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The evolution of China's policies on marine and coastal ecosystems in climate change adaptation

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Marine and coastal ecosystems play a crucial role in adjusting the process of climate change. Mitigation and adaptation activities involve interdependent carbon and water cycles. Excessive carbon emissions burden the carbon storage capacity of the ocean and then affect the balance and stability of marine ecosystems, leading to global ocean issues such as ocean acidification and the calcification of marine life. While many studies have been conducted on this issue, there is a lack of policy analysis on how countries deal with climate change, particularly in the area of marine and coastal ecosystems' policies. In 1992, China ratified the *United Nations Framework Convention on Climate Change*, and China actively participated in the governance of marine and coastal ecosystems adapting to climate change. This article reviews and textually analyses China's policies related to the adaptation of marine and coastal ecosystems to climate change in 1992–2023. It adopts policy-oriented jurisprudence to illustrate natural and social factors which drive the evolution of China's policies on marine and coastal ecosystems in climate change adaptation. To achieve the optimal policy results, this article recommends further enhancing the mechanism of policy implementation and management, innovating the system of policy incentives and supervision, and optimizing the framework of policy effectiveness evaluation on the basis of further policy goals.

KEYWORDS

climate change, marine and coastal ecosystem, adaptation, adaptive policies, policy-oriented jurisprudence

1 Introduction

Anthropogenic carbon emissions increase the concentration of carbon in the atmosphere, subsequently triggering global warming. In the late 1980s, the mean global surface temperature had been anomalously high, with 1990 and 1991 being the warmest years on record (IPCC, 1992). The unusual global high temperature poses a significant threat to natural ecosystems. The ocean, which covers 70% of the Earth's surface, together with marine and coastal ecosystems, constitutes an essential component of the global ecosystem. The carbon and water

cycles closely link marine and coastal ecosystems to the climate system. Thus, marine and coastal ecosystems are particularly sensitive to climate change, while also playing a pivotal role in responding to it. The impact of climate change on marine and coastal ecosystems was first observed in the form of sea-level rise (IPCC, 1995). The escalation of global warming, ocean warming, acidification, and oxygen loss have been increasingly observed by the international community ever since the 21st century (IPCC, 2007). These phenomena of ocean warming, acidification, and oxygen loss significantly affect marine habitats, intensifying stress on marine species such as fishes, algae, and other marine organisms, thereby posing a threat to marine biodiversity (IPCC, 2019).

Marine and coastal lives and livelihoods have been exposed to the atmospheric changes beyond their resilience and ecological tipping points, leading to a weakening of the service functions provided by marine and coastal ecosystems and having negative effects on socioeconomic systems (IPCC, 2022). This in turn jeopardizes human well-being and productivity, leading to issues such as submergence of coastal areas and threats to fisheries development caused by climate change. Coastal areas and low-lying coastal countries, including many least developed countries and small island developing states, are particularly vulnerable to climate change (Chang et al., 2020). Implementing measures and actions in marine and coastal ecosystems to adapt to climate change is an effective way to pursue global sustainable development. Consequently, the international community gradually recognized the important link between climate change and the ocean, and reached new Sustainable Development Goals after the completion of the Millennium Development Goals (MDGs) period. In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, comprising 17 Sustainable Development Goals and 169 targets, aimed at creating a better world for human beings in harmony with nature (United Nations, 2015).

Considering that climate change poses a severe threat to future sustainable development by increasing coastal vulnerability (IPCC, 2014), the United Nations General Assembly has designated “conserve and sustainably use the oceans, seas and marine resources for sustainable development” as the Sustainable Development Goal 14 (United Nations, 2015). Goal 14 outlines actions for addressing climate change in marine and coastal ecosystems, with a focus on climate change adaptation. It encompasses seven sub-targets, including addressing marine pollution, promoting sustainable fisheries, protecting marine and coastal ecosystems, and minimizing the impact of ocean acidification. Due to the integrated nature of Goal 14, strong inter-linkages exist among these sub-targets. They collectively work towards enhancing the health, productivity, sustainability and resilience of marine and coastal ecosystems. Specifically, these sub-targets aim to foster climate-resilient sustainable development while improving the adaptability of marine and coastal ecosystems to climate change. To counteract the harmful impacts of climate change on the ecosystems and their services, innovative adaptation solutions are inevitable (IPCC, 2022). In recent years, ocean-based adaptations, especially marine technology and marine and coastal nature-based solutions, have been implemented globally to support the UN Sustainable Development Goals (United Nations, 2022).

Under the guidance of Sustainable Development Goal 14, states have increasingly recognized the urgency and significance of implementing adaptation measures in marine and coastal ecosystems, requiring concerted efforts from each state to continuously implement relevant measures (Tai et al., 2020). China has actively conducted adaptive measures in marine and coastal ecosystems to enhance its capacity for addressing climate change and achieving Sustainable Development Goals. Due to its complex climate and fragile environment, China is highly vulnerable to climate change’s impacts on its natural ecological system (Li et al., 2011). With a winding and irregular coastline extending over 32,000 kilometers (Ministry of Natural Resources of the People’s Republic of China, 2022), China’s coastal environment faces challenges such as sea-level rise, degradation of coastal wetlands and marine species, and the decline of coral reefs and mangroves, resulting in adverse effects on fisheries, offshore aquaculture, and port navigation (The Report Preparation Committee of the People’s Republic of China, 2011). As one of the world’s largest developing countries, China is under the pressure of economic development and resources consumption (State Council Information Office of the People’s Republic of China, 2021a). However, as a responsible major state, China has attached importance to climate change, proposing green development and low-carbon lifestyles.

In light of the cumulative negative impacts of climate change on marine and coastal ecosystems, as well as on economic and social systems, China has prioritized climate change adaptation in seven key areas, including the marine sector. Policies of climate change adaptation for marine and coastal ecosystems encompass multiple fields and multifaceted issues. Accordingly, China has developed planning and blueprints for climate change adaptation in marine and coastal ecosystems, enacting various policies for marine environmental protection, climate change response, and biodiversity conservation. China’s response to marine environmental problems caused by anthropogenic climate change holds significant implications. Enhancing the resilience of marine and coastal ecosystems to climate change and promoting the transformation of the marine economic structure can help strike a balance between environmental protection and economic development. As a responsible major state in global climate change governance, China fulfills its obligations and responsibilities, effectively addressing the well-being and development of 18% of the world’s population, facilitating the goal of effectively restoring at least 30% of degraded terrestrial, inland water, and marine and coastal ecosystems by 2030 (UNEP/CBD, 2022), and promoting the sustainable development of global shipping and fisheries.

China’s policies of climate change adaptation are continuously evolving alongside socioeconomic transitions and advances in climate governance (Teng and Wang, 2021). In 2022, China issued the National Strategy for Adaptation to Climate Change 2035, a significant achievement in climate change adaptation policy in the new stage. The Strategy comprehensively addresses water resources, terrestrial ecosystems, marine, and coastal zones, among other aspects. The interactive process among various policies before the formulation and implementation of the Strategy reveals the

development of China's climate change adaptation policies. The Strategy aims to enhance the climate resilience of natural ecological system and socioeconomic system. How do the various policies on marine environment protection, climate change response, and biodiversity conservation interact with each other under the goal-based strategy?

