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Specific application of nature-based solutions in ecological restoration

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Abstract. As a result of the growing human capacity to exploit and the rising and demand for natural resources, the earth is now experiencing ecological overload.Ecological restoration has emerged as a significant concern that human beings must confront. The notion of "Nature-based Solutions" introduced by the International Union for Conservation of Nature (IUCN) in 2004 has garnered increasing scholarly interest in recent years . As to the IUCN, nature-based solutions refer to measures that safeguard, responsibly oversee, and rehabilitate both natural and modified ecosystems. Since the concept of "nature-based solution" was put forward, numerous scholars have made various attempts to use it in the field of ecological restoration. Through the method of literature review, this paper elucidates the basic principles of ecological restoration and nature-based solutions. This research studies the specific implementation of nature-based solutions in ecological restoration, focusing on their specific application in water body and land restoration. Additionally, this paper summarizes the advancements made in this field of research and provides illustrative examples of nature-based solutions applied in ecological restoration.

Keywords: ecological restoration, nature-based solutions, water body

1. Introduction

With the improvement of science and technology and the rapid development of industry, human beings have improved their ability to use and demand natural resources. As a result, the rate at which resources are being consumed has accelerated, leading to the world being in a condition of ecological overload. The conflict arising from the growing human demand for natural resources and the limiting capacity of the Earth's ecosystem services has resulted in several significant environmental issues, including global warming, ozone layer depletion and biodiversity loss. The International Union for Conservation of Nature (IUCN) proposed the concept of "Nature-based solutions" (NbS) in 2004 as a means to tackle the societal difficulties caused by ecological degradation and protect human well-being.

Numerous academics have attempted to use the concept of "nature-based solution" in the field of ecological restoration since it was first proposed. Scholars from Wuhan Botanical Garden, Chinese Academy of Sciences proposed the theory of "near nature accurate restoration of degraded ecosystems" which is based on the concept of "natures-based solutions" [1]. Scholars from College of Land Science and Technology, China University of Geosciences (Beijing) and Key Laboratory of Land Regulation, Ministry of Natural Resources collaborated to summarize the technology for mine ecological

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restoration based on NBs. The proposal suggested that NbS (Nature-based Solutions) significantly improved landform and soil remodelling techniques in mine ecological restoration. These methods were found to be superior to traditional approaches in terms of soil resistance to water erosion, sustainable stability and visual effect. Additionally, they closely resembled the original landform, thereby enhancing the service function of the mine ecosystem and facilitating the sustainable development of mine ecology [2]. Furthermore, the Department of Territorial and Spatial Ecological Restoration of the Ministry of Natural Resources of China has released a compilation of China's Typical Ecological Restoration Cases, which provides a comprehensive overview of China's hands-on expertise in implementing nature-based solutions, featuring a total of 18 cases.

Through the method of literature review, this study examined the application of nature-based solutions in the field of ecological restoration. It synthesised the research advancements in this area and offered valuable insights for future reference.

2. Overview of the principle of ecological restoration and Nature-based solution

2.1. Ecological Restoration

The International Society of Ecological Restoration initially described the ecological restoration as "the act of aiding in the restoration, reconstruction, and enhancement of ecosystems that have been degraded or damaged." Furthermore, during the process of ecological restoration, numerous scientists have proposed various definitions of ecological restoration. One is "ecological restoration is based on using ecological knowledge to understand how ecosystems work and to use that. understanding to recover ecosystem conditions that maintain their structure and function [3]." Ecological restoration is the practice of restoring natural ecosystems, with the option of using artificial methods to support natural succession. It encompasses various aspects as natural ecological restoration, social-ecological restoration and economic ecological restoration. It requires careful consideration of the interplay between regional development , social economy, and the balancing of ecological, social and economic factors.

The amount of ecosystem services that humans now use globally is 1.6 times greater than the amount that nature can sustainably give, and the annual loss of ecosystem services to the globe exceeds 10% of global economic output [4]. To meet the growing demand for ecological services , it is imperative to address the issue of repairing degraded ecosystems. The term "nature-based solutions" (NbS) refers to the creative conservation efforts that the International Union for Conservation of Nature (IUCN) has been implementing for decades in order to help preserve, manage, and restore the environment while providing people with real and long-lasting benefits.

2.2. The principle of Nature-based Solutions

In 2016, the IUCN established a global definition for Nature-based Solutions (NbS). NbS refer to actions aimed at safeguarding, responsibly managing, and restoring both natural and modified ecosystems. These actions are designed to effectively and adaptively address societal concerns, while also offering benefits to both human well-being and biodiversity.[5]. The United Nations Environment Programme defines nature-based solutions as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater coastal and Marine ecosystems in order to respond effectively and adaptatively to social, economic and environmental challenges, while generating benefits for human well-being, ecosystem services, resilience and biodiversity[6]." Nature conservation can be mainstreamed across key economic sectors throughout major economic sectors, according to IUCN, with the help of nature-based solutions. NbS, or nature-based solutions, serve as both a valuable tool and a crucial method for addressing the dual challenges of worldwide biodiversity decline and climate change. The NbS standard consists of eight criteria and 28 indicators that precisely outline the content and necessary circumstances for the successful application of the NbS idea. Additionally, these criteria and indicators serve as a strong foundation for the creation and verification of the NbS.

