safeguard the integrity of ecosystems and natural resources but also attach great importance to the protection of potential cultural values such as recreation, education, scientific research and education, and spiritual and cultural aspects. From the calculation results, Taian cultural tourism products are mainly concentrated in the Taishan and Cuwen scenic areas—two key tourism development areas. Focusing on two major scenic spots to start with, it can adopt a vertical compensation mechanism, starting with comprehensive ecological protection compensation. Second, it should identify the key protection direction of the compensation area. Finally, it should establish the protection priority of Tai'an cultural service products and protect key cultural service products.

4.2 Eco-carrier premium: "cultural empowerment model"

The accounting results show that the quantity of added value of the landscape in Tai'an accounts for only 3.17% of the total value of cultural services. Therefore, there is an urgent need to improve the supply capacity of cultural service products in Tai'an, create cultural tourism in Tai'an, and improve cultural popularity so as to drive the added value of the surrounding real estate. Ultimately, real estate is used as a carrier to realize the value of cultural services. In addition, the quantity of the added value of hotels is small. The leading role of Taishan should be utilized so that the value of national scenic spots and parks in Tai'an is attached to hotels and B&Bs to realize this premium: utilizing the good ecological environment to encourage hotels and B&Bs to increase the number of rooms such as observation rooms, Taishan and Dawenkou culture themed rooms, and make full use of tourism and cultural recuperation products to stimulate the development of the hotel industry. Cultural empowerment helps "green water and green mountains" value realization.

4.3 Eco-industry development: "branding model"

Tai'an city has a long and splendid Chinese civilization and has cultural influence. It should give full play to the advantages of Taishan, highlight its characteristics, and create an ecological characteristic brand. It can create a specialty food brand and increase its popularity by utilizing local specialty food such as red scale fish, Tai'an pancakes, Taishan three beauties, and Tai'an fried chicken. In this process, targeting the needs of the masses is crucial. Encouraging the development of the Tai'an pre-cooked food brand system and selling it as tourist attractions can increase the income of the tourism industry and realize ecological products. The local culture of Tai'an can be utilized, such as Taishan culture, Yan's family training and family style, canal culture, water margin culture, Taishan stone daredevil culture, and other aspects, integrating them with the natural landscape, to develop and shape a wide range of unique Tai'an cultural tourism industry brands.

5 Conclusions and prospect

5.1 Conclusions

1. This study analyzes the value accounting frameworks of ecological products in China and abroad. Based on the definition of cultural service products, following scientific, comprehensive, systematic, and practical principles, it takes all aspects of cultural services into account. Finally, the original indicator system is refined, resulting in a more comprehensive indicator system for cultural service products that covers four major indicators: tourism and recuperation, leisure and recreation, added landscape value, and scientific research and education. This provides a new perspective on the value of scientific research and education in ecosystems.
2. In terms of the accounting model, this study incorporates a new parameter, the number of recreation hours per square meter, into the leisure and recreation indicator. The accounting scope of the leisure and recreation indicator covers person-hours in five types of park: comprehensive, community, specialized, street, and pocket parks. Furthermore, the landscape appreciation indicator clearly stipulates that the ecological products on the accounting list must meet the usage and transaction requirements for the base year. A new model has been established for calculating the value of the scientific research and education indicator. These improvements offer a new quantitative approach for accounting the value of CES, enabling its more accurate and detailed quantification.
3. This study takes the historical city of Tai'an as an example to verify the feasibility of the cultural service product indicator system and its accounting methodology system as constructed in this study. The calculation results show that the CES value of Tai 'an city was 5,306 million CNY in 2022. The value of leisure and entertainment is the highest, and the value of landscape value is the lowest. The calculation results can provide data reference for the relevant policy formulation of Tai'an City.
4. Accounting for the value of cultural service products in Tai'an City can promote its cultural benefit assessment and its sustainable development. The following optimization suggestions are proposed to realize the value of cultural services in Tai'an City. 1) Promote the reward and subsidy mode, and help realize the value of cultural services in Tai'an City with ecological protection compensation. 2) Promote the cultural empowerment mode and realize the value of cultural services with the premium of ecological carriers as the entry point. 3) Promote the branding mode and write a new chapter to realize the value of cultural services, with ecological industry development as the main focus.

5.2 Conclusion and prospect

The current cultural service value accounting system has certain limitations and needs gradual improvement in practice. First, data support needs to be strengthened. The existing ecological monitoring system has not yet fully integrated the core data required for cultural service accounting, which may affect the reliability and comparability of valuation results to some extent. Second, model construction requires further optimization. In the value accounting of services such as tourism and recuperation, it is necessary to better separate the inputs of the human economic system. At present, artificial costs like infrastructure and operation management are sometimes included in the ecosystem value, which may lead to certain deviations. Third, there is room for expansion in research depth and breadth. Quantitative research on cultural services has mainly focused on relatively obvious indicators, and measurement methods for core dimensions such as spiritual pleasure and aesthetic experience need exploration. The research scope is somewhat limited to several prominent service types, making it hard to fully reflect the complete value spectrum of cultural services.

Data availability statement

The datasets presented in this article are not readily available because due to limitations imposed by the Information Security Law of the People's Republic of China The authors signed a confidentiality agreement, and the data cannot be shared. Requests to access the datasets should be directed to Teng Zhao, zt2022tt@163.com.

Author contributions

CX: Conceptualization, Investigation, Methodology, Supervision, Writing – review and editing. TZ: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Validation, Writing – original draft. YS: Conceptualization, Formal Analysis, Methodology, Validation, Writing – review and editing. GY: Formal Analysis, Methodology, Resources, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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