Under the policy-oriented jurisprudence, the study adopts policy content analysis to summarize policies on environmental protection, marine environment protection, climate change response and biodiversity conservation, with a focus on the goals, options, actions and outcomes of China's policies on marine and coastal ecosystems in climate change adaptation. Hence, the study is structured as follows: Section 2 introduces the policy-oriented jurisprudence and policy content analysis as the theoretical and methodological framework. Section 3 identifies periodic goals of China's policies on marine and coastal ecosystems in climate change adaptation. Section 4 analyzes the characteristics of various policies on marine environment protection, climate change response and biodiversity conservation in different stages. Section 5 interprets the factors influencing the development of relevant policies. Based on the clarification of future goals, Section 6 provides action recommendations to promote the enforcement and implementation of relevant policies. Finally, Section 7 presents the conclusions. The study aims to explore the gap between policy goals and practical effects, providing references for other developing states through action recommendations for policy implementation.

2 Theory and methods

This section introduces the theoretical framework and methods adopted in the study. The study utilizes a policy-oriented jurisprudence approach to analyze relevant policies concerning marine and coastal ecosystems in climate change adaptation. The policy-oriented jurisprudence is also referred as the New Haven Approach. The analysis methods involve policy content analysis to explore the characteristics of these policies. The following provides a detailed explanation of the above-mentioned theoretical framework and analysis methods.

2.1 Theoretical framework: policy-oriented jurisprudence

The policy-oriented jurisprudence offers a comprehensive, contextual, problem-oriented framework for analyzing social problems and the legal responses designed to address them (Wiessner and Willard, 2001). To achieve value-based decision-making, policy-oriented jurisprudence defines the five intellectual tasks to aid in comprehending and shaping policies (Lone, 2021). In this study, the five intellectual tasks are utilized to analyze the policies related to marine and coastal ecosystems in climate change adaptation and to illuminate their evolution.

The theoretical framework of policy-oriented jurisprudence is centered around the five intellectual tasks, with the core focus on problem-oriented analysis. The first task involves goal clarification,

which identifies the social problem to be solved by policies, thus clarifying the intended outcomes of policy implementation; the second task explores the historical trends of relevant policies, considering participators, perspectives, areas, base values and strategies involved in the process of policy-making; the third task examines the factors that have shaped or influenced the historical trends of these policies and evaluate past legal responses; the fourth task involves predicting the further developments of policy goals or the content; the fifth task proposes strategies to achieve the initial policy goals (Suzuki, 1974). In summary, to demonstrate the complexities of policy evolution, the Five Intellectual Tasks encompass goal clarification, trend analysis, factor analysis, predictions and recommendations (Lone, 2021).

Drawing upon the five intellectual tasks rooted in policy-oriented jurisprudence, Section 3 of this study analyzes the periodic goals of China's environmental governance and identifies the main problems faced by the society during each period (Task One). Section 4 conducts trend analysis and explores the interactions among various policy areas, demonstrating the evolution of policies concerning marine and coastal ecosystems in climate change adaptation (Task Two). Section 5 analyzes the features of marine environmental problems from natural factors and examines the international and national responses from social perspectives during each period (Task Three). Section 6 focuses on the National Strategy for Climate Change Adaptation 2035, issued in 2022, predicts future goals related to marine and coastal ecosystems in climate change adaptation (Task Four), and provides action recommendations for the implementation and enforcement of relevant policies (Task Five).

2.2 Analysis method: policy content analysis

The policy content analysis is instrumental in identifying the characteristics of policies and offering suggestions for the optimization of policy implementation. It summarizes basic policy characteristics, including the policy release period, issuing agency, fundamental principles, and related measures (Krippendorff, 2019). Therefore, this study adopts policy content analysis to determine the characteristics of policies pertaining to environmental protection, marine environment protection, climate change response, and biodiversity conservation. The analysis seeks to investigate the evolution of policies concerning marine and coastal ecosystems in climate change adaptation.

Firstly, content analysis is applied to policies issued between 1992 and 2023, with a specific focus on the adaptation of marine and coastal ecosystems to climate change. In terms of policy searching, these policies are obtained from the open-access of official websites, such as the Ministry of Ecology and Environment of the People's Republic of China, the Ministry of Natural Resources of the People's Republic of China, the Ministry of Foreign Affairs of the People's Republic of China, National Development and Reform Commission, and China Meteorological Administration. Secondly, the study divides the research intervals into four periods: 1992–1999, 2000–2007,

2008–2015, and 2016–2023. Each period spans seven years and the study illustrates the interactions among various policy areas concerning the adaptation of marine and coastal ecosystems to climate change in different periods. The year 1992 is chosen as the research starting point due to the formulation of the *UNFCCC*, which prompted China to make great efforts and contributions to the global response to climate change. Thirdly, policy content analysis is primarily applied in Section 4, summarizing the basic characteristics of the policies involved in different stages, mapped in terms of participants, perspectives, areas, base values, strategies, and outcomes.

3 Goals clarification of China's policies on marine and coastal ecosystems in climate change adaptation

The problem-oriented approach contributes to policy making, and goal clarification is key to identifying and addressing social issues by specifying policy goals and promoting policy evolution. As China's social economy rapidly developed, the progress of environmental governance evolved from the general framework into special regulations in the areas of climate, marine and biodiversity. Climate governance involves a wide range of key areas, and the growing perspectives to seek solutions has led to the clarification of policy goals at each stage. The core objectives in each stage vary, and the construction of integrated goals is crucial for promoting synergies among various policies.

In the initial stage of China's Economic Reform and Opening Up, economic development was a primary concern for the country. With a strong focus on economic construction, the policy goals emphasized economic development. However, the extensive model of economic growth inevitably causes adverse impact on ecosystem. In the 1990s, environmental issues became increasingly prominent in China, with many regions experiencing frequent natural disasters due to climate change. Recognizing the importance of environmental protection, China established the goal of striving to control the aggravating trend of environmental pollution and ecological damage basically in its environmental policy (*State Council of the People's Republic of China, 1996*). During this stage, policies mainly consisted of general provisions on environmental protection.

In the early 21st century, China faced intensifying environmental problems, with climate change gradually becoming the focus of environmental protection efforts. As the integrity of the ecosystem implies, climate governance needs to coordinate with other policy fields, such as agriculture, water resources, forests and ocean. However, general provisions on environmental protection had limited effectiveness in addressing specific environmental problems. In response to the environmental goal of constraining the trend of ecological environmental deterioration, China established special goals in the climate and marine policies (*State Council of the People's Republic of China, 2000*). To address climate change, China prioritized climate change mitigation and set energy conservation and emission reduction as the goal, aiming to significantly lower carbon intensity. Meanwhile, China set a

target of fully implementing the overall requirements of energy conservation and emission reduction (*State Oceanic Administration of the People's Republic of China, 2007a*). Climate change mitigation was desired to control the rising temperature rate. Considering the costs and benefits of climate governance, the cost of mitigation is much lower than adaptation, and the effect of mitigation would be obvious in the short term. Thus, China paid more attention to mitigation in the early stage of climate governance.

