Evaluation of the importance of ecosystem services in the upper reaches of the Tarim River

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Abstract: Using RS and GIS technology, the four sub-ecosystem service functions of water conservation, soil and water conservation, windbreak and sand fixation, and biodiversity, which are the most significant ecological factors in the study area, are selected to establish a model and method for evaluating the importance of ecosystem services in arid and semi-arid areas. A comprehensive study of the desert oasis eco-city in the upper reaches of the Tarim River in southern Xinjiang, quantitatively and qualitatively reveals the importance of ecosystem services in the study area and the spatial distribution laws along the upper reaches of the Tarim River. Concluded as follows: (1) The area of extremely important water conservation area accounts for 14.9% of the total area of the study area. The extremely important areas are mainly distributed in patches in the southern Tian Shan Mountains and the source of the Tarim River; (2) The area ratio of extremely important areas for water and soil conservation is 17.9%, and the extremely important areas are mainly distributed in Wensu County at the southern foot of the Tian Shan Mountains; (3) The area ratio of the most important areas for windbreak and sand fixation is only 0.4%, and the most important areas are mainly distributed along the southern side of the Tarim River in Alar City; (4) The area ratio of the most important areas for biodiversity is 67.9%, and the most important areas are distributed in a belt on both sides of the Tarim River basin and around the reservoir. (5) The evaluation results of the ecosystem service function using graphics overlay are: extremely important accounted for 55.6% of the total research area, highly important area ratio was 26.1%, medium important area ratio was 14.3%, and general important area ratio was 4.1%. Ecosystem service function is the natural environmental conditions and utility of human survival formed and maintained by the ecosystem and its ecological processes. 1997 Costanza et al. The value estimation of natural capital of global ecosystem service is studied, and strongly promotes the economic value evaluation research of ecosystem service function. Since then, many scholars have applied Costanza and other methods to study the service value of different ecosystems in different regions. During the same time, Chinese scholars serve the national land ecosystem and forest, grassland, farmland, wetlands and rivers. A large number of deep research has been carried out on the service functions of ecological system types. It has improved people's understanding and understanding of the research of regional ecosystem service function, but at the same time,

1. Introduction
In the 21st century, the process of urbanization is unprecedented. While urbanization brings benefits to global social and economic development, it also brings significant ecological impacts on the regional life support system and production and living environment. The development of landscapes, forests, fields, lakes, sands and seas is coordinated to build a community of life. A consensus has been reached on building a beautiful China\(^1\), "three lines" (red lines for ecological protection, permanent
farmland protection lines, and urban development boundary lines) are being developed throughout the country and the work of national land and space planning is being carried out. The assessment of the importance of ecological functions is a prerequisite for delineating the red line of ecological protection and developing the content of land and space planning. Ecosystem service function is defined as the formation of ecosystems and ecological processes, maintaining the natural environmental conditions and utility for human survival, providing humans with food, medicine and other raw materials for production and living, and creating and maintaining the earth's life support system to form humans Environmental conditions necessary for survival.

Since the end of the 20th century, foreign scholars holdren, ehrlich, westman, cook, ehrilship, gordon irene, daily, etc. have been keen to study ecosystem service functions. In 2001, Chinese scholars wu gang et al. conducted research on the service functions of the changbai Mountain forest ecosystem; in 2005, peng jian et al. reviewed the relevant research progress on the evaluation of ecosystem service functions at home and abroad, taking shenzhen as an example, using ecological economic principles and methods to evaluate the economic value of ecosystem services. By 2009, Fu Bojie et al. focused on the main terrestrial ecosystems, studied "China's main terrestrial ecosystem service functions and ecological security", and proposed indicators and models for the evaluation of ecosystem service functions.

