Research on water ecological security in alar section of tarim river basin

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Abstract. As the mother river of southern Xinjiang, the Tarim River is the lifeline of the economy, natural ecology and the lives of all ethnic groups in the southern Xinjiang oasis. Alar city is located in the upper reaches of the Tarim River with an arid climate, scarce precipitation throughout the year, strong evaporation, lack of water resources, and fragile ecological environment. The deterioration of the water quality in the Tarim River basin, the sandification of the revetment, the serious soil erosion, and the deteriorating ecological environment have become the main factors restricting the sustainable development of the social economy and ecological environment of Alar City. This research investigates the current situation of the ecological environment of the Tarim River basin, and makes the following research on the Alar section of the Tarim River through GIS spatial analysis:

1. Construct an ecological corridor in the study area;
2. Designate an ecological protection zone;
3. Shaping the pattern of water ecological security;
4. The task of ecological restoration is determined in order to provide a theoretical basis and scientific basis for the comprehensive development and utilization of resources in the Tarim River basin, soil and water conservation, and ecological environment protection.

1. Introduction

The Tarim River is the only inland river in my country, creating a desert oasis city for the Taklimakan Desert[1]. At the source of the Tarim River, Alar is not only the place where the ancient and modern silk roads meet, but also the only city where the Tarim River passes through the city,[2] it is the only new urbanization pilot city selected among the seven cities of Xinjiang Corps in the new era, the city of Alar, the first division, was born and prospered by the Tarim River. The Tarim River is the lifeblood of its urban development. Standing in the context of the silk road economic belt and the construction of new urbanization, the Tarim River basin has become an important lifeline for the functional reorganization, water ecological security, resource integration, and overall development of the division. The two banks of the Tarim River will become the first division of the exhibition. The image of the water oasis in Alar, the key area that stimulates the vitality of the city.[3-4]

Since the 18th National Congress of the Communist Party of China, the Party Central Committee with Comrade Xi Jinping as the General Secretary has stood at the strategic and overall heights and put forward a series of new ideas, new thesis and new requirements for the construction of ecological civilization and ecological environmental protection, in order to strive to build a beautiful China and realize China's sustainable development of the nation, towards a new era of socialist ecological civilization, pointing out the direction and path of realization.[5] It is necessary to promote sustainable development in Xinjiang, strengthen ecological and environmental protection, promote the prevention and control of water pollution in key river basins, lakes, and oases, and strengthen the construction of wetlands. In December...
2015, alar was included in the second batch of units in the pilot demonstration area of ecological civilization.[6] However, there are a series of ecological and environmental problems in the Tarim River.[7-8] With the increase of population and social and economic development, excessive disorderly development and inefficient utilization of water resources, the water flow to the main stream decreases year by year, the water quality of the main stream deteriorates, the downstream river breaks off, the lakes dry up, and the large natural poplar forest dies. Environmental problems such as water waste, water loss, water salinity, water environmental pollution, water biodiversity imbalance, ecological balance was damaged, leading to the structure and dysfunction of some ecosystems, thus threatening the sustainable development of ecology, society and economy of arar.[9-10] Therefore, creating a water ecological security pattern, saving water resources, and protecting the ecological environment of the Tarim River are the keys to promoting harmony between man and nature, adhering to green development, and building a beautiful southern Xinjiang.

On March 1, 2019, the United Nations General Assembly approved the "United Nations Decade 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. Ecological restoration is a new phenomenon in restoration ecology. The term refers to the process of assisting the restoration of an ecosystem that has been degraded, damaged or destroyed.[11-13] My country has accumulated rich practical experience and theoretical results in the treatment of typical ecological environment elements such as river wetland degradation, soil pollution, mine abandonment, land desertification, and water pollution.[14-16] Among them, the ecological restoration of river wetlands includes: ecological bank slope restoration, river buffer belt trench construction, river water quality purification, biological habitat restoration.[17-18] There have been a wealth of theoretical progress and practical cases in the research of ecological restoration at home and abroad, but there are few studies in this area in semi-arid areas. Therefore, it is extremely important for the improvement of the Tarim River, the construction of ecological landscapes and the creation of biological habitats.