In 2008, China enacted the first policy on climate change response titled *Responding to Climate Change: China's Policies and Actions* (2008). Because China implemented a series of policies and measures to address climate change during the 11th Five-Year Plan (2006-2010)¹, climate change adaptation gradually became a priority. In 2011, China enacted the 12th Five-Year Plan for National Economic and Social Development, which established the policy orientation for green and low-carbon development over the next five years, and clarified the goals and tasks of climate change response. Subsequently, China began to take climate change adaptation seriously, aiming for the gradual resilience of marine and coastal ecosystem service functions. The policy on marine environment protection set a target of carrying out environmental comprehensive governance, pollution prevention, ecological protection and restoration (*State Oceanic Administration of the People's Republic of China, 2007b*). Similarly, the policy on biodiversity conservation required efforts to effectively curb the decline of biodiversity in key areas (*Ministry of Environmental Protection of the People's Republic of China, 2010*). The policy on climate change aimed to enhance adaptation capacity and shape the pattern of overall planning between climate change response and environmental protection (*Ministry of Ecology and Environment of the People's Republic of China et al., 2022*).

In 2016, China ratified the *Paris Agreement*. In response to global climate governance, the outline of the 14th Five-Year Plan for National Economic and Social Development and Vision 2035 was released by the National People's Congress of the People's Republic of China, setting new requirements for climate change adaptation in the new stage (*National People's Congress of the People's Republic of China, 2021*). The National Strategy of Climate Change Adaptation 2035 was issued in the period of the 14th Five-Year Plan (2021-2025), which emphasized the need to improve the policy system, regime, and mechanism for national adaptation to climate change. In order to realize the goal of Carbon Peaking and Carbon Neutrality, promote the Beautiful China Initiative, and create a climate-adaptive society, various policies are in focus. Policies on environmental protection, climate change response, marine environment protection, and biodiversity conservation work collaboratively to accomplish and promote laws, regulations, standards, and monitoring systems. The synergies among climate, marine and biodiversity governance are crucial for the adaptation of

¹ The full name of The Five-Year Plan is the Outline of the Five-Year Plan for National Economic and Social Development of the People's Republic of China, which is an important part of China's long-term national economic plan.

marine and coastal ecosystems to climate change. Additionally, the synergies among various policy types are prerequisite for achieving the maximum outcome.

4 Historical trends of China's policies on marine and coastal ecosystems in climate change adaptation

Following the clarification of China's policies' goals on marine and coastal ecosystems in climate change adaptation, this section undertakes a policy content analysis to illustrate the historical trends of policies. The policies concerning marine and coastal ecosystems in the context of climate change adaptation span multiple areas, covering environmental protection, climate change response, marine environment protection and biodiversity conservation. The interactions among these policy areas are crucial for enhancing the adaptation of marine and coastal ecosystems to climate change. The links between each policy type have experienced phases of isolation, interaction, convergence and synergies by the application of the policy content analysis method (participants, areas, perspectives, base values, strategies) as detailed in Section 2. To further investigate the connections among these relevant policies, their basic characteristics are presented in table format.

4.1 Isolation among policies on environmental protection and marine environment protection in 1992–1999

During the period of policy isolation, China's focus was primarily on environmental protection. And the relation between policies was reflected in the policies on environmental protection and action plans for marine environment protection. The basic characteristics of policies during the period of 1992–1999 are shown in [Table 1](#).

Since the 1990s, China has promulgated general provisions on environmental protection, marine action plans and guidelines. These were originally characterized by a lack of integration between them. The general provisions on environmental protection were issued by the State Council of the PRC. These

policies primarily concentrated on controlling the deterioration of the ecological environment, aiming to achieve comprehensive balance among diverse environmental elements but neglecting the specificity of each element and its interaction. For example, in August 1996, the State Council issued the Decision on Several Issues Concerning Environmental Protection. The decision further enforced the basic national policy of environmental protection and made broad arrangements on environmental protection work. However, it did not regulate climate warming response or adaptive measures of the marine ecosystem. Notably, China developed some action plans related to marine environmental protection, including the Action Plan for Protection on Coastal Wetlands, the Action Plan for Protection on Marine Biodiversity and Guidelines for the Planning and Monitoring of Marine Dumping Areas ([National Environmental Protection Agency of the People's Republic of China, 1996](#)). These action plans and guidelines emphasize the importance of promoting marine ecosystem conservation and resilience. The proposed measures included the management of natural reserves, the improvement of monitoring and environmental impact assessment systems, and the establishment of protection catalogs. These provisions later converged with climate change adaptation policies in subsequent stages, and can even be seen as the forerunners of adaptive measures in the field of marine and coastal ecosystems. However, during China's initial period of climate governance, relevant policies lacked systematic objectives and coordinated measures. Therefore, each field was characterized by a single-line arrangement, with no interaction between two separate environmental elements.

4.2 Interaction among general provisions on environmental protection, policies on marine environment protection and biodiversity conservation in 2000–2007

During the stage of policy interaction, China had not yet formulated special climate policies in direct response to climate change. The interaction was reflected in the policies on general provisions on environmental protection, marine environment protection and biodiversity conservation. During the period of 2000–2017, the basic characteristics of the interaction among various policies are presented in [Table 2](#).

TABLE 1 Isolation among environment and marine policies in 1992–1999.

Participants	Areas	Perspectives	Base Values	Strategies
State Council (State Council of the People's Republic of China, 1996)	General Provisions on Environmental Protection	Control of environmental deterioration	Serve for economic development	Comprehensive arrangements for environmental protection work
State Oceanic Administration (dissolved) ²	Marine Environment	Prevention of marine environment pollution	Restoration of marine ecosystem	Protection of coastal zones and wetlands

² State Oceanic Administration of the PRC, established in 1964, is the administrative institution of national marine planning, legislation and administration. In 2013, the administration was reorganized by the state council. However, the Ministry of Natural Resources of the PRC was established on March 13th, 2018, and the State Oceanic Administration was dissolved.

TABLE 2 Interaction among environment, marine and biodiversity policies in the period of 2000–2007.

Participants	Areas	Perspectives	Base Values	Strategies
State Council (State Council of the People's Republic of China, 2001) Ministry of Environmental Protection (dissolved) ³ (Ministry of Environmental Protection of the People's Republic of China, 2006) ³	General Provisions on Environmental Protection	Prevention of environmental pollution	Coordination of social economic development and environmental protection	Implementation of comprehensive governance on environmental protection
State Oceanic Administration (dissolved) (State Oceanic Administration of the People's Republic of China, 2007c)	Marine Environment	ⓄEmphasis on marine environment protection ⓄRestoration of service functions of marine ecosystem	Coordination of marine resources exploitation and marine environment protection	Implementation of comprehensive governance in key sea areas and control emission increments
State Council State Council of the People's Republic of China, 2007)	Biodiversity Conservation	Conservation and restoration of ecological systems	Priority given to ecological protection	Ecosystem-based management

Since 2000, special policies on marine environmental protection and policies concerning biodiversity conservation have emerged, and each type of policy responds to climate change. The policies in various areas started to interact with each other, which was reflected in the interactive goals and measures of marine and coastal ecosystems in climate change adaptation. China has realized the importance of adaptation, but its comprehensive capacity for economic development was too limited to conduct large-scale adaptive actions. To coordinate economic development and environment protection under climate change, mitigation was the main goal and measure of climate governance in this stage. Early adaptation served mitigation by providing observations and forecasts. General Provisions on Environmental Protection regulated some adaptive measures on marine and coastal ecosystems, such as marine environment protection, and offshore ecological restoration. The policies on marine environment protection were mainly designed for mitigate, and adaptive measures concerned some reactive actions of monitoring and forecasting, exerting an indirect role in tackling climate change. The policies on biodiversity conservation prioritized the conservation and restoration of ecosystem by establishing natural reserves and ecological conservation zones to provide institutional guarantees for the conservation of marine and coastal ecosystems. Thus, the interaction reflected each element of “marine”, “atmosphere” and “biology” may play a joint role in tackling climate change, rather than isolation from each other. However, as the interaction was still in the initial stage, various policies mainly played an indirect role in climate change. These policies highlighted climate change mitigation assisted with reactive adaptation, laying the foundation for the next stage of more proactive adaptation to climate change.

