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Article

Estimation of Water Resources Ecological Service System Value in Tarim River Basin -- From a Full Value Chain Perspective

Quan Lu [1,2] Duo Hua[2,3] Yanjun Li[1,*] and Dezhen Wang[4,5*]

1.College of Economics and Management, Huazhong Agricultural University, WuHan, 430077, China; luquan0122@163.com (Q.L.)
2.College of Economics and Management, Tarim University, Alar, 843300, China; luquan0122@163.com (Q.L.)
3.School of History, Xinjiang University, Urumqi, 830046, China; huatote@163.com（D.H.）
4.College of Economics and Management, Xinjiang Agricultural University, Urumqi, 830052, China; dezhengumei@163.com(D.W.)
5.Business School, Yulin Normal University, Yulin 537000, China; dezhengumei@163.com(D.W.)
* Correspondence: lyj@webmail.hzau.edu.cn (Y.L.); dezhengumei@163.com(D.W.)

Abstract: The estimation of ecological service system value of water resources in Tarim river basin is of great significance for resource allocation management and ecological protection. However, there is still no unified and complete evaluation method for ecological service system value of inland river in China. Based on the perspective of the whole value chain, the study classifies its ecological service functions, and divides 11 sub-categories into 4 categories (supply, regulation, culture and support) as evaluation indicators to carry out quantitative evaluation. The results showed that the total value of ecological service system in Tarim river basin in 2018 was 4156.5247×10^8 Yuan, and the value of regulating function, cultural function, supporting function and supply function were successively from high to low, which were as follows: 2565.6825×10^8 Yuan, 1009.5471×108 Yuan, 884.0770×10^8 Yuan, 20.3350×10^8 Yuan, among which the value of regulation function is dominant.

Keywords: Tarim river; ecological service function value; river ecosystem; evaluation indicators

1. Introduction

Ecological service system that is material produced by ecosystem and ecological processes and maintain a good living environment for human service performance [1], the water ecological system as the foundation of human survival and development is closely related to the people well-being [2], especially in northwest China arid social economic and social economic development and ecological environment protection is very important. As the most important oasis agricultural region in China, The Tarim river basin is one of the most arid regions in China and even the world, with the largest gap between water supply and demand and the most vulnerable ecology, as well as one of the regions with the highest agricultural water consumption ratio and lowest water resource utilization efficiency. With the economic development and agricultural area expansion of Tarim river Basin, the water system has been cut off and the service function of water resource ecosystem has been declining. The lower reaches of Tarim river Basin have become the disaster area of serious ecological degradation in recent years [3], and the problems of resource allocation management and ecological protection are prominent. The first document of the Central Government in 2020 points out that it is necessary to "accelerate the launch and construction of a number of major water conservancy projects and supporting facilities" and "promote large-scale water supply projects" in order to build a moderately prosperous society in an all-round way. The government Work Report of the two sessions in 2020 once again proposes the construction of "two new and one major". Comprehensive and systematic study and calculation of the value of water resources ecosystem service system in Tarim river basin has become an urgent demand for policy implementation.

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The concept of ecosystem service system has been gradually defined since it was put forward, but the definition of watershed ecosystem is still controversial [1,2,4-11], and there are few studies on the full value of domestic inland rivers [12-21], and the comprehensive system measurement and pricing of watershed ecosystem service system value is also open to discussion [13,19-26]. Therefore, it is particularly important to study the ecological service system value of Tarim river basin. In Tarim river basin as the research object of this research, through the United Nations in one thousand ecosystem assessment classification method combined with the actual situation of the development and utilization of river and its ecosystem structure characteristics, classifying its ecological service function, finally in four kinds of functions (supply, regulation, culture, support) in class 11 and as evaluation index, Select the corresponding assessment method (monetization of evaluation, such as the market value method, replacement cost method), carries on the quantitative evaluation, so as to the Tarim river basin, the allocation of resources management and ecological protection to provide the theory basis of a systematic, ease river basin water resources shortage, to provide reference for the sustainable development of social economy.