In 2011, xiangbao et al. analyzed three important ecosystem service functions: the importance of biodiversity conservation, the importance of water conservation and the importance of soil conservation, and the importance of the ecosystem service functions of the chengyu Economic zone evaluation. In 2013, li yuechen et al. evaluated the importance of ecosystem services in the three gorges reservoir area, quantitatively and qualitatively revealed the importance of ecosystem services in the study area and its spatial distribution rules in 2018. He xiaoyan according to ecological the content of the systematic comprehensive evaluation carried out the ecological function zoning of dalian on march 1, 2019, the united nations general assembly approved the "united nations ten-year ecosystem restoration plan for 10 years", which will be implemented from 2021 to 2030. It aims to expand the restoration of degraded and damaged ecosystems. The theory and method system of ecological restoration of land and space is under development continuously improve. Chen yang et al. combined the ecosystem service function with the ecological protection and restoration project of landscape, forest, field, lake and grass. For example, preliminary exploration of the practice of ecological protection and restoration of mountains, waters, forests, fields, lakes and grasses in the South taihang area with the goal of improving the supply capacity of ecological products and maintaining ecological safety. With a view to providing a theoretical basis for the planning of land and space and the overall development of landscapes, forests, fields and lakes. However, there are few studies in this area in arid and semi-arid regions, so the research on the evaluation of the importance of ecosystem services in the upper reaches of the tarim river is extremely important. Through a large number of literature reading and collation, the ecosystem service functions of arid and semi-arid regions can be divided into six functional types.

As shown in the table:

| Classification | Ecosystem service function | Classification | Ecosystem service function |
|----------------|---------------------------|----------------|---------------------------|
| Supply function | Provide water, energy, gas, soil, minerals, biomass and other materials and energy | Circulation function | Nutrient cycle |
| | | | Waste recycling |
| | | | Pollinate |
| | | | Genetic inheritance |
| | | | Pollutant diffusion |
| Conservation function | Conserve the soil | Support function | Economic benefit |
| | Conserve water | | Social benefit |
| | Stable atmosphere | | Research Education |
| | Conserve water and soil | | Medical supplies |
| | Nurturing habitat | | Popular science |
| | Windbreak and sand fixation | | |
| | Regulate the microclimate | | |
2. Overview of the study area
The study area starts from the southern foothills of the Tianshan Mountains in the north, to the northern edge of the Taklimakan desert in the south, Shayao County in the east, keeping county in the west, and adjacent to the Aksu River, Tarim River, Tailan River, and Duolang River. 30°30′-81°58′, north latitude 40°22′-40°57′, belongs to the extreme continental arid desert climate in the warm temperate zone, with sparse precipitation throughout the year, large evaporation, arid climate, soil desertification, and serious salinization. Ecological environment is very fragile.\[39\] The topography of the study area can be divided into the alluvial fine soil plains of the Tarim river, the alluvial slope gravel and fine soil plains in front of the keeping mountain, the alluvial fine soil and gravel valley slopes of the Wushi Valley, and the floods of Kaya Yuerqin River and Tailan River. There are 4 landform units in alluvial slope gravel and fine soil plains. The landforms are composed of Tianshan mountains, alluvial plains and deserts from north to south. Among them, mountains account for 8.60% of the total area of the study area, plains account for 83.20%, and deserts account for 8.20%. Regional rivers are mainly replenished by melting ice and snow water. The main major rivers are the Kumurik River, Toshi Wadi, Aksu River, Tarim River, Harayuerqin River, and Tailan River. The Wadi Toshi and the Kumurik River are the two major tributaries of the Aksu River, the Aksu River is one of the three major tributaries of the Tarim River, and the Harayuerqin River and the Tailan River are independent rivers. The Tarim River mainly undertakes the Aksu River. The dynamics of the river for many years are similar to those of the Aksu River. However, due to the large changes in the flood inflow of the Hotan River, especially the sudden increase in floods, the Tarim River is different from the Aksu River. The runoff is 6.655 billion m³, the minimum annual runoff is 2.67 billion m³, the multi-year average runoff is 4.801 billion m³, the multi-year average runoff is 155.06 m³/s, and the minimum flow during the dry season is 0.42 m³/s. Soil conditions in the study area: (1.1) The eastern strata are mainly Q3-4al+pl alluvial deposits, including Q1x conglomerate, N2 sandstone, siltstone, and Q3al alluvial strata; (1.2) In the north, there are middle and low mountains and hills, and the exposed strata are the lower Pleistocene xiyu formation, including Q1x conglomerate, N2 sandstone and siltstone; (1.3) The exposed stratum in the southeastern hilly area is the upper Pleistocene Q3al+pl sandy gravel stratum, located at the top of the hill, underneath is the lower Pleistocene xiyu formation Q1x-N2 conglomerate and siltstone; (1.4) The Holocene alluvial layer (Q4al+pl) is distributed on the alluvial-diluvial fine soil plain of the Tarim river. The lithology is gray fine-grained soil sand, gray-brown silt sand, and light gray-gray-yellow silty clay.

