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Ecological Restoration Technology of Desertification Land and Application Scope of Sand Industry

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Abstract: This article focuses on the ecological restoration technology of desertification land and the application scope of sand industry. In view of the severe global desertification problem, which has a serious impact on ecology and economy, this article aims to clarify the scope of application of the two and provide scientific basis for desertification control and sand industry development. Through literature review and theoretical analysis, this article systematically sorts out the theoretical basis and technical system of ecological restoration technology of desertification land, discusses the relevant theories and models of sand industry, and analyzes its application scope in combination with physical geography and socio-economic factors. The results show that different ecological restoration technologies and sand industry models have their own applicability under different natural and socio-economic conditions, and it is necessary to comprehensively consider various factors for reasonable selection and layout. The research emphasizes that ecological restoration technology and sand industry model should be accurately matched according to specific conditions, so as to realize the coordinated development of ecology and economy in desertification areas.

1. Introduction

Desertification, as one of the serious ecological and environmental problems facing the world today, is eroding a large number of land resources at an unprecedented speed [1]. According to relevant data, a considerable proportion of the global land area has been affected by desertification, and this trend is still continuing [2]. Desertification not only leads to a sharp decline in land productivity, but also degrades a large number of farmland and pastures, which seriously threatens food security and the development of animal husbandry. At the same time, the severe weather phenomena such as sandstorm caused by it have extremely adverse effects on the ecological environment, air quality and residents' production and life in the surrounding areas [3-4]. In China, the problem of desertification can't be underestimated, and the vast northwest region and some northern provinces suffer greatly [5]. Therefore, desertification control has become the top priority of ecological environment protection in China and even in the world.

Under this background, it is of great theoretical and practical significance to study the ecological restoration technology of desertification land and the application scope of sand industry. Theoretically, it is helpful to improve the theoretical system of desertification control and provide

solid theoretical support for the follow-up research to systematically sort out the principles and characteristics of various ecological restoration technologies, as well as the development model and theoretical basis of sand industry. From a practical point of view, clarifying the application scope of different ecological restoration technologies and sand industries in different regions can provide accurate guidance for desertification control practice, improve the scientificity and effectiveness of governance, and avoid resource waste. At the same time, it is also conducive to the rational distribution of sand industry, to achieve a win-win situation of ecological and economic benefits, and to promote the sustainable development of desertification areas.

In this article, the theoretical basis and technical system of ecological restoration technology of desertification land are deeply analyzed, and the related theories and models of sand industry are comprehensively discussed. Combined with natural geographical conditions and socio-economic factors, the application scope of the two is analyzed in detail.

2. Desertification land ecological restoration technology theory

The ecosystem has certain self-regulation and recovery ability, which is an important basis for ecological restoration of desertification land. After eliminating the disturbance and improving the environment, the damaged ecosystem can gradually return to its original state [6]. Desertification land soil usually has problems such as loose structure and low fertility. According to the principle of soil science, improving soil structure and fertility is the key to restoration. Reasonable irrigation and drainage measures can adjust soil moisture, improve soil aeration, create a good soil environment for plant growth, and help vegetation restoration and ecological improvement in desertification land.

The principle of plant ecology provides guidance for vegetation restoration in desertification land. The harsh environment in desertification areas requires plants to have special ecological adaptability [7]. Drought-tolerant plants specialize in morphological structure and physiological functions, such as having developed roots to get water deep underground, or degenerating leaves into spines to reduce water evaporation. In the process of ecological restoration, according to the principle of plant ecology, choosing plant species that adapt to local climate and soil conditions is helpful to improve the survival rate and stability of vegetation, accelerate the process of ecological restoration of desertification land and rebuild a stable ecosystem.

3. Related theories and models of sand industry

3.1. Concept and theoretical basis of sand industry

Sand industry refers to the development of an industrial system with desert characteristics, supported by science and technology, by making full use of light, heat, land and other resources in the sand area [8]. Its theoretical basis covers ecological economics and circular economy theory. Ecological economics emphasizes the interdependence and coordinated development of economic system and ecological system, and sand industry creates economic benefits on the premise of protecting ecology by rationally developing sand resources. The theory of circular economy advocates the efficient utilization and recycling of resources, and the sand industry can realize the recycling of waste and reduce the pressure on the environment by building an industrial chain.