2. Research status and theoretical review

2.1. Research progress of ecosystem service system value

The basic concept of ecosystem was first elaborated by The British ecologist Tansley [4], which formed the research system of modern ecology. The ecosystem service function can be traced back to Man and Nature (George Marshd), who realized the reaction of human beings to the environment and proposed that the ecosystem service function of forests should be managed scientifically, moderately transformed and developed. Since the 1990s, studies on ecosystem services have been increasing. Natural Services: Natural Ecology Determines Society (Daliy) systematically summarizes the theories and methods of relevant scholars and the value measurement of ecosystem services [5]. The Millennium Ecosystem Services Assessment (MA) of the United Nations divides the value of ecosystem services into four categories: supply function, regulation function, cultural function and support function [1], making the assessment of ecosystem services a hotspot in the field of ecological research. This paper evaluates the ecosystem services in the Tarim river basin from this perspective. However, attention should also be paid to the unassessability of ecosystem services proposed by Serafy and Aryes [6-7]. Domestic studies on ecosystem service value appeared later. Zhang used substitution cost method and shadow engineering method to evaluate the water conservation and soil retention function of Fugong forest [8], and Bi evaluated the service function of specific forest ecosystem in Hebei province [9]. At the end of the 20th century, the evaluation of the value of regional ecosystem services was gradually improved. Ouyang et al. used the evaluation method of ecosystem services to calculate the value of six types of services while clarifying the connotation and evaluation indicators of domestic terrestrial ecosystem services [10]. Xie et al. (2001) predicted six development trends of ecosystem services while describing relevant progress in this field [11], and then improved the concept of ecosystem services while calculating the value of China's ecosystem services based on the extended labor value theory (Xie et al.) [2].

2.2. Research progress on the value of water resources ecological service system

2.2.1. Theory of water resources ecological service system value

The measurement of water ecosystem service function started from the rapid evaluation model of wetland type proposed by Larson [12]. Later, on the basis of ecosystem service function, Young proposed an evaluation model of recreational value of water [13]. Wilson et al. took freshwater ecosystem service functions as a starting point to elaborate previous studies, which mainly focused on river recreational function assessment [14]. Similar to the research on the value of ecosystem services in China, the evaluation of water ecosystem services in China has just started. Ouyang et al. defined river ecosystem services as the benefits it brings to human beings [15]. Fan, such as when defining the concept of river ecosystem pointed out that it is not independent and closed ecosystems [16]. The comprehensive evaluation of river ecosystem service function has not been carried out in the early stage, and most of the studies focus on the evaluation and measurement of a specific factor in a specific water area in China, such as alpine wetland grassland resources in western China (Li) and reed resources in Bosten lake wetland in Bazhou (Sun) [17,18]. In the later period, the comprehensive assessment of ecosystem service function of Haihe River and its tributaries gradually increased. For example, Yang, Zhu, Tian et al. studied the ecological service function and value assessment of Weihe river basin, Beijing section of Yongding river basin and Chishui river basin in Shaanxi [19-21].

2.2.2. Types and evaluation methods of water resources ecosystem service system value

Based on different research perspectives, domestic scholars have different cognition of river ecosystem service types. Zhao et al. divided river ecosystem service types into direct use value and indirect use value, and calculated four function types according to water ecosystem service system value. Five direct use values, such as aquatic products and hydropower generation, and seven indirect use values, such as environmental purification and carbon sequestration, were constructed [22]. Ouyang et al. divided it into four types of functions (supply, regulation, culture and support) as an indicator system from the perspective of full value chain (MA project) [23]. Li divided water environmental purification into five categories based on MA project based on supply-demand balance assessment [24]. Xie et al. innovated the method of value equivalent assessment by expanding the six types of ecosystems and subdividing them into two levels, thus achieving high reliability of the measurement results [25].

Based on the choice of research methods, the measurement methods of river ecosystem service system value can be divided into physical evaluation method and monetary value method to quantify its ecosystem service value. At the end of the 20th century, Ma was involved in the field of economics when he studied the terrestrial ecological service system [26]. Since the 21st century, the level of scientific research technology and education in China has been constantly improving, and the number of published studies in this field has entered the fourth place in the world (Gong), and the evaluation methods have also made continuous progress [27]. Gao defined physical evaluation method through research, data statistics and so on within the basin ecological service value in the form of physical measurement, suitable for hydroelectric power value, river water and sediment value such as physical value, but for the value of water storage storage, water purification and other non-food is difficult to measure [28]. Hao in domestic river ecosystem service functions are reviewed, the research methods are summarized, the evaluation methods on monetary value method is used, the basin ecological service function of quantitative for money (including shadow engineering method, the results of reference method, etc.) [29], Fan argued that monetary willingness to pay (WTP) can reflect the general. However, it should also be recognized that some ecosystem services and products cannot be measured by price, and existing evaluation methods are controversial [16].