3. Data acquisition and processing
The data of this research mainly come from three aspects: (2.1) Read literature and field research to obtain basic information; (2.2) Obtain statistical yearbooks, hydrological monitoring data, meteorological observation data, surface parameters, etc. of the study area through official websites at home and abroad; (2.3) The natural resources bureau of the study area provides three-tone data, remote sensing images, land use status maps, a map of urban vegetation types in the upper reaches of the Tarim River, a map of key protected species and the distribution of endemic, cherished, and endangered species; natural reserves, desert parks, and scenic spots in the study area, Distribution map of other key ecological regions. Soil erosion intensity type map (2020), DEM data (1:50,000), soil type data. Graphic data is vector data supported by GIS software, and statistical data is table data supported by access and excel software.

4. Research method
This study uses ArcGIS and RS technology to carry out the evaluation of the importance of ecosystem service functions in the upper reaches of the Tarim River. In view of the importance of water
conservation, soil and water conservation, biodiversity maintenance, and wind-proof and sand-fixing ecosystem service functions in arid and semi-arid areas, the importance The model is established in the system. The evaluation model is shown in table 2. The importance of the system is evaluated quantitatively and qualitatively, and the arcgis software is used to superimpose the graphs to obtain the spatial distribution law of ecosystem service functions in the study area, and obtain the comprehensive ecological system in arid and semi-arid regions. The service function importance evaluation chart, and the technical route is shown in Figure 1.

![Ecosystem service functions in arid and semi-arid regions](image)

**Figure 1: Technology roadmap**

**Table 2: Evaluation model**

| Ecological service name | Evaluation method | Impact factor |
|-------------------------|-------------------|---------------|
| Restrain Water source   | Water balance equation⁹ | Total water conservation (m³) : |
|                         |                   | $TQ = \sum_{j=1}^{10} (P_i - R_i - ET_i) \times A_i \times 10^4$ |
| maintain Water and soil | Modified general soil and water loss equation (RUSLE)¹⁰ | Soil and water conservation (t/hm²a) : |
|                         |                   | $A_i = A_{p} - A_{r} = R \times K \times L \times S \times (1 - C)$ |

Pi: Rainfall (mm)
Ri: Surface runoff (mm)
ETi evapotranspiration (mm)
Ai: Area of i-type ecosystem (km²)
i is the i-th type of ecosystem type in the study area
j is the number of ecosystem types in the study area

Ac: Soil and water conservation (t/hm² a)
Ap: Potential soil erosion
Ar: actual soil erosion: R is the rainfall erosivity factor (MJmm/hm²a) K is the soil erodibility factor (thm²/hm²MJmm⁻¹)
L and S are topographic factors
L is the slope length factor
S is the slope factor
C is the vegetation coverage factor
Windproof Sand fixation amount

Modifying the wind erosion equation to calculate the amount of windbreak and sand fixation:\[ SR = S_{Lmax} - S_L \]

\[ S_L = \frac{2 \cdot e \cdot Q_{MAX} \cdot e^{-\left(\frac{z}{L_{MAX}}\right)^2}}{S^2 \cdot Q_{MAX}} \]

\[ Q_{max} = 109.8 \left( WF \times EF \times SCF \times K' \times C \right) \]

\[ Q_{MAX} = 109.8 \left( WF \times EF \times SCF \times K' \times C \right) \]

SR is the amount of sand fixation (tkm-2a-1)

SL potential is the potential wind erosion (tkm-2a-1)

SL is the actual wind erosion (tkm-2a-1)

QMAX is the maximum transfer amount (kg/m)

Z is the maximum occurrence distance of wind erosion (m)

WF is the climate factor (kg/m)

K' is the surface roughness factor

EF is the soil erodibility factor

SCF is soil crust factor

C is the vegetation coverage factor

- Population density
- Surface type: land cover type, vegetation type, soil type
- Climatic variables: annual average temperature, seasonal variation of annual average precipitation, annual temperature difference, dryness, solar radiation
- Ecological indicators: vegetation net primary productivity, NDVI, soil thickness, soil nitrogen content, soil carbon content, etc.
- Humanistic indicators: GDP, population density, road density, township density, river density, etc.

