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RECEIVED 06 March 2025

ACCEPTED 06 May 2025

PUBLISHED 26 May 2025

CORRECTED 09 July 2025

CITATION

Cheng G, Liao H and Li X (2025) Experiences and lessons learned from mangrove conservation in China.
Front. For. Glob. Change 8:1588710.
doi: 10.3389/ffgc.2025.1588710

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Experiences and lessons learned from mangrove conservation in China

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Mangrove forests are recognized as one of the most biologically diverse marine ecosystems on the planet, along with coral reefs and seagrass beds, and are known as the planet's three major marine ecosystems. As China has increased its efforts to protect mangroves on all fronts, the area of mangrove forests has grown steadily since the beginning of this century, and China is now one of the few countries in the world with a net increase in the area of mangrove forests. China's top-level design, legislation and practice, supervision, protection and restoration policies, publicity and education on mangrove protection have achieved noticeable results, and a mangrove protection model with Chinese characteristics has been explored and formed, and mangrove forests, the "guardians of the coast," are becoming a shining business card of beautiful China. Therefore, China's important experience in striking a balance between mangrove protection and economic development can provide a reference for other mangrove areas worldwide, and is of great significance in solving the global problem of mangrove forests in danger.

KEYWORDS

mangrove protection, marine ecosystems, top-level design, legislative practice, conservation practice

1 Introduction

Mangroves are one of the most productive ecosystems on earth, providing a wide range of essential ecosystem services (Nagelkerken et al., 2000; Arkema et al., 2013) such as coastal protection and conservation of coral reefs and juvenile fish species. However, mangrove ecosystems are among the most fragile and threatened ecosystems in the world and have experienced significant losses due to human activities such as urban development, aquaculture recycling and coastal landfills (Zheng and Takeuchi, 2020). It has been recorded that more than 50% of mangrove forests have disappeared globally since the 1980s (Hamilton and Casey, 2016; Spalding et al., 1997). The Global Mangrove Status Report 2022 (hereinafter referred to as the Report) released by the Global Mangrove Alliance points out that, due to human causes such as deforestation and land encroachment, as well as the impact of natural factors such as climate change and storms, 5,245 square kilometers of mangrove forests have disappeared globally since 1996, and the world is now left with only 147,000 square kilometers of mangrove forests (Leal and Spalding, 2022). The mangrove area in China has experienced a sharp decrease to a steady increase, as shown in Figure 1 (Jia et al., 2021). From the early 1980s to 1995, when the China Biodiversity Conservation Action Plan was released, conservation and restoration led to a steady increase in mangrove areas (Zheng and Takeuchi, 2020). China's white paper "Marine Ecological Environmental Protection in China," released on July 11, 2024, shows that the area of mangrove land in the country has grown to 29,200 hectares, an increase

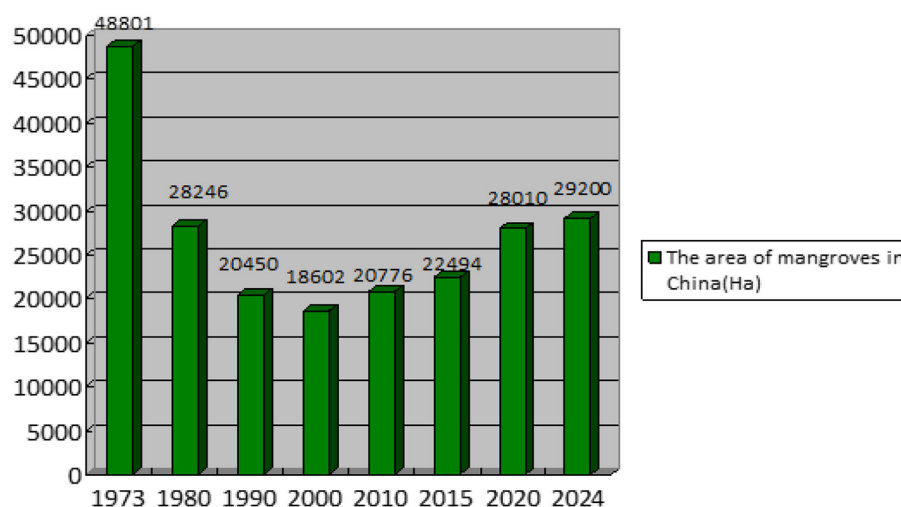


FIGURE 1
The area of mangroves in China.

of about 7,200 hectares from the beginning of this century (China's marine ecological environment protection, 2023). The steady increase in the area of mangrove forests in China illustrates China's achievements in mangrove conservation and the development of a Chinese program to manage mangrove ecosystems in China. Therefore, understanding the long-term dynamics of China's mangrove forests and understanding the top-level design, legislative practices, and practical initiatives of China's mangrove conservation is of great theoretical significance and practical utility for other countries and regions to effectively carry out mangrove conservation.