2.3. Existing problems in the research on the value of water resources ecological service system in China

The number of papers published in the field of water resource ecosystem service value measurement is still increasing year by year. As an emerging interdisciplinary hotspot, China has made great achievements in recent years, but there are still some shortcomings in its research, which can be summarized as follows:

(1) The definition of river ecosystem service system is still controversial. The concept of ecosystem service system has been defined continuously since it was put forward at the beginning of last century. However, the definition of river ecosystem is still controversial. For example, the river ecosystem is defined as the river flowing water ecosystem (Zhao;

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Hao) [22,29], river ecosystem is different from river flow ecosystem, it is not independent and closed ecosystem (Fan) [16], should include river and its watershed surrounding areas, sources, reservoirs, wetlands, etc., should not be separated and measured in the study.

(2) The neglect of inland river research. Domestic researches mostly focus on Haihe river and its tributaries (Yang; Zhu; Tian) [19-21], and few estimates are made on the value of the inland river. As the longest inland river in China, The Tarim river has bred the Western civilization for thousands of years in its basin. With the social and economic development in the basin, the cultivated land area has increased and the river salinization has gradually increased, causing serious damage to the ecosystem in the basin. River ecosystem restoration faces severe challenges. How to construct an evaluation index system of ecological service value suitable for Tarim river basin according to the actual situation of Tarim river basin? How to quantify the ecological service value of Tarim river basin? All these will provide basic theories for resource allocation, ecological compensation policy and the construction of "two new and one important".

(3) Lack of comprehensive and systematic evaluation and measurement of water ecological service system value. With the continuous improvement of relevant research, domestic research on ecological services is no longer limited to a specific factor in a specific region, and the indicator system is gradually improved, and the research and calculation of various functions and values of ecological services system from multi-dimensional dimensions, such as mountain forest, river to province, region and country (Zhu; Xie)[20,2]. Although the value of water ecological service system has been comprehensively described, the research perspective is still expanded based on four functional types (Zhao et al.; Li; Ouyang et al.) [22-24], there is still a lack of comprehensive and systematic evaluation and measurement of ecosystem service value of watershed water resources.

Based on the above problems, this study theory and MA in economics related ecological service system classification method, based on literature review and data analysis the composition of Tarim river basin water resources ecological service value, the corresponding index system and study its value evaluation method, to a comprehensive system of quantitative evaluation of the Tarim river basin ecological service value, In order to provide scientific basis for the exploitation and utilization of water resources and ecological compensation policy, alleviate the environmental problems in the basin and promote the sustainable development of the economy in the western region.

3. Overview of the research area and research methods

3.1. Regional Overview

The research area of this paper is within 250M on each side of the main river and its headwaters of Tarim river, including wetlands and reservoirs in the surrounding area. The Tarim River originates from the Kunlun Mountains and the Tianshan Mountains and is the confluence of Hetian river, Yeerqiang river and other rivers. Its main stream is 1321km long, which is the largest inland river in China and the fifth in the world. The Tarim river basin is the general name of nine river systems around the Taklimakan Desert, namely Ariya River, Chechen River, Aksu river, Kaidu river and Kongque river, totaling more than 140 rivers. The rivers in the Tarim river basin are mainly supplied by the snow and ice of the Kunlun Mountains and The Tianshan Mountains, and are pure waste inland rivers.

Import nine water systems have been in the history of the Tarim river, the Chechen River, Ariya River water system successively with the Tarim river blocks the flow, groundwater only link, to form the pattern of "four source for" at present, namely the Aksu river (588 km) in the universe, the Yeerqiang river (1165 km) and Hetian river (319 km) surface contact with the Tarim river remains. The Kaidu river and Kongque river supply water to the lower reaches of the mainstream of Tarim river through Kuta canal. In the first half of the 20th century, kongque river had a surface water connection with Lop Nur, with a maximum length of 942km. In the 1970s, the river was only 520 km, while

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Kaidu river was 560km. The basin area of the "four sources and one trunk" is 250,300 km^2, accounting for 85.4% of the total area of the Tarim river basin. As the source of the "main stream" of the Tarim river, the "four sources" play an important role in the generation, development and evolution of the Tarim River. The following are the "four sources and one trunk" of the Tarim river basin.

