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International Comparison of Distribution, Change and Restoration of Blue Carbon Ecosystem in Coastal Wetlands

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ABSTRACT

Coastal wetlands (salt marshes, mangroves, seagrass beds), as important blue carbon ecosystems, have unique value in global carbon cycling and carbon neutrality goals.In this paper, the coastal wetland is taken as the main research object, and its global distribution pattern and driving factors of space-time change are systematically combed, so as to evaluate the role of biological diversity in carbon storage and recovery. Through a comparative analysis of the policies and practices of China, Australia, Indonesia and other countries in terms of protection, restoration and governance。 The serious threats to the blue carbon reservoir, such as reclamation, aquaculture expansion, pollution and sea level rise, were revealed. Based on literature case analysis, this paper proposes a multi-dimensional blue carbon management framework, emphasizing the need to strengthen the capacity-building of developing countries, promote the development of the international blue carbon market, and deepen the research on the blue carbon biodiversity synergy mechanism.At the same time, advocating the integration of new methods such as remote sensing and microbiology, narrowing the gap between research and practice through international cooperation, in order to maximize the contribution of coastal wetlands to global carbon neutrality.

KEYWORDS

Blue carbon; Coastal wetland; Mangrove; Biodiversity; MRV

1 Introduction

In a narrow sense, blue carbon refers to the carbon stored in the soil, biomass (including aboveground and underground parts) and non living biomass (such as litter) of mangrove, intertidal salt marsh and seagrass bed [1].These coastal ecosystems play a significant role in the fixation and storage of atmospheric carbon dioxide, and their soil carbon density per unit area and long-term storage potential are often higher than those of terrestrial ecosystems.In addition to the carbon sequestration function, the coastal blue carbon can also provide important ecosystem services such as habitat, beach consolidation and wave elimination, water purification, and fishery resources maintenance.It is the core content of nature based solutions (NbS) in the marine field [2].

However,the coastal wetlands around the world are suffering from rapid loss and degradation, leading to the release of carbon pools, decline in ecological functions, and a sharp decline in biodiversity.The current research not only needs to quantify the reserves and dynamics of blue carbon, but also needs to cooperate to deal with global issues such as climate change, biodiversity loss and sustainable development. This paper aims to provide scientific basis and policy recommendations for curbing the degradation of blue carbon ecosystems and improving its ecological function by summarizing the distribution characteristics, change drivers, restoration strategies and policy tools of coastal wetlands, and conducting international comparative studies.

2 Literature review

2.1 The development and distribution of blue carbon

In 2009, the United Nations issued a report entitled "blue carbon: carbon fixation by healthy oceans - rapid response assessment", which proposed the concept of "blue carbon".The carbon fixed by organisms in the world's oceans is called "blue carbon", accounting for 55% of the world's "green carbon" stored by photosynthesis.Mangroves, salt marshes and seagrass beds are known as the three coastal blue carbon ecosystems. Due to their unique anaerobic or anoxic environment, carbon absorption can be stored in a large range for a long time (up to a thousand years), with high carbon sequestration capacity and ecological resource value [3].

2.2 The regional distribution and carbon storage characteristics of blue carbon ecosystem

Mangroves in the world are mainly distributed in tropical and subtropical estuaries and bays, salt marshes are mostly

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found in temperate and subtropical estuarine plains, and seagrass beds are more widely distributed, covering temperate to tropical shallow waters. In China, mangroves are widely distributed in Guangdong, Hong Kong and Macao, and in Shenzhen, Zhuhai, Guangzhou, Huizhou, Jiangmen and Zhongshan of Guangdong Province [4].

Mangroves usually have upland biomass and deep soil carbon pools. Salt marshes exhibit significant soil carbon accumulation in coastal areas with high deposition rates. Although the aboveground biomass of seagrass beds is low, they play a role in sediment and long-distance organic matter transport.In the past few decades, due to human activities and global climate change and other factors, mangroves around the world are facing serious problems such as the reduction of area, the decline of biodiversity and the degradation of ecological functions, so mangroves have also become one of the most threatened ecosystems in the world.For example, mangrove degradation is particularly serious in Southeast Asia, the west coast of Africa and some regions of Latin America; Some salt marshes in Europe and North America have also lost a large amount of area under historical reclamation.