Note: Formula source ecological protection red line delineation guide

4.1. Evaluation of the importance of water conservation

Water conservation is extremely important to the ecosystem service functions of arid and semi-arid regions. The study area is the source of the melting ice and snow of the Tarim river and the water conservation area in the upper reaches of Tarim, covering 6 tributaries and 8 reservoirs. Water conservation is extremely important to the ecosystem service functions of arid and semi-arid regions. The study area is the source of the melting ice and snow of the Tarim river and the water conservation area in the upper reaches of Tarim, covering 6 tributaries and 8 reservoirs. The water conservation capacity mainly depends on the water conservation capacity of the surface cover layer and the soil water conservation capacity, and is affected by factors such as the surface cover status, vegetation structure, and soil physical and chemical properties.
4.2. Evaluation of the importance of soil and water conservation

Soil and water conservation refers to the prevention and control of soil erosion, protection, improvement and rational use of water and soil resources in mountainous, hilly and windy sand areas, maintenance and improvement of land productivity, in order to give full play to the economic and social benefits of water and soil resources, and to establish a comprehensive ecological environment science and technology. Soil and water conservation is the function of the ecosystem to reduce soil erosion caused by water erosion through its structure and process. The influencing factors of soil and water conservation function include climate, soil, water volume, topography and vegetation. The amount of water and soil conservation, that is, the difference between the amount of potential soil erosion and the amount of actual soil erosion, is used as the evaluation index of the ecosystem’s water and soil conservation function. The soil and water conservation evaluation model is shown in Table 2, and the importance evaluation is shown in Figure 3.
4.3. Evaluation of the importance of windbreak and sand fixation

Wind-proof and sand-fixing is an ecological construction activity carried out in arid and semi-arid areas to maintain water and soil and prevent sandstorms and other severe weather. Windbreak and sand fixation reduce soil erosion caused by wind erosion through its structure and process, and it is one of the important regulation services provided by the ecosystem. The function of windbreak and sand fixation is closely related to factors such as wind speed, rainfall, temperature, soil, topography and vegetation. The amount of wind prevention and sand fixation (the difference between the potential wind erosion amount and the actual wind erosion amount) is used as the evaluation index of the ecosystem's wind prevention and sand fixation function. The evaluation model of windbreak and sand fixation is shown in Table 2, and the importance evaluation is shown in Fig. 4.

Figure 3. Assessment of the importance of soil and water conservation in the upper reaches of the Tarim River

Figure 4. Assessment of the importance of windbreak and sand fixation in the upper reaches of the Tarim River
4.4. Evaluation of the importance of biodiversity conservation

Biodiversity refers to a variety of living organisms in a certain area, including animals, plants and microorganisms, which regularly form a structurally stable ecosystem.\[35\] This diversity includes the species diversity of animals, plants, and microorganisms, the diversity of species heredity and variation, and the diversity of ecosystems. The function of biodiversity maintenance is the role played by the ecosystem in maintaining the diversity of genes, species, and ecosystems, and is one of the most important functions provided by the ecosystem. The function of biodiversity maintenance is closely related to the distribution and richness of rare, endangered and endemic animals and plants, mainly including first and second national protected species and other species with important conservation value. The biodiversity evaluation model is shown in Table 2, and the importance evaluation is shown in Figure 5.

![Figure 5. Assessment of the importance of biodiversity in the upper reaches of the Tarim river](image)

5. Analysis on the Evaluation Results of the Importance of Ecosystem Service Functions

The importance of ecological factors such as water conservation, soil and water conservation, windbreak and sand fixation, and biodiversity in the study area reflects the importance of a certain ecological function, and does not reflect the spatial variability of the ecosystem's comprehensive service functions in the upper reaches of the Tarim river Therefore, according to the importance of each ecological factor, the spatial overlay function of ArcGIS is used to superimpose the distribution map of the importance of each ecological factor. The calculation formula is as follows:

\[
PT_j = \frac{1}{n} \sum_{i=1}^{n} PT_i
\]

In the formula, PT\(_j\) is the importance index of the comprehensive service function of the ecosystem of space unit j; PT is the importance level of the ecosystem service function of i. This classification method using Natural break ArcGIS is a cut-off point obtained by the use of statistical Jenk optimization method[^33^]. The pt is divided into 4 levels, and a comprehensive evaluation map of the importance of ecosystem services in the upper reaches of the Tarim river is drawn (Figure 6). The following evaluation results are obtained: the total area of the study area is 6919.25 km\(^2\), the area of extremely important ecosystem service function is 3844.69 km\(^2\), accounting for 55.6% of the total area; the area of highly important ecosystem service function is 1806.63 km\(^2\), accounting for 26.1% of the total area;
ecology. The medium and important area of system service functions covers an area of 989.38km², accounting for 14.3% of the total area. Ecosystem service functions are generally important areas with an area of 278.56km², accounting for 4.12% of the total area (as shown in Table 3).