3.2. Evaluation indexes and methods of ecological service system value of Tarim River

In the whole value chain perspective of ecological service system can be divided into supply, regulation, culture, support four types of function, through the classification of the MA program method and combining with the actual situation of the development and utilization of the Tarim river channel and its ecosystem structure characteristic, the classification of ecological service function of Tarim river basin [1], divided in four kinds of function of 11 sub-types as evaluation index, Physical evaluation method and monetary value method are used to carry out quantitative evaluation, that is, the watershed ecological service function is quantified as money. The evaluation indicators and methods are shown in Table 1.

Table 1. Evaluation indexes and methods of ecological service system value in Tarim river basin.

Function value	Evaluation index	Evaluation method	Calculation formula
Supply	Water supply	Market valuation method	Water supply by industry * Water price
	Aquatic products	Market valuation method	Total output value of fishery * (Tarim river basin area/Total basin area of The Autonomous Region)
	Hydraulic electrogenerating	Market valuation method	Total hydroelectric power * Hydroelectric power price
Adjustment	Water resources are stored and regulated	Shadow engineering method	Basin potential water storage * Cost per unit of storage capacity
	Water quality purification	Substitution costing	River pollutant carrying capacity * Cost of pollutant treatment
	Transportability of sediments	Substitution costing	Annual sediment transport * River clean-up costs
Culture	Tourist recreation	Market valuation method	Total tourism revenue * (Scenic spots in Tarim river basin /Number of scenic spots in Autonomous Region)
	Scientific research and teaching	Achievement reference method	Total area of watershed * cultural and scientific research value of ecosystem per unit area
	Aesthetics	Achievement reference method	River length * Aesthetic value of a river per unit length
Support	Biodiversity	Achievement reference method	Species to be protected * Biological value
	Provide habitat for living things	Achievement reference method	Average value of habitat provided * watershed area

4. Evaluation and analysis

4.1. Evaluation of supply function value

4.1.1. Value of water supply

The evaluation method of the supply value of Tarim River is the market value method, that is, the water supply of various industries and the current water price of Tarim River basin are used as evaluation indexes to measure the supply value of Tarim River basin. The calculation formula is:

$$V_1 = \sum (Q_{1i} \times P_{1i}) \quad (1)$$

In the calculation formula, V_1 is the water supply value of Tarim river (Yuan); Q_{1i} is the water supply (m^3) of i uses in Tarim river basin; P_{1i} is the price (Yuan · M^{-3}) of "four sources and one trunk" water of Tarim river.

According to the water price adjusted by the Bureau of Management in 2018 in No.1741 [2016], the comprehensive agricultural water price in Hetian Irrigation area of Tarim river basin is 0.0065 Yuan/m^3. The price of comprehensive agricultural water in Kashi irrigation area is 0.0153 Yuan /m^3; The price adjustment of comprehensive agricultural water in Aksu River Irrigation area is 0.0143 Yuan/m^3; The price of comprehensive agricultural water in Kaidu river irrigation area is 0.0405 Yuan /m^3, and that in Kongque River irrigation area is 0.0932 Yuan/m^3. The price of comprehensive agricultural water supply in mainstream irrigation area is 0.0039 Yuan /m^3; Urban housing and commercial water is 0.5 Yuan/m^3; Industrial consumption of water was 0.2 Yuan/m^3; The water fee for agriculture, animal husbandry and livestock shall be levied on sheep as the unit of standard livestock, and the annual water fee for each sheep shall be 1 Yuan /m^3.

Table 2. Annual water consumption of "Four sources and one trunk" of Tarim River Uint：10^8m^3.

Rivers	Available water resources	Water consumption			Agricultural water consumption
		Live	Industry	Livestock	
Hetian	50.66	0.899	0.315	0.218	22.89
Yeerqiang	73.24	1.748	0.727	0.407	43.19
Aksu	95.899	1.067	1.793	0.233	45.5
Kaidu-Kongque	42.93	1.335	3.983	0.166	12.94
Trunk	47.34	0.097	0.031	0.035	9.78

Source: Zhang et al. Discussion on maximum irrigated area of "nine sources and one trunk" in Tarim River [30].