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3. Application of NbS in water restoration

Water contamination is mostly caused by industrial effluent, agricultural wastewater, and home wastewater. Unprocessed wastewater containing nitrogen, phosphorus, and other substances leads to eutrophication of the water body. This causes a proliferation of microorganisms and plankton, leading to a decrease in dissolved oxygen levels. As a result, fish and other aquatic animals perish, decompose, and ultimately result in the formation of foul-smelling and discoloured water bodies. Furthermore, the wastewater may contain a significant quantity of heavy metal elements and toxic organic substances that are resistant to biological degradation, which leads to the accumulation of these substances in the geochemical cycle, posing a significant threat to biosafety..

The management of the Guanting Reservoir watershed is a prime example of the implementation of nature-based solutions. The water consumption in the upper reaches of Guanting Reservoir has increased due to social development, leading to a gradual decrease in the amount of water entering the reservoir. Additionally, the discharge of a significant amount of domestic wastewater has intensified water pollution and caused siltation in the reservoir, resulting in severe bank collapse. After 1997, the Guanting Reservoir was removed from the Beijing municipal drinking water delivery system due to numerous issues. The government has adopted extensive management of Guanting Reservoir to enhance the water ecology and environmental quality of Beijing. The reservoir region has undergone several ecological restoration efforts, which involve the complete removal and decomposition of silt and pollutants in the reservoir water. This has been achieved by the implementation of a built wetland project that utilizes black soil depression. The nitrogen and phosphorus pollution load in the water was decreased and the growth of algae was controlled by implementing a ban on fishing and preventing the release of filter-feeding fish species in the reservoir. Building ecological conservation forest to protect biodiversity and standardize the order of land use, the amount of water in the reservoir has been increased through the combined transfer of water. In the lower Shanxia section, efforts have been made to restore the ecological balance and address pollution. This has been achieved through the implementation of measures such as the construction of urban reclaimed water reuse facilities, sewage treatment facilities and stormwater utilization facilities.s a result, the rate of sewage treatment has significantly increased, leading to better control of sewage discharge. Through the construction of artificial wetlands, ecological protection belt and other measures, effectively weaken the downstream river pollution, improve the ecological environment. The final water quality is obviously improved, the ammonia nitrogen in Yongding River reservoir area is reduced by 66.4%, and the ammonia nitrogen discharged from the dam is reduced by 90% [7].Simultaneously, there was a significant enhancement in both the quality of water and the environment it supports.

4. The application of NbS in land restoration

A collaborative report by the United Nations Environment Programme (UNEP) and the Rome-Food and Agriculture Organization (FAO) reveals a growing trend of soil degradation, posing a significant risk to global food security. Soil pollution originates from two main categories, which are natural sources and man-made sources. Over the past three centuries, the natural environment has faced a growing exposure to both natural and manmade toxic substances due to the rise in industrialization, urban expansion, and agriculture. According to the report, the use of pesticides increased by 75% between 2000 and 2017. In 2018, the global use of synthetic nitrogen fertilizer reached 109 million tons. The use of plastics in agriculture has grown significantly in recent decades, with 708,000 tonnes of non-packaging plastics consumed in the agricultural sector in the EU region alone in 2019. The rapid resolution of the conflict between human exploitation and the conservation of the soil's ecological environment is necessary [8].

The middle and lower sections of the Yellow River in China are representative regions characterised by a delicate ecological environment and a significant conflict between human activities and the land. Taking Yulin City of Shaanxi Province as an example, the climate of Yulin city is arid, precipitation is scarce, time and space distribution is uneven, and water resources are extremely poor. There are various types of landforms, including sand beaches, hills, and gullies. The area of mountain

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gully landform accounts for 70.3% of the total area of Yulin City. In areas characterised by mountain gully landforms, there is a high level of surface erosion, resulting in significant loss of soil and water. The surface vegetation shows distinct patterns of horizontal zoning, and the ecology is highly diverse, making it susceptible to human activities. At the same time, the mineral resources in this area are rich in reserves, and the intensity of resource development has led to a variety of environmental problems such as mining subsidence, ground cracks, environmental pollution, soil erosion, etc., which have a great negative impact on the ecosystem of this area, and the contradiction and conflict between resource development and ecological protection are obvious. Drawing from ecological restoration concepts like Nature-based Solutions (NbS), scholars and departments have developed fundamental principles such as “sand control in the northern regions, soil control in the southern regions, and integrated water management.” They have developed a practical “water conservation and restoration model” that focuses on storing high-quality water and building silt dams. Additionally, they have devised an “ecological restoration model” that combines the protection of farmed land with high-quality development. Innovative ecological restoration models such as “comprehensive treatment and restoration model of small watershed based on the integration of light, water, ladder, agriculture and energy storage” and “protection and restoration model based on the full ecological elements of mountains, rivers, forests, fields, lakes, grass and sand” have successfully addressed local environmental issues [9].

5. Conclusion

This paper provides a concise overview of the application of nature-based solutions in ecological restoration and the principles of nature-based solutions, summarizes the main causes and hazards of water pollution in the water body restoration part, illustrating the guiding role of NbS in ecological restoration practice by taking Guanting Reservoir watershed management as a typical case. This research examines the current state of worldwide soil damage in the context of land restoration. It specifically focuses on the implementation of nature-based solutions (NbS) in land restoration, using Yulin City in Shaanxi Province, China as a case study, which is situated on the Loess Plateau. However, the selection of specific cases in this paper is relatively limited, which fails to fully reflect the various application scenarios of NbS, such as the application of ecological restoration under more geomorphic conditions and climatic conditions. The effect of NbS application is also insufficient, and there are no detailed indicators to describe the ecological restoration effect. The concept of natural selection scheme is proposed at a time when the social problems caused by the destruction of ecological environment are becoming increasingly severe. Currently, it holds significant practical importance and is expected to have more comprehensive applications in the future.

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