The main contributions of this paper are as follows. First, this paper analyzes in detail the top-level design of mangrove protection in China at three administrative levels: the central government, provincial governments and municipal governments. Second, to gain a comprehensive understanding of mangrove ecosystem protection in China, this paper introduces and analyzes mangrove protection legislation from the legislative level of the three levels of government. Thirdly, taking Zhanjiang, a representative mangrove protection area, as an example, the paper summarizes and elaborates upon the levels of policy, regulation, education and publicity, social participation, and the practice of scientific protection. This paper provides a comprehensive introduction to the Chinese model of mangrove protection by taking into account the top-level design of China's mangrove ecosystem protection, the legislative practice as well as the case analysis, and offers feasible suggestions to other countries and regions in formulating the relevant policies, enacting the legislations as well as the practices of mangrove protection. It provides feasible suggestions for other countries and regions to formulate relevant policies, legislation and practices on mangrove protection.

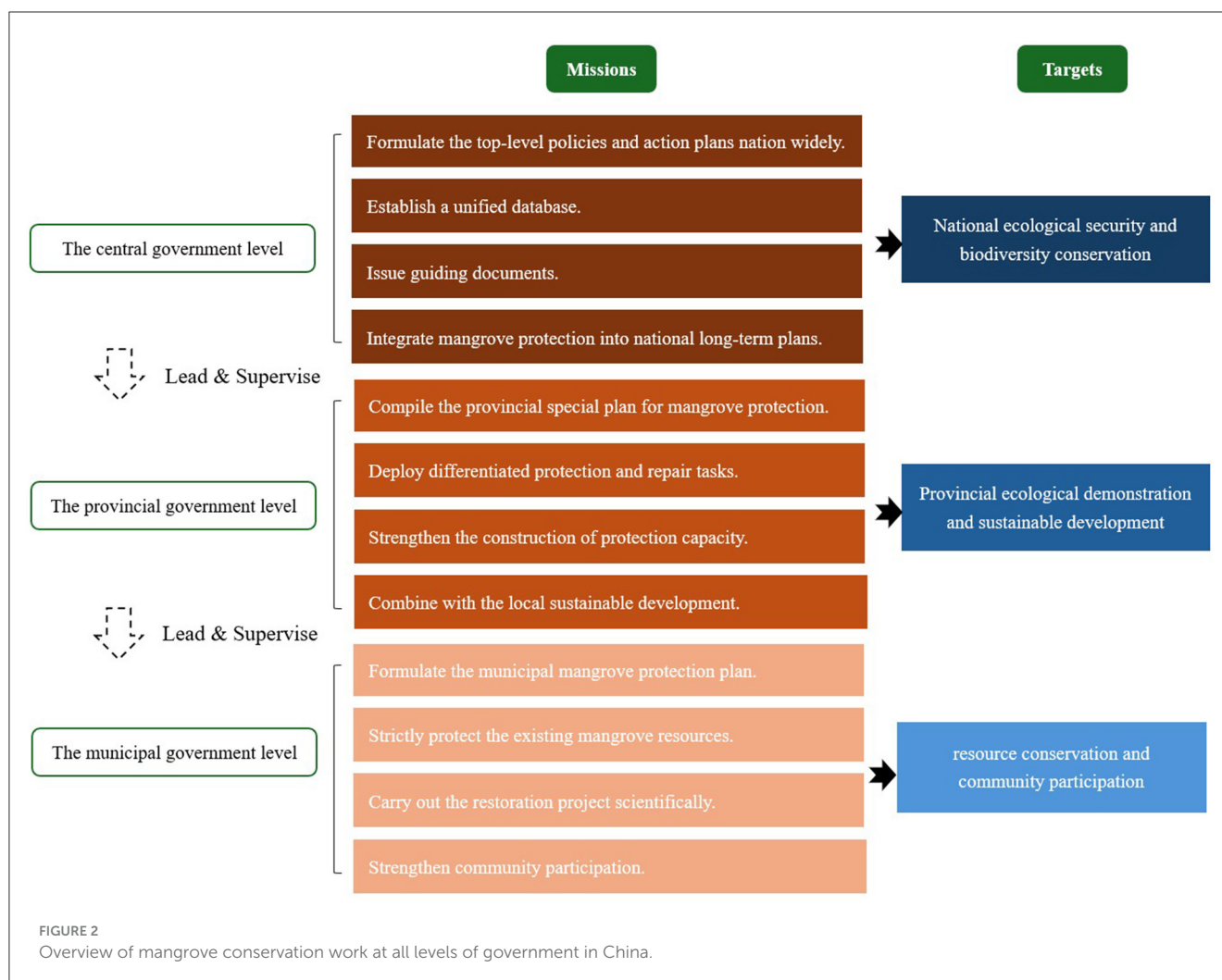
The rest of the paper is organized as follows: Section 2 describes the top-level design of mangrove protection by the central government, provincial governments, and municipal governments. Section 3 presents the legislative practices of mangrove protection at each of the three levels of government. Section 4 describes the

successful experience of mangrove protection in Zhanjiang City in terms of legislation, regulation, education, and social participation, using a city with typical mangrove protection as an example. Section 5 summarizes the whole paper.