As shown in Table 2, the agricultural water consumption in Hetian river irrigation area is 22.89×10^8m^3, the price of comprehensive agricultural water is 0.0065 Yuan /m^3, and the value of agricultural water supply is 0.148785×10^8 Yuan. The agricultural water consumption in Yeerqiang river irrigation area was 43.19×10^8m^3, the price of comprehensive agricultural water was 0.0153 Yuan /m^3, and the value of agricultural water supply was 0.660807×10^8 Yuan. The agricultural water consumption of Aksu river irrigation canal is 45.5×10^8m^3, the price of comprehensive agricultural water is 0.0143 Yuan /m^3, and the value of agricultural water supply is 0.65065×10^8 Yuan. The agricultural water consumption in Kaidu River- Kongque river irrigation area is 12.94×10^8m^3, and the average price of comprehensive agricultural water is 0.06685 Yuan /m^3, and the value of agricultural water supply is 0.865039×10^8 yuan. The agricultural water consumption in the mainstream irrigation area is 9.78×10^8m^3, the price of comprehensive agricultural water is 0.0039 Yuan/m^3, and the value of agricultural water supply is 0.038142×10^8 Yuan [30]. The total value of agricultural water supply of "four sources and one trunk" in Tarim river is 2.363423×10^8 Yuan.

The total water demand is 5.146×10^8m^3, the water price is 0.5 Yuan/m^3, the total value is 2.573×10^8 Yuan; The total industrial water demand is 6.818×10^8m^3, the water price is 0.2 yuan /m3, the total value is 1.3698×10^8 Yuan; The water requirement for livestock is 1.024×10^8m^3, which is 1 Yuan /m^3 per standard livestock per year, and the total value is 1.059×10^8 Yuan.

The water supply value V_1 of Tarim River is 7.365223×10^8 Yuan.

4.1.2. Value of aquatic products

The evaluation method of aquatic product value of Tarim river basin is market value method. The calculation formula is:

$$V_2 = \frac{Q_2}{S} \times P_2 \tag{2}$$

Where, V_2 is the value of aquatic products in Tarim river Basin; Q_2 is the area of Tarim river basin; S is the watershed area within the autonomous Region; P_2 is the total output value of Xinjiang fishery. According to the China Statistical Yearbook, in 2018, the total output value of fishery in Xinjiang was 2.809 billion Yuan [31]. Xinjiang has more than 570 rivers, 139 lakes and 479 reservoirs, with a total water resource of $858.8\times10^8 m^3$ [32], of which, the total water resource of Tarim river basin is $367.56\times10^8 m^3$ [33]. Accounting for 42.80% of the total output value of Tarim River basin fishery is about 12.0225×10^8 Yuan.

4.1.3. Value of hydropower generation

The evaluation method of Tarim river hydropower generation value is market value method. The calculation formula is:

$$V_3 = Q_3 \times P_3 \tag{3}$$

Where, V_3 is the value of hydropower generation in Tarim River Basin (Yuan); Q^3 is the total amount of hydropower generation in Tarim river basin (KW·h); P_3 is power generation price of Tarim river (Yuan $\cdot KW^{-1} h^{-1}$).

The average power supply to the power system of Tarim river Basin for many years is 4.5108×108KM·h [34]. According to the national on-grid price of 0.21 Yuan/KW·h, the power generation benefit of the basin is 0.947268×10^8 Yuan.

4.2. Adjustment function value evaluation

4.2.1. Value of water resources storage and regulation

The Tarim river not only has the functions of water supply, fishery and hydroelectric power generation, but also has the functions of storage, regulation and storage to regulate drought and flood disasters. The evaluation method of water resources storage, regulation and storage value of Tarim river basin is shadow engineering method. The calculation formula is:

$$V_4 = Q_4 \times P_4 \tag{4}$$

In the formula, V_4 is water storage value of Tarim river Basin (yuan); Q_4 Total water resources of Tarim river basin (m^3); P4 is storage capacity cost per unit storage (Yuan $\cdot m^{-3}$). The total amount of water resources in the Tarim river basin is $367.56\times10^8 m^3$ [35]. The unit storage and regulation value of Tarim river is calculated to be 2565.233×10^8 Yuan based on the investment and construction unit storage cost of 61,000 yuan [36].

4.2.2. Value of water purification

The cost substitution method is used to quantitatively evaluate the value of water purification of Tarim river ecosystem from the salinization and alkalization prevention and control of river basin to a certain extent. The calculation formula is as follows:

$$V_5 = \sum (Q_5 \times P_5) \tag{5}$$

Where, V_5 is the purification value of Tarim River basin (Yuan); Q_5 is the sewage carrying capacity of Tarim river basin (t); P_5 is the cost of pollutant treatment (Yuan · T-1). Salinization is the main pollution in the Tarim river basin, and its main pollutants are sulfate and chloride, etc. The salinity in the mainstream is high, so it is not suitable for irrigation water [36]. Xu et al. calculated that the sewage carrying capacity of Tarim river was

769,800 t [37]. Due to the limitation of water quality and quantity, evaporation and desalting method was adopted for treatment. The total value of purification of Tarim river was calculated as 0.2309×10^8 yuan by referring to the calculation of evaporation and desalting method of China Water Network, which cost about 30 Yuan T^{-1}.