4.3 Convergence among general provisions on environmental protection, policies on climate change response, marine environment protection and biodiversity conservation in 2008–2015

The feature of climate change adaptation denoted a complex policy problem in the convergence among climate and marine policies (Wilson and Termeer, 2011). China formulated policies for addressing climate change, which included adaptive measures for marine and coastal zones. General provisions on environmental protection and the policies on marine environment protection also regulated adaptive measures for marine and coastal ecosystems in detail. Policies on biodiversity specifically contained the item of climate change response. During the period of 2008–2015, the basic characteristics of the convergence among various policies are presented in Table 3.

In 2008–2015, policies on environmental protection, marine environment protection and biodiversity conservation continued to play role in environmental governance. Meanwhile, the State Council of the PRC issued several policies on climate change response. The complexity of environmental governance allowed for participants in policymaking to strengthen their cooperation and information exchange, leading them to jointly formulate and promote relevant policies. Accordingly, the goals and measures of these policies demonstrated the convergent aspect of combined climate change mitigation and adaptation as a response to climate change. With respect to adaptive measures for marine and coastal zones, the general provisions on environmental protection detailed the content of carbon sequestration of marine life, biodiversity conservation and ecosystem restoration. Climate policies involved adaptive measures in marine fields, and marine environmental policies were specifically stipulated from the aspects of early warning, functional zone planning and protected areas to have a more proactive impact on climate governance. The biodiversity policies also revealed the interconnectivity of multiple fields, not only by formulating action plans for the adaptation of biodiversity to climate change, but by designating priority areas for marine biodiversity protection. The convergence of different areas of policies promoted the promulgation of the National Strategy of Climate Change Adaptation in 2013, which marked the beginning of coordinated national efforts on

³ National Environmental Protection Agency of the PRC, established in 1984, was responsible for the planning, coordination, supervision and guidance of environmental protection in China. On March 15th, 2008, the ministry was dissolved and regrouped into the Ministry of Environmental Protection of the PRC, which was subsequently organized as the Ministry of Ecology and Environment of the PRC.

TABLE 3 Convergence among environment, climate, marine and biodiversity policies in the period of 2008–2015.

Participants	Areas	Perspectives	Base Values	Strategies
State Council (State Council of the People's Republic of China, 2011)	General Provisions on Environmental Protection	Improving the quality of the ecological environment	Sustainable development	Integrated Reform Plan for Promoting Ecological Progress
State Council (State Council Information Office of the People's Republic of China, 2008) National Development and Reform Commission, Ministry of Water Resources, et al. (National Development and Reform Committee of the People's Republic of China, Ministry of Finance of the People's Republic of China et al., 2013)	Climate Change	①Controlling greenhouse gases emissions ②Strengthening the capacity in climate change adaptation	Low-carbon development	①Paying equal importance to mitigation and adaptation ② Conducting more proactive measures in climate change adaptation
State Oceanic Administration (dissolved) (State Oceanic Administration of the People's Republic of China, 2014) (State Oceanic Administration of the People's Republic of China, 2015)	Marine Environment	①Monitoring marine environment quality ②Planning marine major functional zones ③Managing marine protected areas	Respect for the nature and intensive development	The mechanism of marine protection and restoration under overall planning for land and marine development
Ministry of Environmental Protection (dissolved) (Ministry of Environmental Protection of the People's Republic of China, 2010)	Biodiversity Conservation	Sustainable use of biological resources	Natural resilience	Identifying priority areas for conserving biodiversity in marine and coastal zones

climate change adaptation. The Strategy takes into adaptation costs, the economic or social conditions in different regions, technology and environmental capacity, and prioritizes measures that coordinate mitigation and adaptation. The Strategy is also designed to address adaptation work from seven fields: infrastructure, agriculture, water resources, coastal zones and related sea areas, forest and other ecosystems, human health and tourism (National Development and Reform Commission of the PRC, 2013).

The convergence of policies has bolstered both the tangible and intangible infrastructure for adapting to climate change, thereby enhancing the resilience of marine and coastal ecosystems to the impacts of climate change. It is worth highlighting that the most recent amendment of the *Environmental Protection Law of the People's Republic of China* in 2014 has given legal credibility to the ecological red line system in vital ecological function zones, ecologically sensitive areas, and fragile regions (National People's Congress of the People's Republic of China, 2014). The merging of climate, marine, and biodiversity policies from 2008 to 2015 indicates a close interrelationship among them. The dynamic changes in atmospheric, marine, and biological ecosystems contribute to the overall coherence and comprehensiveness of governance strategies. This policy convergence has also transitioned adaptive measures for marine and coastal ecosystems from being reactive to proactive, making a direct contribution to addressing climate change rather than merely aiding in mitigation efforts.

4.4 Synergies among general provisions on environment protection, policies on climate change response, marine environment protection and biodiversity conservation in 2016–2023

The synergies among climate, marine and biodiversity policies, characterized by original visions, concepts and principles, are

putting stresses on problem orientation and promoting the application of new approaches. The adaptive measures of marine and coastal ecosystems are more comprehensive in responding to climate change. During the period of 2016–2023, the basic characteristic of synergies among various policies is presented in Table 4.

Since 2016, the policies on climate change response, marine environment protection and biodiversity conservation have demonstrated a “systematic concept” and “overall coordination to a synergistic effect” as their key characteristics. Guided by Xi Jinping's thoughts on ecological civilization, the general provisions on environment protection embed systematic concepts in constructing the supporting system for ecological protection and restoration. The climate policies regarded “marine and coastal zones” as important areas in the adaptation of natural ecosystems to climate change, and advance the adaptation work in marine and coastal zones systematically. Marine environmental policies have added a section of responding to climate change in particular (Ministry of Ecology and Environment of the People's Republic of China et al., 2022). The role of marine and coastal ecosystems encompass both adaptation and mitigation goals, prompting the addition of climate change response sections to marine environment policies, thereby strengthening the climate resilience of these ecosystems (Ministry of Ecology and Environment of the People's Republic of China et al., 2022). Furthermore, biodiversity policies emphasized the use of Nature-based Solutions (NBS) to enhance the ability of marine life to adapt to climate change, making NBS a coordinated approach to addressing both climate change and biodiversity loss (State Council Information Office of the People's Republic of China, 2021b).

The synergies among environment, marine, climate and biodiversity policies facilitate the formulation of the National Strategy of Climate Change Adaptation 2035. The Strategy develops the principles of scientific adaptation, systematic adaptation,

TABLE 4 Synergism among environment, climate, marine and biodiversity policies in the period 2016–2023.