Table 3: Evaluation of the importance of ecosystem services in the upper reaches of the Tarim River

| Grade          | Importance of water conservation area/Km² | Importance of soil and water conservation area/Km² | The importance of windbreak and sand fixation area/Km² | Biodiversity importance area/Km² | Ecosystem service function importance area/Km² |
|----------------|------------------------------------------|-----------------------------------------------|-----------------------------------------------------|---------------------------------|----------------------------------------------|
|                | proportion                               | proportion                                     | proportion                                         | proportion                      | proportion                                   |
| Extremely important | 1033.94                                | 14.9%                                         | 123.44                                             | 17.9%                           | 289.50                                      |
| Highly important  | 1103.00                                | 15.9%                                         | 61.44                                              | 0.9%                            | 1806.63                                    |
| Moderately important | 1557.44                                | 22.6%                                         | 380.56                                             | 5.5%                            | 526.94                                      |
| Generally important | 3224.88                                | 46.6%                                         | 6353.61                                            | 91.7%                           | 4296.19                                    |

Figure 6. Evaluation of the comprehensive importance of ecosystem service functions in the upper reaches of the Tarim River
6. conclusion and discussion
The upper reaches of the Tarim River has an important ecological geographical location, which is the "lifeline" for the normal production and life of cities in southern Xinjiang. This area is of great significance to maintaining the stability of the regional ecosystem. In view of the special geographical location and climate of the study area, this study focuses on water conservation. Starting with the four ecosystem service functions of water and soil conservation, windbreak and sand fixation, and biodiversity, an in-depth and detailed analysis of the ecosystem service functions of the study area was carried out, and the importance of the study area’s ecosystem coverage function and its space were revealed quantitatively and qualitatively. Distribution characteristics and laws.

Research indicates: (1) The area ratio of areas above the highly important protection of water conservation has reached more than 30%; the extremely important areas are mainly distributed in patches in Wensu County in the south of Tianshan Mountains. (2) The extremely important water and soil conservation area has a relatively small proportion, with an area ratio of 17.9%; the extremely important water and soil conservation area is mainly distributed in the southern foot of the Tianshan Mountains. (3) The area of general important areas for windbreak and sand fixation accounted for the largest area of 62.0% of the total area; followed by highly important areas with an area ratio of 26.0%; the most important areas were basically distributed in patches in the Tianshan mountains with better vegetation coverage and the source of the Tarim River. (4) The importance of biodiversity is an absolute advantage, accounting for 67.9% of the total area. The extremely important areas are distributed in a ring along both sides of the Tarim River basin. (5) The extremely important area of ecosystem services accounts for 55.6% of the total area of the study area; the extremely important area is basically distributed along the upper two sides of the Tarim River and the ridges on the south side of the Tianshan mountains; the highly important area is basically along the extremely important area along the Tarim River both sides of the tributaries are distributed in the shape of a ring and a small part are scattered.

The basic data studied in this paper are mainly obtained from remote sensing image interpretation and GIS spatial analysis. Errors in data processing will inevitably affect the accuracy of the analysis results. Nevertheless, the geographic spatial pattern characteristics of the importance of ecosystem services in the study area can still be obtained. Fully reflect, in order to plan for the land and space, establish a life community of mountains, rivers, forests, fields, lakes, grasses and sand, and provide data reference and theoretical basis for ecological restoration projects [36].

However, due to the lack of data, this study only studies the importance of ecosystem service functions in a single period of time in the region. If time series data is available, it can better reflect the temporal and spatial evolution of ecosystem service functions and the stability of ecosystem structure in the study area. This still needs to be further explored and studied in the future.

Fund Project: Regional Project of Alar Science and Technology Bureau of the First Division (No:2018XX03); The central government supports local university projects (TDZKSS202011)

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