4.2.3. Value of sand transport capacity

The sediment transport capacity of Tarim river adopts substitution cost method, and the calculation formula is as follows:

$$V_6 = Q_6 \times P_6 \tag{6}$$

Where, V_6 is the value of sediment transport capacity of Tarim river basin (Yuan); Q_6 is the annual sediment transport of Tarim river basin (t); P_6 is the cost of river cleaning (Yuan T^{-1}). Tarim river basin is located in the northwest, and the cost of river cleaning in the north is 1.5 Yuan · t^{-1} as the basis [20]. The average annual sediment transport in The Tarim river basin is shown in Table 3 [38]. Considering the different influences of time distance and distance of data on the event, the calculation is based on the moving weighted average method, and the average annual sediment transport is adjusted with the weights of 3, 2 and 1 respectively. After the weighted average, the average annual sediment transport is 0.1457×10^8t. The annual sediment transport value of Tarim river basin is 0.2186×10^8 Yuan.

Table 3. Annual sediment transport of Tarim river. Unit: Ten thousand tons.

Year	Sediment runoff
Mean 2001——2006	1169.50
Mean 2007——2012	1629.67
Mean 2013——2018	1975.83
Weighted mean	1457.28

Source: Ministry of Water Resources, PRC. Bulletin of River Sediment in China [37]

4.3. Evaluation of cultural function value

4.3.1. Tourism entertainment value

The tourism and entertainment value of Tarim rver rasin was calculated by using the market value method, and A total of 107 A-level scenic spots were verified in The Tarim river basin in Southern Xinjiang in 2018, including 4 5A scenic spots, 22 4A scenic spots, 47 3A scenic spots, 32 2A scenic spots and 2 1A scenic spots [39], as shown in the Figure 1. In 2018, there were 317 A-level scenic spots in Xinjiang Autonomous Region. According to the sample survey conducted by the statistical company, the total tourism revenue of Xinjiang Autonomous Region in 2018 was 252.232 billion Yuan, up 40.82% year on year. Meanwhile, there are 107 A-level scenic spots in The Tarim river basin, accounting for 33.75% of the total number of A-level scenic spots in the Autonomous Region. Therefore, the tourism and entertainment value of The Tarim river basin in 2018 is conservatively calculated to be 851.3825×10^8 Yuan. It should be pointed out that, due to the price and geographical location difference of scenic spots in the northern and southern Xinjiang, their value results may be high, and with the development and progress of scenic spots in the Tarim river basin and the increase of people's demand for tourism, the tourism and entertainment value of the basin will continue to improve.