3.2. Main modes of sand industry

Characteristic agriculture mode in sandy area: utilize the unique natural conditions in sandy area to develop characteristic agriculture adapted to sandy environment. The sandy area has sufficient

light and large temperature difference between day and night, which is suitable for planting some crops with drought tolerance and good quality [9]. As shown in Table 1:

Table 1 Characteristic agricultural model in sandy area

Characteristic agricultural products	growth characteristics	Main uses and industrial direction
sea buckthorn	Drought-resistant, wind-blown sand-resistant, and suitable for sandy environment	Fruit is used to produce fruit juice and health care products; Branches and leaves can be used as feed
desert-living cistanche	Parasitic on the roots of Haloxylon ammodendron and fond of arid desert environment	As a Chinese herbal medicine, it is used in the pharmaceutical industry; Develop health care products
Sandy watermelon	Drought tolerance, good adaptability to sandy land	Directly sold as fruit; Can be used for producing processed products such as watermelon juice

New energy industry model in sandy area: the sandy area is vast, with long sunshine time and abundant wind resources, which has natural advantages in developing new energy. Solar photovoltaic power generation is widely promoted in sandy areas. By building photovoltaic power stations, solar energy is converted into electric energy and incorporated into the power grid. At the same time, wind power generation is gradually emerging, and rows of wind turbines stand in the sand area, continuously generating clean energy. The new energy industry in the sand area not only provides electricity for the local area, but also transports surplus electricity to other areas, creating considerable economic benefits and having little impact on the environment, which is in line with the concept of sustainable development.

Eco-tourism mode in sandy area: With people's pursuit of diversification of tourism experience, the unique natural scenery and cultural landscape in sandy area have attracted many tourists. In some desert areas, recreational projects such as desert exploration, sand skiing and camel riding have been developed. At the same time, local historical and cultural relics, such as the remains of the ancient Silk Road, have been excavated to carry out cultural experience tours. By improving the tourism infrastructure, such as building desert resorts and tourist service centers, the tourist reception capacity will be enhanced, which will promote the development of local catering, accommodation, handicraft sales and other related industries and promote the economic growth in the sand area.

4. Desertification land ecological restoration technology system

(1) Engineering technology

Engineering technology plays a key role in sand fixation and stabilization in the initial stage of ecological restoration of desertification land. Among them, sand barrier setting is a common means. Grass grid sand barrier can effectively reduce wind speed, fix sand dunes and weaken the ability of sand erosion by tying wheat straw, rice straw and other materials in a grid shape on the surface of sand dunes. Clay sand barrier uses the cohesiveness of clay to lay a protective layer on the surface of sand dunes to reduce sand dune movement. In addition, water conservancy projects are of great significance for improving water conditions in desertification areas. For example, in areas with water source conditions, the construction of diversion canals, irrigation pumping stations and other facilities can introduce water into desertification land and provide necessary water support for vegetation growth.

(2) Bioremediation technology

Vegetation restoration is the core link of ecological restoration of desertification land. Choosing suitable plants is the key, such as Salix psammophila, Caragana korshinskii and other shrubs, which have developed roots and strong drought tolerance, can take root and grow in harsh environment, and effectively prevent wind and fix sand. There are many ways to plant trees and grass, including direct seeding and seedling planting. Direct seeding afforestation is suitable for plants whose seeds are easy to germinate and rich in provenance, which is simple to operate but has high requirements on the environment. The survival rate of planting seedlings is relatively high, which is suitable for some rare or difficult to germinate plant varieties. At the same time, it is also an important means to close the sand to facilitate afforestation and grass cultivation. By closing the sand to protect, we can rely on the power of nature to promote the natural restoration of vegetation.