2 Top-level design of mangrove conservation in China

2.1 Protecting mangroves has become the consensus in China

Since 2012, the important strategic decision of "vigorously promoting the construction of ecological civilization" (National People's Congress of the People's Republic of China, 2012) has been proposed, and a profound consensus has gradually emerged across all sectors of Chinese society. This consensus underscores that respecting the laws of nature, adhering to the principles of natural change, and protecting the abundant resources of nature are not only the core principles of sustainable development but also the foundation for fostering a harmonious symbiotic relationship between humanity and nature. Establishing this concept marks a fundamental shift in our attitude toward nature and emphasizes the importance of living in harmony with nature, thus laying a solid foundation for sustainable development in the future. The construction of ecological civilization has even been elevated to one of the important connotations of Xi Jinping's thought on socialism with Chinese characteristics in the new era, and is under constant development. As the largest ecosystem component, the oceans provide resources for human production activities but are also an important birthplace of human civilization and a channel for world interaction, cultural dissemination and civilization transmission (Chen et al., 2017). General Secretary Xi Jinping also emphasized a point during his visit to Guangdong in 2023: Strengthening the construction of marine ecological civilization is an important part of the process of promoting the construction of ecological



civilization. Mangrove forests are “national treasures” and should be guarded like eyes (Su and Yan, 2023). Maintaining the marine ecosystem and promoting the harmonious coexistence of humans and nature are the core elements of building China’s maritime power. During the eighth collective study session of the Political Bureau of the Central Committee of the Communist Party of China, General Secretary Xi Jinping pointed out that: “In this new era of the 21st century, human society has entered a new stage of extensive development and utilization of marine resources. The oceans are increasingly important to developing national economic structures and the openness of foreign economic exchanges (Xi, 2013).

2.2 The preparation of plans for mangrove protection has become a regular feature of the work of Chinese governments at all levels

China prepares plans for mangrove protection at three levels (as shown in Figure 2).

Firstly, it is good to do mangrove protection planning at the central government level. In 2019, China’s Ministry of

Natural Resources (MNR) and the State Forestry and Grassland Administration (SFA) jointly carried out a special survey on mangrove resources, mapped out the national mangrove forests, and established a database for the special survey on mangrove forests. In 2020, China’s Ministry of Natural Resources (MNR) and the State Forestry and Grassland Administration (SFA) jointly issued the Circular on Strengthening Mangrove Protection and Restoration and the Special Action Plan for Mangrove Protection and Restoration (2020–2025; Ministry of Natural Resources and State Forestry and Grassland Administration, 2020). The Special Action Plan for Mangrove Protection and Restoration (2020–2025) insists on implementing mangrove protection and restoration in accordance with the ideas of overall protection, systematic restoration and comprehensive management, maintaining mangrove habitat connectivity and biodiversity, and realizing the overall protection of mangrove ecosystems; it follows the law of mangrove ecosystem succession and internal mechanism, and adopts the combination of natural restoration and moderate artificial restoration to implement mangrove ecosystem restoration. Following the law of mangrove ecosystem succession and internal mechanism, adopt the combination of natural restoration and moderate artificial restoration to implement ecological restoration. For the outstanding problems of mangrove protection and

restoration, clearly prioritize the restoration within the mangrove nature reserve and gradually expand it to other suitable restoration areas. Most of the existing national-level mangrove nature reserves in China, including Shenzhen Futian, Hainan Dongzhaigang, Guangxi Shankou, Guangxi Beilun River Estuary, Fujian Zhang River and Guangdong Zhanjiang, were established in the early 1990s. Based on long-term satellite remote sensing monitoring data for mangroves in China, the area of mangroves within each reserve has expanded compared to the initial period of establishment (as shown in Figure 3). In 2022, the Ministry of Natural Resources and the State Forestry and Grassland Administration organized the preparation of the National Wetland Conservation Plan (2022–2030; [State Forestry Grassland Administration the Ministry of Natural Resources, 2022](#)), which included mangrove wetlands in the scope of protection and restoration key support.

Secondly, mangrove protection planning is well done at the provincial government level. Including Guangdong, Guangxi, Hainan, Fujian, Zhejiang and other coastal provinces will prepare provincial mangrove protection special planning as a new era of ecological civilization to promote the construction of specific actions and the implementation of mangrove protection and restoration of the important hand. For example, the Guangdong Provincial Department of Natural Resources and the Guangdong Provincial Forestry Bureau jointly organized the preparation of the Guangdong Provincial Mangrove Protection and Restoration Plan (2021–2025; [Guangdong Provincial Department of Natural Resources, 2020](#)), which is based on the endowment of mangrove forests in Guangdong Province and the results of their protection and restoration, and systematically deploys the tasks of mangrove forest protection, restoration and restoration, protection capacity building and sustainable development. Another example is that the Forestry Bureau of Hainan Province has prepared the Special Plan for the Protection of Mangrove Resources in Hainan Province (2024–2035; [Forestry Bureau of Hainan Province, 2024](#)), which compiles the status of mangrove wetland resources in Hainan Province, the main achievements and problems, formulates the objectives of mangrove protection and restoration in the province, and plans five aspects of the tasks and key projects, so as to provide solutions for the implementation of the tasks of mangrove protection and restoration.