Participants	Areas	Perspectives	Base Values	Strategies
Central Committee of the Communist Party of China, State Council (Central Committee of the Communist Party of China and the State Council of the People's Republic of China, 2018) Ministry of Ecology and Environment (Ministry of Ecology and Environment of the People's Republic of China, 2021)	General Provisions on Environmental Protection	①Protection of the ecological environment ②The Uphill Battle for Prevention and Control of Pollution	①Innovative, coordinated, green, open, and shared development ② The community with the shared future for humankind	Goal-based solution and construction of ecological civilization
State Council (State Council of the People's Republic of China, 2021) Ministry of Ecology and Environment, National Development and Reform Commission, et al. (Ministry of Ecology and Environment of the People's Republic of China et al., 2022)	Climate Change	①The adaptation of natural ecosystems to climate change ②The adaptation of economic and social systems to climate change	①Climate resilience ②Comprehensive capacity in climate change adaptation	Nature-based solution in climate change adaptation
Ministry of Ecology and Environment, Ministry of Natural Resources, et al. (Ministry of Ecology and Environment of the People's Republic of China et al., 2022)	Marine Environment	①The quality and stability of marine ecosystems ②Response to marine environmental emergencies and ecological disasters ③Response to climate change	Center on the improvement of marine environmental quality	Synergistic strategy on pollution prevention and carbon reduction
Central Committee of the Communist Party of China, State Council (General Office of the Central Committee of the Communist Party of China et al., 2021)	Biodiversity Conservation	①Optimization of in-situ conservation and improvement of ex-situ conservation ②Improvement of biosecurity governance ③Ecosystems stabilization	The harmonious co-existence of human and nature	Integrated protection and restoration of ecosystems

coordinated adaptation and co-governance. To encourage coordinated efforts of multiple participants for climate change response, the Strategy also applies Nature-Based Solutions (NBS) in climate change adaptation. The Strategy integrates adaptation efforts with ecological civilization construction, Beautiful China Initiative and high-quality economic development. The National Strategy of Climate Change Adaptation 2035 also updates seven major sectors involving infrastructure, agriculture, water resources, coastal zone and related sea areas, forests and other ecosystems, human health, tourism and other industries into two major systems: the natural ecosystem and socioeconomic system. The adaptation of marine and coastal zones is an important element in the natural ecosystem. Adhering to the principle of holistic protection and restoration, the adaptive measures of marine and coastal ecosystems contribute to the sub-goals of enhancing the quality, stability and resilience of the marine ecosystem, promoting sustainable development of fishery resources, strengthening the management of marine biodiversity and invasive species management ([National Development and Reform Commission of the PRC, 2022](#)).

The synergies among marine, climate, and biodiversity policies have facilitated further advancements in relevant legislation. During the period of 2016–2023, the *Constitution of the People's Republic of China* was amended in 2018, incorporating ecological advancement in the preamble to promote coordinated material, political, spiritual, social and ecological advancement ([National People's Congress of the People's Republic of China, 2018](#)). With the promotion of ecological advancement, the *Marine Environment Protection Law of the People's Republic of China* also needs to be revised. Thus, the draft version of the Marine Environment Protection Law was discussed and sought for public opinions

from December 30, 2022, to January 28, 2023. It was reconsidered by the Standing Committee of the National People's Congress on June 26, 2023, intending to strengthen its planning role in marine environment protection by implementing the system of object responsibility and evaluation ([National People's Congress of the People's Republic of China, 2023](#)). However, at present, there is still a lack of specific legislation to promote synergies among policies in the field of climate change. Therefore, further efforts are needed to advance the implementation of climate change-related policies for China's marine and coastal ecosystems.

In sum, the synergistic relationship among climate, marine and biodiversity policies is reflected in the close cooperation among policy makers, complementary goals across different governance areas, and coordinated strategies in various fields. Among these policy makers, some administrative agencies have undergone organizational restructuring and integration to facilitate the efficient performance of their governmental functions. Since the adaptation of marine and coastal ecosystems to climate change involves multiple aspects, such as development, finance, and resource utilization, the close cooperation and collaboration among policy makers have promoted climate change adaptation and ecological environmental protection efforts. In terms of policy goals, various policies aim to foster an integrated framework for addressing climate change and ecological environmental protection. Concerning governance strategies, both climate change and biodiversity policies adopt NBS, which serve as a link connecting different policies and promotes the effectiveness of climate, marine and biodiversity governance. It is important to note that the synergistic enhancement of policies is the intended ideal state during policy formulation, and the actual implementation may have certain disparities.

5 The factors shaping the historical trend of China's policies on marine and coastal ecosystems in climate change adaptation

The factor analysis of the development of policies is the third task of the policy-oriented jurisprudence. Political and environmental changes motivate policy makers to identify goals and adjust strategies (Reisman, 2016). And national policies also rely on the interdependence between macro-political and macro-economic development at the regional and global system (Chimni, 2017). Similarly, the development of policies on marine and coastal ecosystems in climate change adaptation is the result of mutual impacts from natural and social factors. Therefore, this section analyzes natural factors, encompassing the features of global climate change at different stages and its effects on domestic climate and environmental situations primarily. Then, it demonstrates social factors as the development of global climate governance, China's performance to international society and socioeconomic development of China.

5.1 Factors shaping isolation among policies on environmental protection and marine environment protection in 1992–1999

Since the 1990s, the impact of global climate change on marine has been manifested by sea-level rise. This rise, which has been exacerbated by global warming, has had widespread effects, modifying ocean circulation and marine ecosystems, with considerable socioeconomic consequences (IPCC, 1992). The phenomenon has highlighted the close links between terrestrial and marine ecosystems and climate change, triggering a chain effect (IPCC, 2001). Northern China has been significantly affected by global climate change, with winter temperatures averaging 0.3–1°C higher than in the previous 30 years (National Environmental Protection Agency of the People's Republic of China, 1991). Climate warming has played a disastrous impact on China's marine and coastal ecosystems, leading to serious coastal erosion, expanded typhoons and tropical storms (National Environmental Protection Agency of the People's Republic of China, 1995).

To ease the threat of climate warming to the ecosystem, international society put global climate governance on the agenda ahead of China's actions. Global climate governance was in the preliminary stage, and relevant international conventions laid the foundation for the interaction among climate change adaptation, marine environment protection and biodiversity conservation. In the institutional arrangements at global governance, climate change would be primarily associated with marine and biodiversity governance. Realizing the role of sinks and reservoirs in marine ecosystems under climate change, UNFCCC is committed to promoting sustainable management of marine sinks and reservoirs (United Nations, 1992b). Global biodiversity governance emphasized the importance of marine ecosystem

stability in biodiversity conservation (United Nations, 1992a). Although the marine environment governance of the International Maritime Organization (IMO) did not involve the issue of climate change, the system of Particularly Sensitive Sea Area provided a new way to protect and restore marine ecosystems (IMO, 1997). In response to climate change, China fully attended the Conference of Parties (COP) to UNFCCC/CBD, and ratified the UNFCCC and CBD in 1992. At this stage, China was an active follower of global climate governance by implementing and enforcing global climate policies.

Driven by global climate change, China entered in the exploratory stage of national climate governance. However, the urgency on economic development enabled China to insist on economic construction as the central task, and place national economic and social development in the first place, with the consideration of environment and ecological protection (National People's Congress of the People's Republic of China, 1996). It is verified by the argument between economic development and environmental protection in the Ninth Five-Year Plan. Thus, for the purpose of promoting sustainable, stable and coordinated economic development, China formulated general provisions on environmental policies regarding the problems of environmental pollution and deterioration in the period of 1992–1999. These kinds of policies did not touch climate warming or treat it as a specific issue, even more, these policies did not regulate marine and biodiversity governance related to climate change.