3 The protection status and main threat factors of blue carbon ecosystem

3.1 The mangrove wetland resources, protection status and main threats in China

According to the survey results of 53 key investigated wetland threat factors with mangrove distribution, the main threat factors of Mangrove in China are pollution, reclamation, infrastructure and urban construction, overfishing and collection, and alien species invasion. Among them, more than half of the key investigated wetlands are affected by pollution. Reclamation, infrastructure and urban construction, overfishing and harvesting also affected more than 1/3 of the key investigated wetlands respectively [5].

3.2 The mangrove wetland resources, protection status and main threat factors in the world

The International Union for Conservation of Nature (IUCN) released the first global mangrove assessment of the red list of ecosystems. More than half of the mangrove ecosystems in the world are in danger of collapse. According to the assessment, nearly 20% (19.6%) of mangrove forests are at high risk, classified as endangered or critically endangered, reflecting the serious risk of collapse in these areas [6].

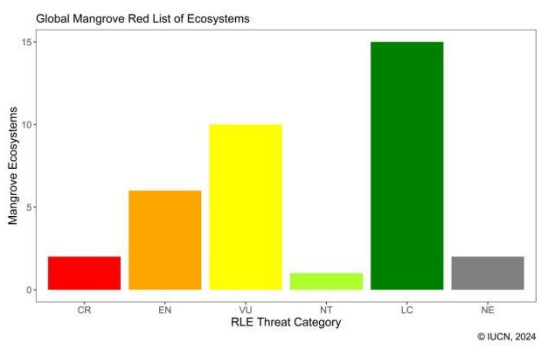

Figure 1

Due to the rise of sea level and the Indian Ocean dipole (IOD), some islands in Maldives have lost more than half of the mangrove coverage since 2020.The rise of sea level makes mangroves show more obvious signs of salt stress (under high salt environment). The roots of trees cannot adapt to the sudden increase of salt content, resulting in the final death of trees.In addition, climate change is an increasingly serious threat to mangrove ecosystems, especially the threat of more frequent and serious weather events and sea level rise.In Brazil, human activities such as aquaculture, oil palm plantations and cultivated land expansion occupy the mangrove area. Brazilian mangrove fishermen face livelihood difficulties due to sea level rise, and mangrove ecosystem is threatened.

In addition, the protection policies of mangroves in various countries have also played a great role.At present, 40% of mangroves in the world have been designated as protected areas. In Brazil, Mexico and Bangladesh, more than 75% of mangroves are protected, while in Malaysia, Papua New Guinea and Myanmar, less than 5% of mangroves are protected.

Therefore, reclamation, aquaculture (especially shrimp ponds) expansion, and land use conversion caused by agriculture and urbanization are the main reasons for the reduction of mangroves in coastal wetlands.The rise in sea level caused by climate change, changes in the frequency and intensity of storm surges. Insufficient sediment supply, and Marine Engineering (such as breakwaters and river channel truncation) have changed the tide and sediment dynamics, and also weakened the self-sustaining ability of wetlands.In addition, different countries have different protection policies for wetland mangroves, which also leads to the uneven status of mangrove reserves.

4 The restoration strategies and effects of blue carbon ecosystem

At present, the global demand for coping with climate change is increasing sharply. China's commitment to carbon sequestration and emission reduction and the use of blue carbon principle to protect and restore salt marsh wetlands, mangroves and seagrass beds, thereby enhancing the carbon storage function of micro biological carbon pump. By strengthening the scientific and Policy Research of blue carbon in the coastal zone, we can build a sustainable blue carbon ecosystem. The global practice of blue carbon remediation shows similarities and differences in strategy and focus.

Taking the North Bank of Hangzhou Bay in China as an example, in view of the situation that the basement of the North Bank of Hangzhou Bay is severely damaged and the wetland ecosystem is facing extinction, the "Fengxian bank salt marsh ecological restoration demonstration project" and the "Jinshan City Beach West comprehensive renovation and restoration project" have been carried out respectively. At present, yingwuzhou ecological wetland, an urban coastal wetland with a total area of about $23.2 \times 104m^3$, has been built [7].