Third, to strengthen mangrove planning at the municipal government level: some Chinese municipalities with a relatively large area of mangrove forests have also formulated mangrove protection plans to strictly protect the existing mangrove forests, and scientifically carry out mangrove afforestation and restoration actions. For example, Beihai City in the Guangxi Zhuang Autonomous Region has 4,210.99 hectares of existing mangrove forests, accounting for 44.72% of the Guangxi Zhuang Autonomous Region, making it the largest municipal area of mangrove resources in the Guangxi Zhuang Autonomous Region ([Deng et al., 2022](#)). The city 2021 formulated the Beihai Mangrove Resource Protection Plan (2020–2030). Another example is Zhanjiang City, Guangdong Province, known as “China’s Mangrove City,” which has 6,412.53 hectares of mangrove forests, accounting for 60.5% of the mangrove forests in Guangdong Province, and is not only the largest city in Guangdong Province with the largest area of mangrove forests, but also the largest city in China with the largest area of mangrove

forest resources ([Shu, 2024](#)). The city officially issued the Zhanjiang Mangrove Protection and Restoration Plan (2021–2025) in 2023.

3 Legislative practice of mangrove protection in China

In order to protect mangrove forests, China has not only constructed a three-tier mangrove protection legislation at the national, provincial and municipal levels, but also carries out all-round protection of mangrove forests from different perspectives, such as forests, wetlands and sea areas.

3.1 National-level mangrove legislative experience in China

Article 9 of the Law of the People’s Republic of China on Marine Environmental Protection, which came into force in 1983, clearly stipulates that “all behaviors damaging mangrove forests are prohibited” [[Law of the People’s Republic of China on Marine Environmental Protection \(NO.9\), 1982](#)], which is the first time that China protected mangrove forests by way of legislation, and lays the foundation for the formulation of laws and regulations related to the protection of mangrove forests in the future. Article 20 of the revised version of the Law of the People’s Republic of China on Marine Environmental Protection of 1999 clearly stipulates that “the State Council and local governments at all levels along the coast have the duty to protect mangrove forests.” The change from “prohibiting damage to mangrove forests” to “protecting mangrove forests” reflects the growing enthusiasm for protecting mangrove forests in Chinese law, and the protection of mangrove forests in coastal areas has gradually attracted national attention. Article 25 of the Forestry Law of the People’s Republic of China clearly stipulates that “the competent forestry department of the people’s government at or above the county level shall, in accordance with the objectives of the protection and development of forest resources, prepare a forestry development plan ([Forestry Law of the People’s Republic of China, 1984](#)).” This provision emphasizes the importance of the State’s protection and development of forest resources, including mangroves. The article does not explicitly mention the specific term “mangrove forests,” but based on the spirit of the legislation and the specific provisions, we can infer that mangrove forests, as part of the forest resources and the environment, should be protected by the Forestry Law. The Wetland Protection Law of the People’s Republic of China, which was enacted and promulgated in 2021, has set up a number of provisions on mangrove protection, which explicitly requires that all local governments should take effective measures to protect mangrove forests, and prohibit the occupation of mangrove forests in addition to major national projects and disaster prevention and mitigation projects so that China’s mangrove forests have been subjected to comprehensive and strict protection by the law since then. For example, Article 34 of the law clearly stipulates that “the local people’s government at or above the county level where the mangrove wetland is located shall organize the preparation of a special plan for the protection of mangrove wetlands, and