Microorganisms play a unique role in desertification land remediation, as shown in Table 2:

Table 2 Common Microbial Remediation Techniques and Their Effects on Desertified Land

Microbial Species	Mechanism of Action	Impact on Desertified Land Remediation
Nitrogen-fixing Bacteria	Converts atmospheric nitrogen into ammonia using nitrogenase enzymes within their bodies	Increases soil nitrogen content, provides a nitrogen source for plant growth, and promotes vegetation development
Phosphate-solubilizing Bacteria	Secretes organic acids to dissolve insoluble phosphorus compounds in soil	Enhances soil available phosphorus content, improves plant absorption of phosphorus, and improves soil nutrient status
Photosynthetic Bacteria	Utilizes light energy for photosynthesis, producing various biologically active substances	Promotes decomposition and transformation of organic matter in soil, improves soil structure, and enhances soil water and fertilizer retention capacity

(3) Chemical improvement technology

Chemical improvement technology improves the physical and chemical properties of desertified soil by using chemical modifiers. Water-retaining agent can absorb and keep a lot of water, reduce soil water evaporation, improve soil water-holding capacity, and provide more lasting water supply for plant growth. Soil structure improver can promote soil particle agglomeration, form a good soil structure, and enhance soil aeration and water permeability. However, the use of chemical modifiers should be cautious, and excessive use may have a negative impact on soil and environment.

5. Ecological restoration technology of desertification land and application scope analysis of sand industry

(1) Analyze the scope of application according to the natural geographical conditions

The climate difference in desertification areas is significant, which has great influence on ecological restoration technology and sand industry. In extremely arid areas with little rainfall and annual precipitation less than 200mm, such as parts of Taklimakan Desert in China, it is difficult to restore vegetation naturally. Engineering sand-fixing techniques such as grass grid sand barrier and stone grid sand barrier are more suitable, which can effectively fix sand dunes and reduce sandstorm activities. However, in semi-arid areas with relatively high precipitation (200-400mm), such as parts of Mu Us sandy land, the vegetation restoration technology in bioremediation

technology is easier to implement, and drought-tolerant shrubs and herbs, such as Haloxylon ammodendron and Artemisia selengensis, can be planted.

Different landforms determine the choice of restoration technology and industrial model. In flat sandy land, large-scale vegetation planting and characteristic agriculture in sandy area are relatively easy; However, in the hilly desert area, it is more suitable to adopt small watershed comprehensive management technology, and build terraces and fish scale pits in combination with the terrain, which is not only conducive to soil and water conservation, but also to the development of forestry and fruit industry. As shown in Table 3:

Table 3 Application of ecological restoration technology and sand industry under different landforms

Topography	Application of ecological restoration technology	Application of sand industry
Flat sandy land	Large-scale vegetation planting technology; Water-saving irrigation technologies such as drip irrigation and micro irrigation	Characteristic agriculture in sand area; Photovoltaic industry in sandy area
Desert hills	Comprehensive management technology of small watershed; Closing hillsides to facilitate afforestation and grass cultivation techniques	Forestry and fruit industry; ecotourism
Desert edge oasis	Vegetation restoration technology based on shelter forest construction; Soil improvement technology	Oasis agriculture; Agricultural product processing industry

(2) Explore the scope of application in combination with socio-economic factors

In desert areas with dense population and abundant labor force, labor-intensive sand industry can be developed, such as processing of characteristic agricultural products and eco-tourism services in sand areas. In areas with sparse population and labor shortage, it is more inclined to develop industries with high degree of automation, such as large photovoltaic power plants and other new energy industries.

Economically developed areas have more funds to invest in the research and development and application of high-tech ecological restoration technologies, such as using unmanned aerial vehicles for sowing and intelligent irrigation systems. At the same time, local policies play a guiding role in the development of sand industry. If policies encourage ecological protection and industrial integration, it will promote the promotion of the coordinated development model of ecological restoration and sand industry.