We still need to strengthen the observation methods of blue carbon flux and accumulation. We will also increase scientific research investment in carbon sequestration amplification technology and blue carbon assessment, including research on mangrove carbon sinks, micro biological carbon sinks and other blue carbon. Blue carbon policies and measures are becoming increasingly clear. Since 2015, the State Council and relevant ministries and commissions have successively mentioned the concept of blue carbon in important documents. From the "marine carbon sink" in 2015 to the "marine ecosystem carbon sink" or the "blue carbon" in line with international standards after 2016, the expression has been continuously deepened. The policy involves the construction of a standard system, the establishment of a trading mechanism and international cooperation [2].

In recent years, while strictly protecting and rationally developing the existing mangroves, China has also carried out a large number of mangrove restoration projects. From 2000 to 2017, China carried out more than 360 mangrove wetland restoration projects. Guided by national and local policies, mangrove planting and restoration are mostly funded by the government, and demonstration bases and demonstration areas are established, which have achieved remarkable results in mangrove restoration [8].

Through literature analysis, the international coastal protection of ecosystem mainly focuses on wave attenuation, reducing coastal erosion, providing storm protection and stabilizing the coastline. For example, in the face of Hurricane sandy, the coastal wetlands have a value of more than 625million US dollars for coastal protection in the northeast of the United States. The Nature Conservation Association took the lead in exploring the financing of the coastal protection benefits of the blue carbon project and put forward the initiative of "investing in blue carbon to create a resilient future".

At present, the benefits of biodiversity can attract support for a series of related policy goals, including the United Nations Sustainable Development Goals, the Aichi Biodiversity Conservation Goals, and the Ramsar Convention. The international community has tried to use financial means to support biodiversity work. Australia's "the wildlands program" and Sweden's "northern forest ecosystem biodiversity credit" have started the pilot development of biodiversity credit based on forest ecosystems. Exploring effective methods to improve the quality of blue carbon ecosystems and increase carbon sequestration capacity can achieve synergistic effects in protecting biodiversity and addressing global climate change.

The protection and development of blue carbon ecosystem has greatly improved the fishery benefits. It not only provides important habitats for fish and invertebrates, but also provides breeding, foraging or breeding places for fish growth and survival, and brings benefits to coastal enterprises and communities. Through organic aquaculture, which covers the aquaculture of fish, crustaceans, mussels, marine macroalgae and microalgae, a multi ecological benign relationship between aquaculture and aquatic ecosystem is constructed. The blue carbon ecosystem in New South Wales and Victoria in the southeast of Australia contributes $35.5 million to Australia's inshore fisheries every year. Therefore, the enormous potential to become the main financing path of the emerging blue carbon market is a direction to explore the payment mechanism of ecosystem services [9].

For the above threat factors, the research cases in the literature are integrated. The summary methods include limiting human disturbance, vegetation restoration, engineering measures restoration, comprehensive socio-economic measures and the participation of government policy formulation. The restoration effect is affected by the sustainability of hydrological conditions and sediment supply, biodiversity, policy support and payment mechanism for ecosystem services. Single species are often inferior to the restoration schemes of diverse ecosystems in terms of resistance to disturbance and long-term stability.

There is still a lack of empirical research on long-term carbon sink gains, especially cross scale and cross regional comparative research.

5 Conclusion

Through literature research, this paper compares the protection, monitoring and research methods of blue carbon wetland ecological environment in different countries at home and abroad.It is not difficult to find that coastal wetlands and mangroves play an important role in achieving the goal of global carbon neutrality. However, many blue carbon habitats, such as mangroves, tidal swamps and seagrass beds, are facing many serious threats and are gradually disappearing from the earth.Timely and effective protection and restoration of these ecosystems can not only increase carbon sinks, but also maintain biodiversity, enhance coastal resilience and provide multiple ecological services. To achieve its long-term climate benefits, it is necessary to promote international collaboration at the ecological, technological, and institutional levels. Establish a standardized MRV system, consider biodiversity and its ecological functions, design effective and sustainable economic incentives and legal protection, and promote the sharing of international technology and experience.Only in this way , blue carbon can become a reliable and effective component of global climate governance from a local project.

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