5.2 Factors shaping interaction among general provisions on environmental protection, policies on marine environment protection and biodiversity conservation in 2000–2007

With the intensification of global climate change on marine environment, ocean acidification has become increasingly serious since the 21st century onwards. It has been predicted that the reduction in the average global surface ocean pH would be harmful to marine shell-forming organisms and their dependent species. The negative impacts on ecosystem have been reflected by consistency of changes in physical and biological systems with warming (IPCC, 2007). Meanwhile, the frequency of meteorologic disasters such as typhoons, floods, and high temperatures in most parts of China has caused losses to social productive forces and social life. China is in the process of industrialization and modernization. So, it is significant for China to give equal consideration to preserving development rights and solving ecological problems. Responding to climate change is a great challenge and opportunity for China's social development (National Development and Reform Commission of the People's Republic of China, 2007).

Climate change adaptation can enhance the capacity of natural, biological and human system. Therefore, the international community was ahead of China in listing climate change adaptation as one of the most critical issues, contributing to the interaction between marine governance and biodiversity governance in climate change adaptation. Associated with disasters arose by sea-level rise, the international

community paid more attention to adaptation. Considering the adverse effects of sea-level rise on islands and coastal areas, the topic of adaptation appeared firstly in COP to UNFCCC to satisfy the specific needs of small island states and states with low-lying coastal areas (UNFCCC, 2000). Because the survival of marine life is deeply threatened by ocean acidification, global biodiversity governance made the adaptation of coral reefs as the starting point (UNEP/CBD, 2000). This led to adaptation work for ecosystem restoration from perspectives of strengthening island biological diversity, identifying species adaptive to climate change, and establishing feasible national systems of protected areas (UNEP/CBD, 2006). To comply with the trend of interaction among global climate, marine and biodiversity governance, China has been actively engaged in activities under the framework of UNFCCC and *Kyoto Protocol*, conscientiously fulfilling its international obligations related to climate change. In 2004, China submitted its Initial National Communications on Climate Change to the secretariat of UNFCCC. Moreover, China presented 12 topic reports to the secretariat of CBD, covering areas such as the funds for biodiversity protection, biofuels, carbon sinks and climate regulation (National Environmental Protection Agency of the People's Republic of China, 2007). Therefore, from 2000 to 2007, China deepened its participation in the issue of global biodiversity and climate change.

Affected by internal factors such as population size, energy construction and economic development, and the changes of policy goals at each stage, China shifted its direction from the focus on mitigation to a combination of adaptation and mitigation in climate governance. Due to its large population size, coal-based consumption, and rapid development, China's overall CO₂ emissions remain high. Initially, the primary goal was mitigation, as reflected in the section of ecological construction and environment protection of the 10th Five-Year Plan (2001–2005), which emphasized the implementation of policies and measures to mitigate climate change (National People's Congress of the People's Republic of China, 2001). However, the achievement of sustainable development required better environmental governance after 2006, particularly in the areas of climate and marine protection. The 11th Five-Year Plan (2006–2010) considered accelerating the development of a resource-conserving and environment-friendly society as an important task in national economic and social development (National People's Congress of the People's Republic of China, 2006). As a result, the Chinese government began exploring adaptive measures to climate change, and its marine and biodiversity policies now emphasize unified planning with due consideration for all concerned.

5.3 Factors shaping convergence among general provisions, policies on climate change response, marine environment protection and biodiversity conservation in 2008–2015

Under the circumstances of the intensification of climate warming, global marine species has been redistributing, with the reduction of marine biodiversity in sensitive regions. Meanwhile,

fisheries productivity continued to decrease. More efforts towards climate change mitigation and adaptation bring increasing complexity of interactions, especially the linkages among human health, water, energy, land use and biodiversity (IPCC, 2014). And global climate change has threatened China's agriculture, forestry, water resources, coastal zones and ecologically fragile areas. Climate change adaptation has become a priority for China at this stage (State Council Information Office of the People's Republic of China, 2008).

To strengthen global action and cooperation for climate change, the international community has made efforts to push the evolution of climate change adaptation from planning and assessment to actions and implementation, particularly at the national level. The COP to UNFCCC adopted Decision 5/CP.17-National adaptation plans, which encouraged parties to consider adaptation plans in an overall blueprint of sustainable development (UNFCCC, 2011). Global biodiversity governance integrated coral reefs and their associated ecosystem functions and services into climate change adaptation, and also called for implementation at the national level. The COP to CBD encouraged the incorporation of ecosystem-based approaches for management and adaptation into development planning and legislative frameworks at each level (UNEP/CBD, 2014). So that, China held a highly responsible attitude in responding to climate change adaptation. China has constructively participated in the international negotiations, and implemented institutional arrangements of adaptation, funds, technology transfer and capacity-building. China was the first to release a national action plan for climate change adaptation (Richardson, 2009). In 2013, China enacted National Strategy of Climate Change Adaptation. The following year, China printed the 2014–2015 China Action Plan for the United Nations Decade on Biodiversity, and promoted formulating an action plan of biodiversity conservation for addressing climate change (Ministry of Environmental Protection of the People's Republic of China, 2016).

Impacted by recent socioeconomic advancements and a focus on policy orientation of climate change response at global level, China's climate governance has developed from exploring adaptation to deepening adaptation in the period of 2008–2015. During this period, China underwent the late stages of both the “11th Five-Year Plan” and “12th Five-Year Plan”. The characteristics of China's socioeconomic development during this time were marked by unbalanced, uncoordinated and unsustainable development. The accelerating of urbanization and industrialization made natural ecosystem under great pressure. Aiming at tackling a tightened constraint between economic growth and environment, “the 12th Five-Year Plan” determined the policy orientation of green and low-carbon development with increasing adaptability to climate change (National People's Congress of the People's Republic of China, 2011). As a result, China enacted the National Strategy of Climate Change Adaptation, which deconstructed policy goals for climate change adaptation and made separate objective plannings for marine environment protection and biodiversity conservation. These initiatives motivated adaptive measures for marine and coastal ecosystems, shifting from reactive to proactive actions.

5.4 Factors shaping synergies among general provisions on environmental protection, policies on climate change response, marine environment protection and biodiversity conservation in 2016–2023

Global climate change will affect the realization of human well-being. At present, the global extinction of species caused by climate change is accelerating, and human survival and development are at risk from biodiversity loss and ecosystem deterioration. Ocean warming has deeply weakened service functions of marine and coastal ecosystem. The long-term loss and degradation of marine ecosystems have undermined the critical role of the ocean in cultural, recreational, and intrinsic values that are essential for human well-being and identity (IPCC, 2019). As a result of ocean acidification, wild-caught and farmed bivalves such as oysters and mussels will absorb increased toxicity of metal pollution in more acidic oceans, which can be harmful to human health (Directorate-General for Environment of the European Commission, 2023). Similar problems also exist in China, where the trend of marine ecological degeneration has not been fundamentally curbed, crucial marine species and habitats are in danger, and the frequency of marine ecological disasters is compromising socioeconomic development and the stability of people's production and living. Therefore, China's adaptation task in marine and coastal ecosystems remains difficult and complex (Ministry of Ecology and Environment of the People's Republic of China et al., 2022).