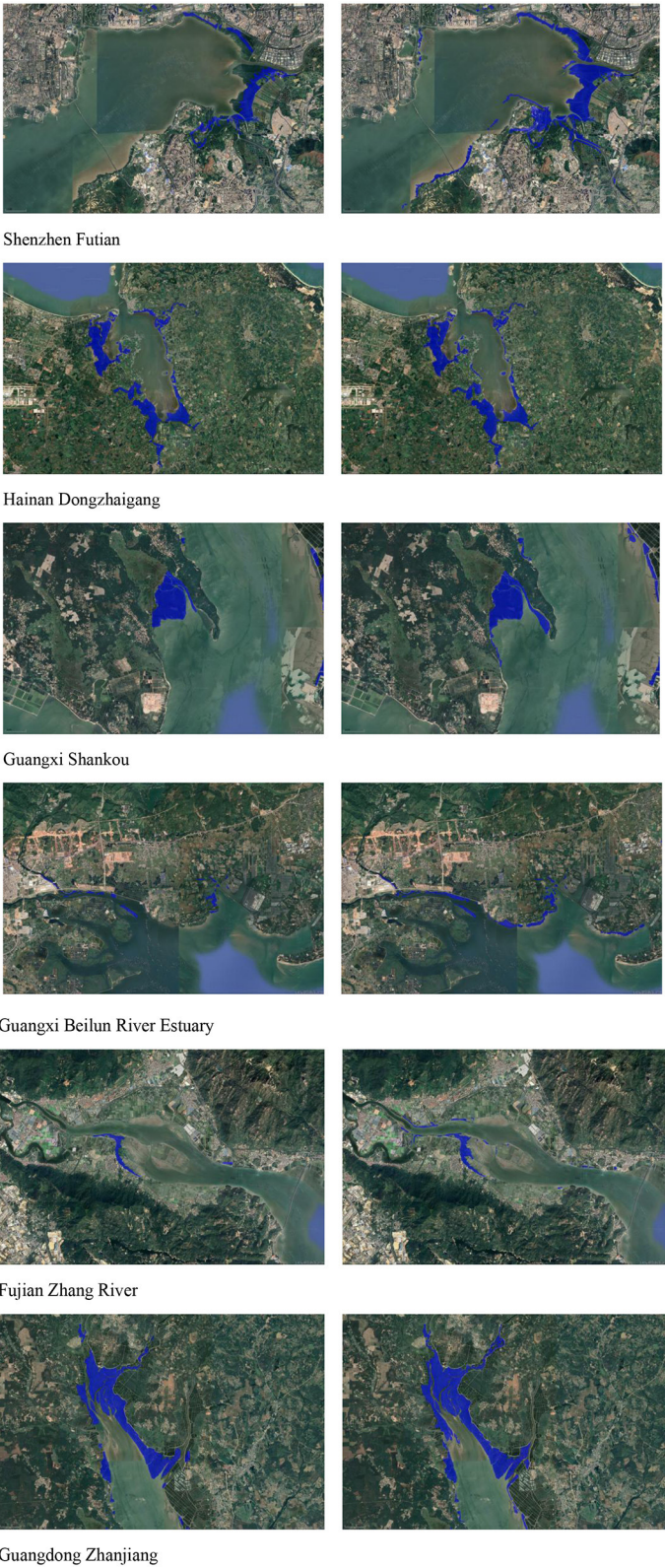


FIGURE 3
Comparison of the area of national mangrove nature reserves in China in 1990 and 2018 (the blue part represents the area of mangroves; the former shows the year 1990 and the latter shows the year 2018; Zhang J. Y. et al., 2021; Zhang et al., 2020; Zhang T. et al., 2021).

take effective measures to protect mangrove wetlands. Mangrove wetlands shall be included in the list of important wetlands; if they meet the criteria for nationally important wetlands, they shall be prioritized for inclusion. The occupation of mangrove wetlands is prohibited” (*Law of the People’s Republic of China on the Protection of Wetlands*, 2021).

3.2 Provincial-level mangrove legislative experience in China

In 1998, Hainan Province of China took the lead in promulgating the Provisions on the Protection of Mangrove Forests, which was the first local regulation on the protection of mangrove forests in China. The Provisions clearly define for the first time the concept and scope of protection of mangrove forests; prohibit the cutting down of mangrove forests and other acts of destroying mangrove forests; stipulate the responsibilities of the relevant management departments for the protection of mangrove forests, and incorporate mangrove forest protection into the planning of the national economy and social development; and stipulate the legal responsibilities for destroying mangrove forests, and set up corresponding compensatory measures for acts of destroying mangrove forests of varying degrees of severity (*Forestry Bureau of Hainan Province*, 1998). Guangdong Province, which has the largest area of mangrove forests in the country, was the first province or region in the country to incorporate mangrove forests into its forest land management with the introduction of the Regulations on the Protection of Forests in Guangdong Province in 1994. The Regulations on Wetland Protection of Guangdong Province promulgated in 2006 added a special chapter on mangrove wetland protection, which clearly stipulates the responsibilities of the people’s governments of the coastal areas and the relevant management departments where the mangrove wetlands are located for the protection, management and inspection of mangrove forests, and stipulates that the people’s governments at or above the county level of the coastal areas should include mangrove forest protection in the wetland protection planning of the region (*Regulations on Wetland Protection in Guangdong Province*, 2006). The Fujian Provincial Wetland Protection Regulations promulgated in 2016 clearly stipulates that the wetland resources include mangrove forests and other plant resources. The Regulations on the Protection of Mangrove Resources of the Guangxi Zhuang Autonomous Region issued in 2018 clearly stipulate that “the unauthorized cutting of mangrove forests will be punished by replanting mangrove forests 10fold, and up to 10 times the value of the mangrove forests cut down will be fined” (*Regulations on the Protection of Mangrove Resources in the Guangxi Zhuang Autonomous Region*, 2018).

3.3 Municipal-level mangrove legislation experience in China, take Zhanjiang as an example

In 2001, the Zhanjiang government officially issued the normative document “Zhanjiang Mangrove Resources Protection

and Management Provisions,” which implements standardized and strict protection and management measures for mangrove forests. In 2017, Zhanjiang enacted the “Guangdong Zhanjiang Mangrove Forests National Nature Reserve Management Measures” The measures are more scientific compared to the provisions of 2001 and have the following characteristics: firstly, it takes into account the relationship between development and protection, adding the First, the relationship between development and protection is taken into account, and the principle of “combining protection priority, strict management, rational utilization and sustainable development” is added; mangrove protection is incorporated into the national economic and social development plan; paid use and eco-tourism are encouraged. Secondly, scientific management is emphasized, and mangrove areas are meticulously divided into core, buffer and experimental zones in order to implement sub-regional management strategies; in addition, problems arising from occupancy are solved through measures such as increasing the area of mangrove forests in other areas, and implementing eco-compensation schemes. Thirdly, the protection of mangrove forests has been strengthened by clarifying the powers and responsibilities of mangrove protection and management organizations, increasing the number of responsible parties and encouraging social supervision (*Measures for the Management of the Zhanjiang Mangrove National Nature Reserve in Guangdong Province*, 2017). 2023 Zhanjiang City also promulgated the “Zhanjiang City Mangrove Wetland Protection Regulations” The regulations, compared to the 2017 approach, added the protection of mangrove land outside the protected area, emphasized the help of the surrounding community to develop the economy, clarified the way of public interest litigation, and put forward the development of cross-border carbon sinks and other techniques of international cooperation, and at the same time in terms of supervision and inspection, the introduction of information monitoring technology, the increase in the system of interviews, and the reporting mechanism is also more. Meanwhile, in terms of supervision and inspection, information monitoring technology has been introduced, an interview system has been added, and the reporting mechanism has been made more specific (*Regulations on the Protection of Mangrove Wetlands in Zhanjiang City*, 2023; Table 1).