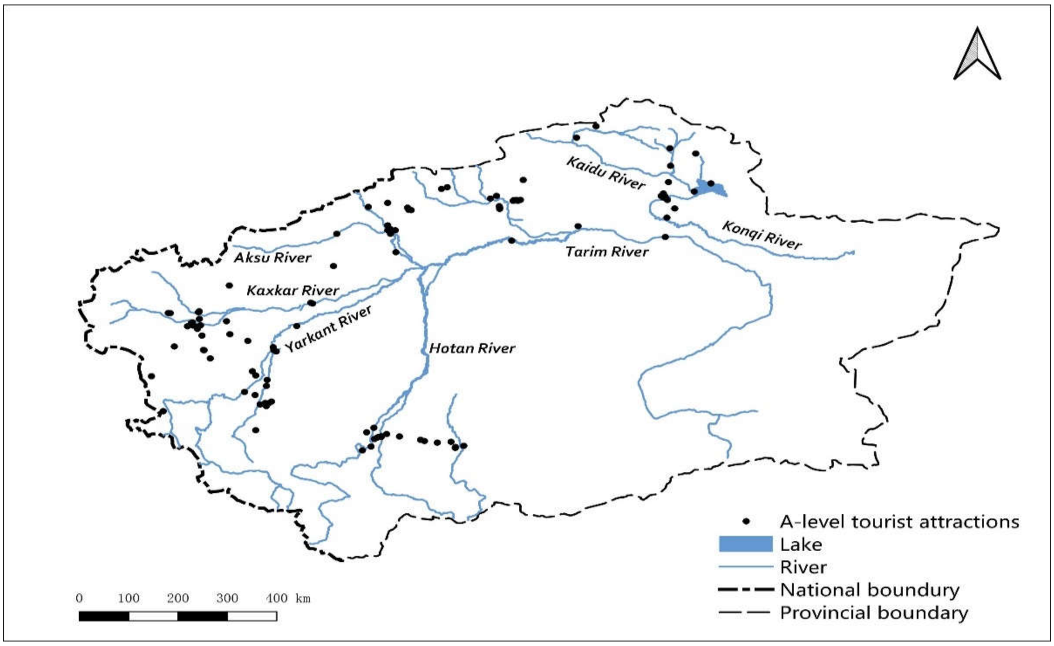

Figure 1. Distribution of A-level tourist attractions in the Tarim River Basin, Xingjiang, China.

4.3.2. Value of scientific research and teaching

The calculation formula of cultural scientific research value of ecosystem per unit area is as follows:

$$V_7 = Q_7 \times P_7 \quad (7)$$

In the formula, V_7 is the scientific research and teaching value of Tarim river basin, Q_7 is the area of Tarim river basin, P_7 is the scientific research and teaching value of wetland ecosystem per unit area. According to the research and teaching value of domestic wetland ecosystem per unit area of 38200 Yuan/km^2 [40], and the area of "Four sources and one trunk" watershed of Tarim river is 250,300 km^2, the research and teaching value of Tarim river is calculated to be 95.6146×10^8 Yuan.

4.3.3. Aesthetic value

At present, there are mainly two evaluation methods for the aesthetic value of wetland rivers: willingness to pay method and achievement reference method. The former is based on questionnaire survey with strong subjectivity, while the latter is improved based on expert consultation. Although the differences between different rivers are ignored, the overall aesthetic characteristics of rivers are still retained. In this paper, the results reference method is used to evaluate the aesthetic value of Tarim river basin V_8, and the formula is as follows:

$$V_8 = Q_8 \times P_8 \quad (8)$$

In the formula, V_8 is the aesthetic value of Tarim river basin, Q_8 is the area of Tarim river basin, and P_8 is the aesthetic value of the river per unit length in the research works of reference scholars. Taking the research results of Xie et al. as reference [41], the land use type area and ecological service value of Tarim river basin are shown in Table 4. The area of Tarim river basin is 250,300 km^2. The value of aesthetic landscape provided by Tarim river basin is calculated to be 62.5500×10^8 Yuan.

Table 4. Land use type area and ecological service value of Tarim river basin.

Item	Proportion /%	Provide aesthetic landscape /Yuan·hm-2	Maintaining biodiversity / 元·hm-2
Woodland	1.25	934.13	2025.44
Grasses	24.14	390.72	839.82
Waters	3.44	1994.00	1540.41
Construction land	0.22	-	-
Desert	67.26	107.78	179.64
Arable land	3.69	76.35	458.08

Source: Spatial and temporal analysis of LUCC and landscape pattern in Tarim river basin from 1990 to 2015 based on GIS and RS [42].

4.4. Support function evaluation

4.4.1. Biodiversity value

In this paper, the value of biodiversity in The Tarim river basin was calculated using the results-referenced method, and the formula is as follows:

$$V_{9i} = \sum (Q_{9i} \times P_{9i}) \tag{9}$$

Where, V_{9i} is the biodiversity value of Tarim river basin; Q_{9i} the number of different species in Tarim river basin; P_{9i} is the price of species i in the reference study. In Tarim Populus euphratica National Nature Reserve, there are eight kinds of animals under state first-class protection, such as wild camel, Xinjiang balihead fish and so on, there are 26 categories of national second-class protected animals, such as whooper swan and Buteo Rufinus. Due to the lack of various biostatistical data in Tarim river basin, this paper calculated the land use type area and its ecological service value of 104.8180×10^8 Yuan based on the research results of Xie et al. [41].

4.4.2. Provide habitat value

In this paper, the results reference method is adopted to calculate the value of habitat provided by Tarim river basin, and the formula is as follows:

$$V_{10} = Q_{10} \times P_{10} \tag{10}$$

V_{10} provides habitat value for Tarim river basin. Q_{10} Area of Tarim river basin; P_{10} unit value of habitat. Based on the research results of Costanzar et al. [42], the annual ecosystem service value of habitat provided by lakes and rivers was 311330.02 Yuan/km^2, and the area of Tarim river basin was 253,300 km^2, and the value of habitat provided by Tarim river basin was calculated to be 779.25904 ×10^8 Yuan.