Since the *Paris Agreement* came into force in 2016, there has been a growing emphasis on the synergies between global climate, marine, and biodiversity governance. The COP to the UNFCCC has played a key role in promoting the understanding and actions related to ocean and climate change under the framework of the UNFCCC (UNFCCC, 2019). The Glasgow Climate Pact 2021 incorporated strengthened ocean-based action into the UNFCCC multilateral process (UNFCCC, 2021). Moreover, the preamble of the Sharm el-Sheikh Implementation Plan underlines the urgent need to address the interlinked global crises of climate change and biodiversity loss in a comprehensive and synergetic manner (UNFCCC, 2022). Global biodiversity governance has also highlighted the synergies among climate change response, environmental protection and biodiversity conservation. The Kunming-Montreal Global Biodiversity Framework set up global targets for 2030, with target eight clarifying the need to “minimize the impact of climate change and ocean acidification on biodiversity” and to “foster positive impacts of climate action on biodiversity”, while making the increase of ecosystem resilience as the ultimate goal of mitigation, adaptation and other actions (UNEP/CBD, 2022). To protect and sustainably utilize oceans, seas and marine resources, a new platform for the discussion of the adaptation of marine and coastal ecosystems to climate change has been created. The 2022 UN Ocean Conference has listed “Managing, protecting, conserving and restoring marine and coastal ecosystems” and “minimizing and addressing ocean acidification, deoxygenation and ocean warming” as two important interactive dialogues (United Nations, 2022).

To comply with the synergetic global governance, China continues to devote efforts to global climate change by upholding its original governance concept. Because climate change is a common challenge for all humankind related to a shared future, China has initiated the concepts of community of shared future for humankind and maritime community with a shared future. Guided by the original concept of global governance, China has been attaching importance to international cooperation on climate change. In this regard, China has promoted the formulation and implementation of the *Paris Agreement* and the negotiations of the Global Goal on Adaptation. As the party of CBD and its protocol, China strove to advance the adoption of the Kunming-Montreal Global Biodiversity Framework in 2022. In the same year, China submitted Materials for the Concept Paper on eight interactive dialogue topics to the UN Ocean Conference, and the Materials contained measures and suggestions on marine and coastal ecosystems in climate change adaptation (China, 2022).

The basic capacity of adapting to climate change is greatly improved as the improvement of legal system and regulation mechanism of environmental protection. Accordingly, China has prioritized “proactive adaptation” as a major task in its National Strategy for Climate Change Adaptation, emphasizing the synergies among climate, marine, and biodiversity policies. This is because climate change adaptation is impacted by the interaction among laws, sustainable development, political, economic and social factors, and involves multiple governance regarding water resources, coastal zones, ecosystem and biodiversity (Afinowi, 2020). Under the guidance of Xi Jinping's thoughts on ecological civilization, China issued National Strategy of Climate Change Adaptation 2035 in 2022. Compared with previous Strategy issued in 2013, the Strategy emphasizes problem-oriented and goal-based approaches, as well as synergistic effects, and makes all-round arrangements on marine and coastal ecosystem in climate change adaptation.

6 The clarification of future goals and action recommendations

Based on the analysis of goals, trends and factors under the policy-oriented jurisprudence, this section makes some predictions on future policy goals, and proposes action recommendations accordingly. The year from 2022 to 2035 will be a crucial period for China to basically accomplish socialist modernization and build beautiful China (National Development and Reform Committee of the People's Republic of China et al., 2022). In 2022, the Ministry of Ecology and Environment of the PRC and 17 other official departments jointly issued the National Strategy to Climate Change Adaptation 2035, which provides prospective arrangements for future China's climate governance. According to goals of China's climate policies, the section deconstructs short-term, mid-term, and long-term goals of climate change adaptation in marine and coastal zones. To achieve the future goals, the following study also draws the policy experiences in Canada, Australia, the United States, and other states to adapt marine and coastal ecosystems to climate change, and proposes actionable recommendations for the implementation of China's policies.

6.1 The clarification of future goals

The primary objectives of the National Strategy for Climate Change Adaptation 2035 are focused on improving the policy system, regime and mechanism for national adaptation to climate change. The Strategy aims to achieve significant enhancement of China's social capacity to climate change, and eventually build up the climate adaptive society. Building a policy system, regime, and mechanism for national adaptation to climate change is a massive and complex undertaking that includes not only the natural ecosystem, such as territories, marine and coastal zones, but also the socioeconomic system, including agriculture, food, health, and infrastructure. Marine and coastal zones are a key area of the natural ecosystem that affect the adaptation of agriculture and fisheries to climate change. Thus, improving the management system for climate adaptation in marine and coastal zones is a crucial step towards building a climate-adaptive society.

At present, China's relevant policies prioritize synergism among atmospheric, marine and biological ecosystems. The policy system, regime and mechanism on the adaptation of marine and coastal ecosystems to climate change are associated with marine environment protection, fisheries management and biodiversity conservation. Based on the strategic goal of national adaptation to climate change, its periodical goals for marine and coastal ecosystems can be divided into short-term goal till 2025, mid-term goal till 2030, and long-term goal till 2035. The improvement of policy systems, regime and mechanisms on the adaptation of marine and coastal ecosystems to climate change will be conducted from two aspects: capacity building and adaptation actions. The capacity building mainly contains the monitoring, early warning and evaluation system on marine disasters and disaster prevention and emergency response capacity in coastal zones and coastal ecosystems. Adaptation actions are represented by marine ecological conservation and restoration projects for blue carbon ecosystems, including mangroves, salt marshes and seagrass beds.

The period between 2023 and 2025 represents an initial period for the adaptation of marine and coastal ecosystems to climate change. The strategic goal during this period is to form policy systems, regime and mechanisms for the adaptation of marine and coastal ecosystems to climate change generally. In terms of strengthening capacity building, China continues to enhance monitoring and early warning of major climate disasters in coastal waters and coastal zones, effectively advance the level of risk comprehensive assessment in sea-level change, and make great progress in disaster prevention and emergency response in coastlines and coastal areas. In terms of conducting adaptation action in the marine field, China still needs to advance marine natural reserves and the construction of blue bay, enhance the carbon sink capacity of marine ecosystems, and promote marine biodiversity and invasive species management. The length of coastline restoration will reach around 400 km by the year 2025, and the protection and restoration of coastal ecosystems and marine environment quality will gain success initially.

The period between 2025 and 2030 indicates a interim period for fulfilling the in-depth adaptation effects of marine and coastal ecosystems to climate change. The strategic goal in the period is to

improve policy systems, regime and mechanisms on the adaptation of marine and coastal ecosystems to climate change generally. The establishment of a marine ecological monitoring system is planned, regarding early warning, impact assessment, and risk management. Additionally, a more resilient comprehensive system for prevention and protection in coastal zones is being formed. As part of this effort, adaptation actions will significantly reduce the vulnerability of marine and coastal ecosystems, leading to productive progress in constructing a system for adapting to climate change at the stage.