2. Research overview and research methods

2.1 Overview of the research area

The Tarim River is located in the northern part of the Tarim basin in the Xinjiang Uygur Autonomous Region. It originates from the Tianshan Mountains and the Karakoram Mountains. Its tributaries include the Aksu River, Tailan River, and Duolang River. It belongs to the warm temperate zone and extreme continental arid desert climate, with sparse precipitation and evaporation throughout the year. The amount is large, the climate is arid, the soil is desertified, the salinization is serious, and the ecological environment is very fragile. The drainage area is 1.02 million km², with a total length of 2,179 km and a river course of 109.05 km.[19] It is the longest inland river in China. The oasis south of the Tianshan Mountains is basically irrigated by the Tarim River (as shown in Figure 1). The Alar city section of the first division of the Tarim River starts at the intersection of the three rivers and ends at the seventh regiment of the 14th regiment of the first division. The river course is relatively straight. In the longer section of the river, it is wide and narrow, shaped like lotus joints, and the river bed is wide and shallow. The sandbars are densely covered with branch roads. The maximum annual 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.[20]
2.2 Research content and technical route

Through literature review, field investigation and use of RS (remote sensing Image) and ArcGIS (geographic information system) technology, this research aims at the current status and existing problems of the ecological environment of the Tarim River Basin, and constructs the Tarim River ecological corridor for the Tarim River in Alar city, create a water ecological security pattern delineation and riparian water ecological restoration, coordinate the planning of landscapes, forests, fields, lakes and sands, delimit protected areas, create an ecological pattern featuring large water surfaces, large green spaces, large agriculture, and large deserts, and build the city of Alar community of life. The research technical route is shown in Figure 2:

![Figure 2 Technology Roadmap](image-url-

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Figure 1 Current situation of the Tarim River Basin
3. Ecological and environmental problems in the alar section of the tarim river Basin

3.1 Serious soil erosion in the study area

The tarim river flows through the northern edge of the taklimakan desert. The riverbed is mainly composed of silt and sandy loam, which is easy to scour. There are very few embankments along the river.

During the flood period, it is allowed to overflow, the soil is loose and the bank stability is poor. In particular, the southern area of division city is flat. As shown in figure 3, the slope is small, and the floods eroded and silted or overflowed during the flood season, causing the river to sway freely, the bank slope was eroded and collapsed, and the soil erosion was the most serious.

![Figure 3 Distribution of soil erosion risk in the Alar section of the tarim river Basin](image1)

![Figure 4 Distribution of desertification in the Alar section of the tarim river Basin](image2)
3.2 Land desertification in the study area

The Tarim River originated fiercely, and the lower reaches were mostly desert grasslands with strong erosion. The main rivers of the 4th and 5th groups in Alar City mostly originate from the southern slope of the Tianshan Mountains. The melting water of the snow-capped mountains has a large difference in height and is coming fiercely. The lower reaches of the river have sparse vegetation and a considerable amount of desert components. The study area is mainly composed of temperate desert, semi-desert inland riparian forest ecosystems and Populus euphratica desert riparian forest ecosystems, [21] As shown in Figure 4. From the perspective of spatial distribution, the overall distribution of woodland resources, grassland resources and water resources is uneven and their distribution range is degrading. The vegetation conditions are mostly concentrated in the Tarim River Basin, but the current over-exploitation and extensive development of agriculture make it difficult to agricultural vegetation coverage has declined. The greening rate of the natural shoreline of the blue line of the Tarim River Basin is relatively low, and the woodland coverage within 500m of the blue line is only 28%, and the water and soil conservation function is not high. [22]

3.3 Serious water pollution in the study area

River water quality is polluted. Farmland irrigation pesticides, fertilizers, and initial rainwater from urban river sections on both sides of the river are directly discharged into the river, and domestic garbage is dumped at will, causing pollution to the river’s water quality. The current pollution problems and water environment problems are shown in Table 1 and Table 2.

Table 1 Current status of water pollution and water environment in the Tarim River Basin