4 Zhanjiang practice of mangrove conservation in China

Zhanjiang City is the city of China’s mangrove forests, the prefecture-level city with the largest distribution of mangrove forests in the country, and has the Zhanjiang Mangrove Forest National Nature Reserve, which is the largest in area and the most concentrated in the distribution in the country. On April 10, 2023, when General Secretary Xi Jinping came to inspect the mangrove growth and the surrounding ecological environment in the mangrove area of Jinniu Island, Huguang Township, Mazhang District, he emphasized that “this mangrove forest is a national treasure, and it should be guarded as if it were an eye.” Therefore, Zhanjiang’s practice of mangrove protection is of typical significance (*Figure 4*).

TABLE 1 Legislation on mangrove protection in China.

Year of legislation	Legislation	Content of the legislation
1983	Law of the People's Republic of China on the Protection of the Marine Environment	All acts that damage mangrove forests are prohibited
1999	The revised version of the Law of the People's Republic of China on Marine Environmental Protection	The State Council and local governments at all levels along the coast have the responsibility to protect mangrove forests
1984	The Forestry Law of the People's Republic of China	The competent forestry department of the people's government at or above the county level shall, in accordance with the objectives of the conservation and development of forest resources, prepare a forestry development plan
2021	Law of the People's Republic of China on Wetland Protection	Local people's governments at or above the county level where the mangrove wetlands are located shall organize the preparation of special plans for the protection of mangrove wetlands, and take effective measures to protect mangrove wetlands. Mangrove wetlands shall be included in the list of important wetlands; those meeting the criteria for nationally important wetlands shall be prioritized for inclusion in the list of nationally important wetlands. The occupation of mangrove wetlands is prohibited
1998	Provisions on the Protection of Mangroves in Hainan Province	Prohibit the felling of mangrove forests and other acts of destruction of mangrove forests; incorporate the protection of mangrove forests into national economic and social development planning; and stipulate the legal responsibility for the destruction of mangrove forests and set up appropriate compensation measures for different degrees of destruction of mangrove forests
2006	Regulations on the Protection of Wetlands in Guangdong Province	A special chapter on mangrove wetland protection is added, specifying the duties of the people's governments of coastal areas and the relevant management departments where mangrove wetlands are located to protect, manage and inspect mangrove forests, and stipulating that the people's governments at or above the county level of the coastal areas shall incorporate mangrove protection into the wetland protection planning of the region
2018	Regulations on the Protection of Mangrove Resources in the Guangxi Zhuang Autonomous Region	Unauthorized cutting of mangrove forests will be penalized with a 10fold replanting of mangrove forests and a maximum fine of up to 10 times the value of the mangrove forests cut down
2001	Provisions on the Protection and Management of Mangrove Resources in Zhanjiang City	Proposed measures to implement normative and strict protection and management of mangrove forests
2023	Regulations on the Protection of Mangrove Wetlands in Zhanjiang City	Techniques such as protection of mangrove land outside protected areas, emphasis on helping neighboring communities to develop their economies, clarification of the modalities of public interest litigation, and international cooperation to develop transboundary carbon sinks were proposed

4.1 Policy practices for mangrove conservation

In order to salvage and restore mangrove resources, Zhanjiang has made policy tilts in mangrove protection to balance the relationship between development and protection. First, to build a “city of mangrove forests” as a leader, and actively build a mangrove special brand: in the policy interpretation of the “Zhanjiang City Regulations on Optimizing the Business Environment,” the goal of building a brand image of Zhanjiang as a “city of mangrove forests” was put forward to enhance the carbon sequestration capacity of the ecosystem (*Regulations on Optimizing the Business Environment in Zhanjiang City, 2021*). The goal of building Zhanjiang's brand image as a “Mangrove City” is to enhance the ecosystem's carbon absorption capacity. In addition, in the Implementation Plan for the Development of Green Finance in Support of Peak Carbon Action in Zhanjiang, the implementation of green financial strategies to support the construction activities of the “Mangrove City” is also actively advocated, as well as the expansion of credit support for the protection and restoration of mangrove forests, and the enhancement of financial assistance related to the mangrove ecological industry, to build a “Mangrove