4.5. Evaluation Results

Based on the perspective of full value chain, the calculation results of water resources ecological service system in Tarim river basin are as follows (Table 5):

Table 5. Calculation results of ecological service system value of Tarim river basin. Unit: 10^8 Yuan.

Function value	Evaluation index	Estimated value	
		Classified assessed value	Subtotal assessed value
Supply	Water supply	7.3652	20.3350
	Aquatic products	12.0225	
	Hydroelectric power	0.9473	
Adjustment	Water resources are stored and regulated	2242.1160	2242.5655
	Water quality purification	0.2309	
	Sediment ability	0.2186	
Culture	Tourist entertainment	851.3825	1009.5471
	Scientific research and teaching	95.6146	
	Aesthetic	62.5500	
Support	Biodiversity	104.8180	884.0770
	Provide habitat for living things	779.25904	
Total			4156.5247

5. conclusions and discussion

5.1. Conclusion

(1) According to the calculation method and evaluation index of ecological service function of Tarim river basin, the value of ecological service function from high to low is regulation function value, cultural function value, support function value and supply function value, respectively: 2565.6825×10^8 Yuan, 1009.5471×10^8 Yuan, 884.0770×10^8 Yuan, 20.3350×10^8 Yuan, with a total value of 4156.5247×10^8 Yuan (Table 5), accounting for 32.45% of Xinjiang's GDP in 2018.

(2) The regulation function was the core function of the Tarim river basin, accounting for 53.95% of the total value of ecosystem services of the Tarim river basin, and was 2596.6214×10^8 Yuan. Among the evaluation indexes, water resources regulation and storage, tourism, entertainment and aesthetic value are the highest, mainly because Tarim river is located in the arid area of northwest China with a broad basin and abundant water resources, accounting for 42.80% of the total water resources in Xinjiang. The supply function of the Tarim River basin accounts for a low proportion, but it also plays a basic role, such as urban agricultural water, fisheries and hydroelectric power generation. Therefore, attention should be paid to the development of the Tarim river basin. With the improvement of the compensation mechanism for ecological protection, the cultural industry and tourism featuring natural scenery and ethnic customs will become ecological, and the cultural and supporting functions of the Tarim river basin will continue to improve.

5.2. Research contributions

(1) Unlike defines river ecosystem for water in river ecosystem, this research taking the more recognition of the United Nations' one thousand ecosystem services assessment "(MA) in the definition, trying to Tarim river main channel and the origin of wetlands, the surrounding areas of the reservoir ecosystem services value system to conduct a comprehensive system of research estimates. (2) At present, Haihe river and its tributaries are mainly studied in domestic researches, while the inland river is studied in this paper. The core value of Haihe river tributaries is mainly its supply function, while the Tarim River basin is dominated by its regulation function. (3) The study of ecological service system value of Tarim River Basin is no longer limited to the calculation of a specific factor

in the basin, but integrates different research perspectives to establish a relatively complete ecological service system evaluation system.

The quantification of its value provides a theoretical basis for the restoration of Tarim river basin ecosystem and the improvement of ecological compensation policy, and also provides a reference for the establishment of the value index of water resources ecological service system in the autonomous region and other inland rivers. Two sessions in 2020, "the government work report," "achieve pollution prevention completed stage", "the construction of water conservancy and other major project" provides a more accurate scientific basis, in order to implement the party central committee and the State Council about western development guidance on the concept of " lucid waters and lush mountains are invaluable assets ", build a national ecological security barrier.

5.3. Limitations and prospects of the study

The limitation of the study is that the difference between intermediate value and final value is not clear, and there is repetition between the evaluated value. Secondly, the estimation of watershed ecosystem service value requires a lot of data support, and the lack of data leads to the limitation of research methods, leading to some deviations in the results of evaluation value, such as the lack of annual tourism income of watershed water conservancy scenic spots and the number of state-level protected animals. In addition, the result reference method may cause some deviation in the calculation results due to the differences of geographical characteristics between basins, so the evaluation method still needs to be further improved.

The relevant data in this paper are based on the 2018 Xinjiang Statistical Yearbook and the research results of relevant scholars, and the evaluation results are the static value of the water resources ecological service system in the Tarim river Basin. Since the time factor has a correlation with the value of ecological service system, its value also changes with the change of time. The analysis of static value will lay a foundation for the subsequent dynamic analysis. Taking the time factor into consideration in the study will be more conducive to understanding the ecological service value and its change trend in different periods of Tarim river basin.

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