| River         | Current status of water pollution                                      | Current status of water environment                      |
|---------------|------------------------------------------------------------------------|----------------------------------------------------------|
| Tarim River   | Urban domestic sewage and agricultural drainage in Alar City            | The current water environment quality is class IV         |
| Hotan River   | There is no sewage outlet into the river along the main stream of Hetian River | The current water environment quality is class IV         |
| Yarkand River | There is no industrial wastewater discharge, and pesticides, fertilizers and household garbage are the main sources of pollution. As the river water bodies are mainly irrigation drainage, groundwater, and lake water leakage and drainage, the water quality is poor | No fixed water quality monitoring section, low water quality monitoring frequency, and incomplete water quality monitoring items |
| Aksu River    | There is no industrial wastewater discharge, and agricultural irrigation pesticides, fertilizers and household garbage are the main sources of pollution. There are no factories and mines on both sides of the strait, and no industrial wastewater and domestic wastewater are discharged into the surrounding area. | No fixed water quality monitoring section, low water quality monitoring frequency, and incomplete water quality monitoring items |
| Tailan River  | There is the possibility of agricultural non-point source pollution in part of the river near the cultivated land, but there is basically no water pollution in this section due to the long-term dry state. There is no farmland drainage problem in the Situan Irrigation District, and the towns have not set up sewage outlets in the Toshigan River. On the side of Wushi County, only farmland drainage returns to the river. Generally speaking, the river section has no pollution and good water quality. | It has been in a dry state for a long time. The current condition is good, there is no black and odor, no pollution and direct discharge. The water quality is clear when there is water at the bottom in individual months. There is no water quality monitoring data, and the current water environment quality cannot be distinguished |
| Tosh, Wadi    | Water environmental quality is class I                                  |                                                          |
| Kashgar River | The river water quality is poor, and the river water environmental quality is grade IV |                                                          |
| Karayuergeron River | The Wutuan irrigation district has farmland drainage side seepage, two farms sewage side seepage, concrete aggregate yard, etc. | Water environmental quality is class III                  |
Table 2 Water pollution and water environment problems in the tarim river basin

| River       | Water pollution problem                                                                 | Water environmental issues                                                                 |
|-------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Tarim River | Mainly, there is agricultural non-point source pollution in some river sections adjacent to cultivated land. Agricultural non-point source pollution caused by the unreasonable use of pesticides and fertilizers in the agricultural production process is an important cause of water pollution. | Due to the cultivation and excessive surface water irrigation in the tarim river irrigation Area, the high-salinity agricultural drainage returned to the river after irrigation caused surface water quality pollution. There is no black and odorous water body section, no eutrophication section, and the river water quality is highly mineralized. Due to the long river course, there are still parts of the shoreline environment that are messy, and there are floating objects on the river surface, and the surrounding environment needs to be further improved. |
| Hotan River | There is no water pollution prevention problem.                                             | The water quality monitoring network is incomplete, and there is a lack of cross-border water quality monitoring stations. |
| Yarkand River | Mainly, there is agricultural non-point source pollution in some river sections adjacent to cultivated land. Agricultural non-point source pollution caused by the unreasonable use of pesticides and fertilizers in the agricultural production process is an important cause of water pollution. | Lack of water quality monitoring, lack of corresponding supporting and fixed water quality monitoring facilities for farmland drainage along the river bank. |
| Aksu River  | Mainly, there is agricultural non-point source pollution in some river sections adjacent to cultivated land. Agricultural non-point source pollution caused by the unreasonable use of pesticides and fertilizers in the agricultural production process is an important cause of water pollution. | Lack of water quality monitoring, lack of corresponding supporting and fixed water quality monitoring facilities for farmland drainage along the river bank. |
| Tailan River | Mainly, there is agricultural non-point source pollution in some river sections adjacent to cultivated land. Agricultural non-point source pollution caused by the unreasonable use of pesticides and fertilizers in the agricultural production process is an important cause of water pollution. | Due to the long river course, there are still some messy coastal environments, and the surrounding environment needs to be further improved. |
| Tosh, Wadi  | No water pollution problem.                                                               | The water environment is good. In addition to the need for irrigation and water diversion in addition to the planting industry, it is still in the undeveloped stage, and there are no problems such as sewage outlets. |
| Kashgar River | San Tuan uses it as the general drainage, and the drainage is farmland drainage and urban sewage drainage. | Drainage is farmland drainage and urban sewage, and the water environment is poor. |
| Karayuergon River | Aquaculture, concrete aggregate production, construction waste, farmland drainage, etc. may all have an impact on the water quality of the river. However, because there is no water quality monitoring along the line, it is impossible to analyze and judge from the data. | The water environment is good. In addition to the need for irrigation and water diversion for planting, the river bank is still in the undeveloped stage, and there are no problems such as sewage outlets. |

4. Ecological security pattern and ecological restoration

4.1 Building an ecological corridor

The construction of an ecological network for biodiversity protection is an important part of the implementation of the theory and practice of the landscape, forest, field, lake and grass life community [23-24]. In conjunction with the construction of important species protection areas, formulate relevant policies for the protection of the core area of the ecological network, so that the core area will be
protected, and complete the ecological network planning based on species distribution and ecological functions; establish a country park and river-type corridor and traffic-type corridor in Alar city. The construction of the ecological network is initially completed, and a more obvious form is formed. The construction of a three-level ecological corridor is shown in Figure 5. The ecological corridor construction is shown in Figure 5, so that the vegetation pattern becomes a patch, belt, network, forest, water, field, and sand. An integrated green ecological network.