City” around the construction of Zhanjiang. Around the theme of “Mangrove City,” introduce authoritative media to carry out cultural publicity and promotion in Zhanjiang, and invest 10 million yuan of project funds to support the development of mangrove coastal tourism (*Notice on the Issuance of the Implementation Program for the Development of Green Finance in Support of Peak Carbon Action in Zhanjiang City, 2023*). Second, the scientific construction of a “mangrove city,” realize the ecological benefit to the people: the introduction of “Zhanjiang City, national forest city construction master plan,” the building of a forest health system, and the mangrove forestation, restoration of the system into the system (*Zhanjiang National Forest City Construction Master Plan, 2020*); the construction of Mazhang Mangrove Theme Park and as the government focus on supervising people's livelihoods to promote; and actively practice “Zhanjiang City Scientific Greening Implementation Program,” the protection and restoration of mangrove forests will be carried out through scientific methods, and according to the plan from 2020 to 2025, it is planned that the area of new mangrove forests will reach 2,813 hectares (*Zhanjiang Scientific Greening Implementation Plan, 2022*). Third, synergize with other policies to play a synergistic role: the protection of mangrove forests is not only protected by special



FIGURE 4

The aerial view of the Zhanjiang Mangrove National Nature Reserve in Guangdong Province (Ye and Lin, 2025).

policies, but also reflected in other policies, such as “Zhanjiang City, Groundwater Management Measures,” “Zhanjiang City, Soil Pollution Prevention and Control Action Plan Implementation Program,” etc., mangrove forests are also set up considerable protection regulations.

4.2 Regulatory practices for mangrove conservation

In fact, the allocation of authority for mangrove protection in various cities and municipalities in China has generally adopted the supervisory model of “government leadership, forestry department in charge, and multi-departmental collaboration,” i.e., the people’s governments in the areas where the mangrove resources are located take the lead in the work and incorporate the protection of mangrove forests into the national economic and social development planning; The local Forestry Bureau is in charge of the comprehensive management and development planning of this work; the departments of public security, environmental protection, marine fisheries, agriculture, land resources, urban and rural planning, water affairs, tourism and transport are in charge of this work in accordance with their respective responsibilities. Zhanjiang, Guangdong Province, has established the Mangrove National Nature Reserve Administration, which is a public welfare institution at the departmental level directly under the Forestry Bureau, and is responsible for the protection and management within the mangrove reserve, mainly for planning and management of the reserve, patrolling and law enforcement, education and publicity, assisting in scientific research, supervising the project situation, and the development

of the community around the reserve. Since its establishment in 2005, this protected area management bureau has strengthened the management of mangrove wetlands in accordance with the law and relevant regulations. It has punished various offenses, such as destroying mangrove wetlands and illegally hunting migratory birds in accordance with the law. These measures have led to a significant reduction in the anthropogenic threats the protected area faces, thus improving the legal environment for ecological protection. At the same time, joint efforts have been made with the Water Affairs Bureau, the Marine Fisheries Bureau and other agencies to crack down on illegal sand pumping and other activities in the protected areas to manage the construction of the protected areas effectively, and to promote the healthy and sustainable development of the protected areas.

4.3 Educational outreach and social participation practices for mangrove conservation

Zhanjiang in mangrove protection education and publicity worthy of reference practices are.

At first, government guidance. The 33 village-level service centers along the coastline of mangrove forests in Mazhang District, Zhanjiang, have been made into mangrove education and publicity points to disseminate knowledge about mangrove protection and to broadly gather a consensus among the masses on the protection of mangrove forests.

Secondly, extensive participation. Various institutions, organizations and social groups in Zhanjiang have participated in



FIGURE 5

Le Fedeli, the general manager of Saint-Hua Glass Container Co., Ltd from France, in Jinsha Bay, Zhanjiang (Lin and Deng, 2024).

the “Volunteers for Mangrove Protection” territory-wide forest protection action, organizing over 10,000 volunteers and more than a dozen activities.

Thirdly, the joint consultation and governance. The government will be related to mangrove protection laws and regulations, policies, according to law to the public and solicit opinions, and promote democratic legislation; at the same time, Ma Zhang District Court set up ‘Ma Zhang Court mangrove protection law station,’ set up “Ma Zhang Court mangrove protection law propaganda group” to carry out Mangrove protection activities to lay the foundation for the public to better participate in policy formulation and public affairs management.

Fourth, improving facilities. The construction of Xiashan Mangrove Wetland Park, Mazhang Zhanjiang Mangrove Education Center and outdoor science base for mangrove wetland ecological protection, etc., will provide the public with places for science education, viewing and recreation. Fifth, the linkage of industry, academia and research. Mazhang District cooperates with universities, colleges, and mangrove research institutions to build mangrove research centers and teaching practice bases, carry out mangrove research forums, and conduct other publicity and promotion activities (Figure 5).

4.4 Scientific conservation practices in mangrove forests

Firstly, mangrove afforestation selects species and achieves income generation after giving ecological priority. For example, in implementing mangrove forestation activities, priority is given to the use of white bone loam, Tung Hua tree, autumn eggplant, red sea olive and other local native species, while the introduction of foreign mangrove species must be strictly limited. The economic value of mangrove species is then taken into account, as in the case of the “fruit tree of the sea,” the white bone loam, the leaves of which can excrete salt and have a high nitrogen content, which is an important green manure resource, and the edible fruits of which have a high economic value.