The period between 2030 and 2035 denotes an influential period for the realization of adaptation purpose for marine and coastal ecosystems to climate change. The strategic goal in this period is to build up a climate-friendly marine ecosystem by improving the quality, stability and climate resilience of the marine ecosystem. In terms of capacity building, China intends to conduct operational investigations, monitoring, evaluation, and early warning of marine ecosystems. It will also implement risk-removing and consolidation measures for major coastal projects, and update design standards for coastal dikes and other projects to address climate disasters. Regarding adaptation actions, China designs to restore approximately 1,200 km of coastline by 2035 and achieve a fundamental improvement in the quality of the marine ecological environment. By 2035, China plans to establish a Multi-sphere Integrated system for climate change adaptation in marine and coastal ecosystems.

6.2 Action recommendations

The policies on the adaptation of marine and coastal ecosystems are currently going through a process of planning, assessment, and implementation. China's policies on climate change response, marine environment protection and biodiversity conservation have entered into a synergistic stage, but their implementation still has a long way to go before achieving maximum synergistic effect. So, China has made some progress in planning the framework of national adaptation to climate change, while there is still certain room to promote the implementation of adaptation policies in marine and coastal ecosystem. To achieve the goals set in National Strategy to Climate Change Adaptation 2035, this part draws experiences from other states, and proposes some action recommendations on implementation, supervision, guarantee and effectiveness evaluation of policies.

Firstly, ecosystem-based management and diversified management tools play an important role in the implementation of policies. Ecosystem-based management is a vital equipment for climate change adaptation. It is an effective resources management method that increases adaptability and resilience to associate marine environment protection, biodiversity conservation, fisheries management and climate change adaptation (Ogier et al., 2016). Australia has already applied the method in fisheries management, which helps the adaptation of fisheries to climate change by strengthening natural ecosystems and the goods and services (Koehn et al., 2011). The development of fisheries management in Canada also moves towards transparency and ecosystem-based management principles (Bryndum-Buchholz

et al, 2021). On the basis of ecosystem-based management, coordinating the application of diversified management tools such as marine protected areas, integrated coastal zone management and environment impact assessment can also enhance the quality and efficiency of marine and coastal ecosystem management. For example, the factors such as climate change, fishery resources and coastal zone management can be considered in the construction of marine protected areas [Green et al., 2014](#).

Secondly, the motivation, supervision and support system of policies are other effective tools to guarantee policy implementation. Due to the dynamic and complex linkage between the marine environment and climate change, the needs for adaptation in human systems reliant on the services produced by natural ecosystems are also complicated. Policy motivation, supervision and support system involve multiple stakeholders, and no single actor can respond to the needs of adaptation independently and effectively. In fact, the coordination of various actors is motivated, supervisory and supporting roles is beneficial to ensure efficiency, fairness, avoid waste, and minimize conflicts in the process of adaptation ([Pecl et al, 2019](#)). Co-management processes and participatory governance play an increasing role in crucial marine sectors for the motivation, supervision and support system of policies. Co-management approach concerns the sharing of responsibility and authority, and the actors in the approach may cover governments, local communities, non-governmental organizations and research institutions ([Reef Resilience Network, 2023](#)). At present, the co-management approach is applied in fisheries and climate change. The fisheries in the United States are moving towards a co-management model through the tool of community development quotas. The co-management model encourages community and other stakeholders' engagement in fisheries management to promote the sustainable fisheries development in coastal areas ([May, 2008](#)). In response to climate change, projects on blue carbon are a testing ground for new thoughts, solutions, and financing mechanisms, especially the co-management approach in practice. India's Sundarbans Mangrove Restoration Project and the Blue Forests Initiative in Madagascar both take the interests of the local community into full consideration and motivate the potential of local management in the community ([Wylie et al, 2016](#)). In the past, China mainly adopted a top-down centralized approach in management. However, good management can play a synergistic effect by coordinating centralized or collaborative governance and various stakeholders ([Tuda and Machumu, 2019](#)). In the future, except for enhancing cross-department cooperation of marine administrative bodies, China can also promote the cooperation among governments, local communities, enterprises and other actors to establish a complete network for the motivation, supervision and support system.

Finally, the evaluation of policy outcomes is a main way to determine the effectiveness of policies. To improve outcomes and make better decisions on the adaptation of marine and coastal ecosystems to climate change, it is necessary to optimize data monitoring, evaluation methods, and evaluation content. The United States has rich experiences in the evaluation of policy outcomes. In 2021, the United States developed a framework to

quantitatively assess the impact of marine protected areas on marine biodiversity. The current marine biodiversity evaluation in the United States improves the previous one that only considered the areas covered by marine protected areas. It also highlights the gaps between geography and taxonomy in biodiversity conservation that were previously overlooked. The evaluation framework can be used in any other area, lay the foundation for more strategic evaluation on marine biodiversity, and greatly advance the decision-making of marine resources spatial management by filling the identified gaps with standardized monitoring and modeling ([The United States, 2022](#)). China can benefit from learning the assessment experiences of the United States. First, it could establish an adequate database. Second, it may construct an assessment framework with unambiguous, reliable, and measurable standards. Third, it might adopt a thorough evaluation approach to assess the impact of measures and planning actions within protected areas on the restoration of marine and coastal ecosystems, as well as the positive or adverse impacts they produce. Thus, practical problems of policies on marine and coastal ecosystems in climate change adaptation will be handled properly.

7 Conclusion

Since the 1990s, the international community has focused on global climate change. Driven by its active participation in international climate negotiations, China has embarked on a journey of climate governance. Relevant policies have gone through the process of the isolated, interactive, convergent and synergistic stages. By analyzing the evolution of China's policies on marine and coastal ecosystems in climate change adaptation, the study proposes some action recommendations on implementation, supervision, evaluation of policies based on further decisions. In this regard, the authors' study concludes that (1) between 1992 and 1999, the relevance between climate and marine governance presented isolated trends. China did not carry out special regulations on the field of climate or marine, and "climate" and "marine" were regarded as single environmental elements without fully interacting with each other. (2) In the period of 2000–2007, relevant policies in China began to interact to deal with climate change by improving the adaptation of the marine and coastal ecosystems; however, the adaptation policy at this stage mainly assisted in mitigation. (3) In the period of 2008–2015, the vicious circle of global warming and oceans intensified, highlighting the urgency of adapting marine and coastal ecosystems to climate change. At that moment, climate, marine and biodiversity policies in China switched from interaction to convergence, and gives full play to the proactive role of marine and coastal ecosystem adaptation to climate change. (4) After 2016, China entered into a new stage on national climate governance. The concepts of "common interests" and "ecological civilization" stimulated China's attention to the concept of climate governance. China put forward new concepts and principles of climate governance and relevant policies regulating adaptive measures in marine-related fisheries, biodiversity and other fields to promote synergies. (5) National Strategy of Climate Change Adaptation 2035 provides prospective arrangements for China's future climate

governance, and clarifies short-term, mid-term and long-term goals of climate change adaptation. To realize further policy goals, China will make more efforts to promote implementation of policies by developing the motivation, supervision and support system of policies, and optimizing the evaluation system of policies. The development of China's coastal and marine ecosystem adaptive policies under climate change reflects China's understanding of the global climate governance and China's determinations and efforts in response to climate governance. And relevant policies are expected to provide some reference for climate governance in developing states.

Author contributions

JB initially conceived and designed the study, but the research was finished jointly by all authors. Original draft and multiple revisions were developed by JB. Methodology and data analysis were carried out by XL. All authors contributed to drafting of the manuscript. All authors approved the submitted version.

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Conflict of interest

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