Construction requirements and functions of the first-level corridor. The width of the corridor should be more than 50 m, and the vegetation construction should be composed of arbor, shrub and grass to form a composite vegetation system. The vegetation of the water corridor should be planted with slope protection plants according to the characteristics of the river to form a natural revetment. The first-level corridor should be used as a channel for the spread and migration of organisms on a large scale. It can also serve as a habitat for many small organisms while meeting the needs of more biological migration. In addition to considering the needs of ecological processes, the corridor design should pay attention to the planning process. The cultural and leisure function construction of the corridor.

Construction requirements and functions of secondary corridors. The width of the corridor should be 20-50 m, and the vegetation construction should be mainly arbor, with shrub and herb buffer zone. The vegetation of the water system corridor should be planted with slope protection plants according to the characteristics of the river to form a natural revetment. The secondary corridor should be used as a channel connecting the habitats and between the primary corridor and the habitat. While satisfying the migration of birds and other organisms, it also serves as a habitat for farmland insects.

Requirements for the construction of third-level corridors. The width of the corridor should be within 10 m, and the vegetation construction can be divided into two modes: wide and narrow: in the wider area, arbor is the main vegetation composition of the corridor vegetation; in the narrower area, the corridor is mainly composed of shrubs and grass. It has become the main channel to communicate the natural habitat of the patch with the farmland substrate, the high-level corridor and the farmland substrate, and it is also the habitat of many farmland insects while meeting the demand for the spread of small-scale organisms in the farmland.

Data from the Alar section of the Tarim River Basin ecological reserve and the Alar section of the Tarim River Basin ecological reserve show that the ecological corridor is a critical component in shaping the pattern of water ecological security.

**4.2 Defining core ecological protection areas and shaping the pattern of water ecological security**

**4.2.1 Delimit the core ecological protection area**

The ecological red line is unified and delineated with nature reserves, surface water source first-level protection areas and underground water source core areas, as well as scenic spots, geological parks, forest parks, wetland parks, etc., to form a "1+N" ecological red line unity. Increase the ecological protection red line to occupy the total area of the city, carry out absolute protection in the area, and ensure the integrity of the red line. As shown in Figure 6, the protection scope is delineated, and nearby
fences within the scope are enclosed and protected. Strict protection and isolation of special animal and plant habitats.

4.2.2 Shaping the pattern of water ecological security
The water ecological security pattern aims at restoring natural hydrological processes and maintaining urban storm flood safety. Through ArcGIS spatial analysis technology, the process of flood and surface runoff is analyzed and simulated, and the key spatial pattern of maintaining storm flood safety in Alar city is identified. On the above basis, construct a flood safety pattern and a rainwater safety pattern, and consider surface and groundwater source protection and groundwater replenishment to form a comprehensive water ecological security pattern. By managing and controlling land use within the pattern, it is possible to protect surface and groundwater resources, maintain and strengthen the continuity and integrity of the regional water system pattern, and ensure flood safety. The water ecological security pattern is shown in Figure 7; the area of the three low and high ecological security zones is shown in Table 3.

| Ecological security pattern type                  | Area (Km²) |
|-------------------------------------------------|------------|
| Low ecological security pattern                  | 882.1287   |
| Moderate ecological security pattern             | 4801.6098  |
| High ecological security pattern                 | 1235.9718  |

Figure 7 Water ecological security pattern of the Alar section of the Tarim River Basin

4.3 Carry out water ecological restoration

4.3.1 Promote river improvement and ecological landscape construction
Promote the construction of natural revetments, natural forms, and water system networks of rivers in the Tarim River Basin to improve the river’s ecological landscape service functions; build and control the
500m buffer zone outside the Blue Line; carry out ecological restoration of rivers and adhere to the concept of near-natural restoration. Re-wild treatment of nearby rivers[26], fully respect the natural laws of the river system, pursue as much as possible to restore the original natural state and natural process of the river, and restore the self-purification ability of the water body as the main line, and on the basis of source control and pollution interception, Protect water-sensitive spaces by adopting ecological protection, restoration, and restoration technical methods. Increase vegetation coverage, control alien species, dredge rivers, remove garbage, protect and rebuild floodplain wetlands, repair riverbed wetlands, rebuild over-hardened river banks, restore biological habitats, build floodplain "stepping stones", protect biodiversity, and create functions a complete and well-balanced aquatic ecosystem will build an ecological corridor with waterfront integration and blue-green interweaving, so as to achieve harmonious coexistence between man and nature.