Secondly, as the national macro-guidance, the Dual-carbon strategy focuses on ecological. In June 2021, the Beijing Entrepreneurs’ Environmental Protection Foundation, the Third Institute of Oceanography under the Ministry of Natural Resources, and the Administration Bureau of Zhanjiang Mangrove National Nature Reserve in Guangdong Province jointly signed a carbon emission reduction transfer agreement for the “Zhanjiang Mangrove Afforestation Project.” The Beijing Entrepreneurs’ Environmental Protection Foundation purchased the first batch of 5,880 tons of carbon dioxide emission reductions at a price

of 66 yuan per ton, which will be utilized to offset the carbon emissions generated by its daily operations and activities. This successful blue carbon trading initiative serves as a model for realizing the ecological value, such as carbon sequestration, derived from mangrove restoration projects. It demonstrates and promotes the attraction of funds for mangrove conservation and restoration, advances the development of the marine carbon sink economy, and supports the achievement of marine carbon neutrality.

Thirdly, the development mechanism is innovative, strengthening forestry research institutions, enhancing cooperation with higher education institutions in the Zhanjiang area, cultivating innovative marine professionals, and jointly restoring mangrove forests. Zhanjiang City has constructed an effective mangrove protection and development system through a diversified model of government guidance, market operation and social participation. Government departments have formulated relevant policies and provided financial support to ensure that mangrove protection is guaranteed with sufficient resources. At the same time, market mechanisms have been introduced to encourage enterprises to participate in the protection and utilization of mangrove forests, and to achieve the sustainable utilization of mangrove resources through eco-tourism and under-forest economy. In addition, Zhanjiang City also actively advocates public participation in mangrove protection and raises public awareness of and participation in mangrove protection through volunteer services, popular science education and other forms. Zhanjiang City focuses on strengthening the role of forestry research institutions to enhance the scientific and professional nature of mangrove protection. The Zhanjiang Bay Laboratory has established a long-term observation base for researching and developing a mangrove aquaculture coupling model on Jinniu Island, located in the Mazhang District of Zhanjiang City. The laboratory is currently investigating suitable species for aquaculture ponds situated in mangrove areas. By comprehensively considering environmental adaptability, ecological value, and economic benefits, six mangrove species have been preliminarily selected as the most suitable. Forestry research institutes in the city continue to strengthen research on mangrove ecosystems, and conduct in-depth investigations into the growth habits and ecological functions of mangrove forests and their adaptive mechanisms to environmental changes. The results of these researches provide a scientific basis for mangrove protection and management and guide the field work. Research institutes also organize regular training courses and seminars to improve the professionalism of practitioners and ensure the professionalism and effectiveness of mangrove protection work. Zhanjiang City has closely partnered with Guangdong Ocean University and other universities to provide students with practical learning opportunities through school-enterprise cooperation and the construction of internship and training bases. This mode of cooperation helps students combine theoretical knowledge with practice and delivers many talents with professional knowledge and practical ability for mangrove protection. These talents play an important role in mangrove protection, scientific research, environmental monitoring, etc., and become the backbone of promoting the development of mangrove protection in Zhanjiang.

Fourthly, we have strengthened technical monitoring, carried out remote sensing verification of human activities in the protected areas, and the special action of supervision and inspection of nature reserves called “Green Shield,” aiming at timely detection and investigation of illegal and irregular development activities in the protected areas.

5 Conclusion

On November 5 2022, President Xi Jinping, in his speech at the opening ceremony of the 14th session of the Conference of the Parties to the Convention on Wetlands, noted that China would promote international exchanges and cooperation and establish an “international mangrove center” in Shenzhen. The establishment of the International Mangrove Center, the first global exchange and cooperation platform for mangrove conservation, will enhance the role of mangrove wetlands in addressing climate change, biodiversity conservation, disaster mitigation and poverty alleviation, and improve human wellbeing, as well as provide practical services to developing countries in terms of technical support, information-sharing, monitoring and assessment of mangrove conservation. China’s successful experience in top-level design, legislative practice, regulation, protection and restoration policies, publicity and education in mangrove protection is significant worldwide.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

GC: Supervision, Writing – original draft, Writing – review & editing, Funding acquisition. HL: Writing – original draft. XL: Data curation, Project administration, Resources, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This study was funded by the Guangdong Provincial Philosophy and Social Sciences 14th Five-Year Plan in 2022 “Discipline Co-construction Project Research on the Collaborative Construction of Emergency Management System for Urban Agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area,” project no. GD22XGL39 and the 2022 Humanities and Social Sciences Research Project of Guangdong Ocean University, “Collaborative Construction of Emergency Management in Large Urban Agglomerations—A Case Study of Guangdong-Hong Kong-Macao Greater Bay Area,” project no. C22808, and the Southern Manne Science and Engineering Guangdong Provincial Laboratory Project “Research on Sustainable Development of Marine Fisheries in Guangdong

under the Background of the” Belt and Road “Strategy,” project no. ZJW-2022-13.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Correction note

A correction has been made to this article. Details can be found at: [10.3389/ffgc.2025.1654452](https://doi.org/10.3389/ffgc.2025.1654452).

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