(3) Comprehensively consider the scope of application of ecological restoration and the coordinated development of sand industry

In the process of ecological restoration, it is necessary to ensure that the selected sand industry model will not damage the ecological restoration results. For example, in the ecologically fragile desert core area, although solar energy resources are abundant, large-scale photovoltaic power station construction may affect the natural restoration of surface vegetation, which requires careful planning. In areas where ecological restoration has achieved initial results, characteristic agriculture in sandy areas can be moderately developed to realize the benign interaction between ecology and economy. The ecological restoration of desertified land and the development of sand industry are long-term processes, which need to be dynamically adjusted according to the changes of ecological environment and industrial development. At the beginning, ecological restoration was the main task. With the improvement of the ecological environment, the development of sand industry was gradually strengthened to form a sustainable and coordinated development model.

6. Conclusions

In this article, the ecological restoration technology of desertification land and the application scope of sand industry are studied comprehensively and deeply. In terms of ecological restoration technology, engineering technology, bioremediation technology and chemical improvement technology have their own unique functions and applicable scenarios. Engineering technology can quickly stabilize sand, bioremediation technology focuses on long-term ecological restoration, and chemical improvement technology can improve soil properties, but its potential risks need to be weighed. For sand industry, characteristic agriculture, new energy industry and eco-tourism model show different development potential according to resource endowment and socio-economic conditions in different regions.

It is found that natural geographical conditions, such as climate, topography, and socio-economic factors, such as population and policies, significantly affect the application scope of ecological restoration technology and sand industry. In practical application, we must fully consider these factors, realize the organic combination of ecological restoration and sand industry development, and avoid paying attention to one thing and losing another. In the future, desertification land control and sand industry development should move towards precision and sustainability. Further in-depth study on the comprehensive application of different technologies and models under complex conditions will help to enhance the comprehensive benefits of ecological protection and economic development in desertification areas and promote regional sustainable development.

References

[1] Cao W, Li Y, Chen Y, et al. Spatial patterns of soil stoichiometry and their responses to land use in a desertified area: A case study of China's Horqin Sandy Land[J]. Land Degradation & Development, 2024, 35(1): 350-359.

[2] Meng N, Wang N, Cheng H, et al. Impacts of climate change and anthropogenic activities on the normalized difference vegetation index of desertified areas in northern China[J]. Journal of Geographical Sciences, 2023, 33(3): 483-507.

[3] Shamsutdinov Z S, Shamsutdinov N Z, Orlovskii N S, et al. Biogeocenotic principles of pasture restoration in the Central Asian Desert[J]. Herald of the Russian Academy of Sciences, 2021, 91(2): 204-212.

[4] Pan Changxiang, Ouyang Qianru, Liao Mengyu, et al. Ecological Restoration Technologies for Desertified Lands and the Applicable Scope of the Sand Industry in the Arid Region of Northwest China [J]. Journal of Desert Research, 2023, 43(05): 155-165.

[5] Han Feng, Liu Zhibo, Yin Wenhua, et al. Ecological Risk Assessment and Optimal Selection of Desert Expressways Based on the Two-Dimensional Cloud Model [J]. Journal of Safety and Environment, 2023, 23(10): 3774-3783.

[6] Jin Bingfu, Zhang Yunji, Hasuerdun, et al. Analysis of the Chromaticity Characteristics of Sediments in the Northern Kumtag Desert and the Causes of Light and Dark Patches on the Dune Surface [J]. Acta Geographica Sinica, 2024, 79(9): 2297-2311.

[7] Yang Yiying, Su Silin, Cao Enzhi, et al. Effects of Large-Scale Photovoltaic Power Plants in the Desert on the Phenotypes and Biomass Allocation of Sand-Fixing Plants [J]. Journal of Desert Research, 2025, 45(1): 162-172.

[8] Li Yuqiang, Wang Xuyang, Zheng Chengzhuo, et al. A Brief Discussion on the Practices of Sand Prevention and Control and Ecologically Sustainable Restoration in the Horqin Sandy Land [J]. Journal of Desert Research, 2024, 44(4): 302-314.

[9] Chen Fangmiao, Huang Huiping, Yang Guang, et al. Analysis of the Changes in the Ecological Environment Quality and Influencing Factors in the Yellow River Basin Based on the Remote Sensing Ecological Index [J]. Journal of Desert Research, 2023, 43(4): 252-262.