4.3.2 Strengthen the protection of water sources and clean water bodies
Strictly protect drinking water sources and river systems, and protect centralized drinking water source protection areas above the team. Focusing on water source protection, set up a 1000m water source protection zone near residents, build a 10m wide water source protection green belt, coordinate water and soil erosion control, non-point source pollution control and improvement of the living environment, carry out small water body near-natural restoration projects, and systematically promote ecological cleanliness construction of small watersheds. strengthen the ecological protection, restoration and construction of wetlands, and reserve ecological wetlands in the estuaries of important tributaries. Vigorously promote the construction of "source control-process resistance control-receptor purification and protection" non-point source pollution and water environment treatment technology system, and improve the water purification function. Establish a 1-2Km buffer zone in the protection of drinking water sources, strictly control the discharge of industrial pollutants, the discharge of sewage and garbage from the company's residential areas, and agricultural non-point source pollution, and promote the construction of a 4-12m buffer zone for water purification.

4.3.3 Vegetation restoration and maintenance of biodiversity
Vegetation plays an important role in preventing and controlling soil wind erosion. When vegetation coverage reaches more than 30%, soil wind erosion basically disappears. Returning farmland to forest and grassland is one of the main measures to control desertified land. We must resolutely stop the destruction of forests and grassland to open up wasteland in order to protect the ecological environment of the basin and prevent desertification.

Water is the key to the survival of vegetation, and ecological water use in the upper, middle and lower reaches must be solved to ensure the survival and reproduction of coastal vegetation. Under the basic guarantee of ecological water use, protect trees (such as populus euphratica, Chinese acacia, sand willow, torch tree, platanus), shrubs (such as camel thorn, haloxylon ammodendron), and focus on the cultivation and expansion of young and strong forests in the basin. Renew mature forests in a planned way, and exert their windbreak and sand fixation functions as far as possible for dilapidated forests and dead trees.

The vegetation restoration construction of shengli Reservoir, duolang reservoir, and shajingzi reservoir shall be based on the environment of different reservoirs, including climate, topography, landform, water quality, water depth, water level change, flow velocity, pH value, transparency, main pollutants, and sediment properties In order to identify the factors that lead to the degradation of wetland vegetation and determine the types of plants used for wetland restoration. Implement water quality restoration, food chain restoration, revetment restoration, non-point source pollution restoration, biodiversity conservation restoration, and science education and other different restoration purposes and site conditions, and configure plant species and density. Adhere to the multi-level and diverse combination of trees, shrubs, herbs, vines, emergent, floating, and submerged plants to form a plant community with diverse landscapes and stable structures.
5. conclusion and discussion

Based on the ArcGIS (Geographic Information System) and RS (Remote Sensing Image) research on the aquatic ecological environment of the Alar section of the Tarim River Basin, the following discussions are made:

5.1 Building an ecological corridor

On the basis of traffic and blue line control, whether to integrate different types of corridors in semi-arid areas to enhance the versatility of corridors, including climate passages, biological migration, material migration, flood control, and environmental protection, as well as consideration of landscape, heritage culture, economy. Use agricultural slack land to plant trees and grass on wasteland suitable for forests, river beaches, sandy land, saline-alkali land and reservoirs, around farmland, and on both sides of roads in a planned way.

5.2 Delimit the core ecological protection area

In non-core ecological protection areas, except for the ecological red line, areas that are of great significance for maintaining the structure and function of the ecosystem are designated as general ecological spaces. Specifically, the Central Tarim River Basin biodiversity protection area should be combined with the general ecological space protection.

5.3 Shaping the pattern of water ecological security

Creating a water ecological security pattern, analyzing and simulating processes such as floods and surface runoff, and judging whether the key spatial pattern of rain and flood safety in Alar city is consistent with the climate characteristics of semi-arid areas, which needs further discussion.

5.4 Determine ecological restoration goals

In the process of ecological restoration of the river basin, we must start from the aspects of reducing land carrying capacity, combining planting and feeding, and using land with high efficiency, so as to fundamentally solve the problems in desertification control. Actively carry out afforestation and grass planting, vigorously build a protection forest system, and increase vegetation coverage. Provide a theoretical reference for the construction and development of a desert oasis eco-city in Alar, Xinjiang.

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