Blue Finance for Coastal Climate Risk Management: Mechanisms, Models, and Implementation Pathways

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Abstract. As the ocean-focused segment of green finance, blue finance draws on ecosystem service valuation, risk diversification, and sustainable development theory. Through blue bonds, climate insurance and other market tools, it internalizes climate risk costs and improves coastal ecological and socioeconomic resilience. This paper constructs four localized blue finance development paths and tiered policy suggestions, and puts forward a three-phase implementation route. The research proves unified standards and multi-layer risk sharing are core supports for blue finance sustainable operation.

Keywords: Blue finance; green economics; coastal climate risk; climate resilience; sustainable ocean development; blended finance.

1 Introduction

Coastal climate risks create huge funding gaps for marine ecological restoration and industrial green transformation, which highlights the necessity of blue finance.

Blue finance is a specialized field within green and sustainable finance that focuses on marine ecosystem restoration, coastal climate resilience, and the development of low-carbon ocean industries (Wang et al., 2024; World Bank, 2025). Standardized financial products can channel private capital toward ocean projects that combine disaster-risk reduction with carbon-sequestration benefits, thereby creating a virtuous cycle of climate-risk governance, marine ecosystem value enhancement, and sustainable returns on capital. Integrating blue finance into coastal climate risk governance cuts extreme disaster losses and incubates emerging blue industrial sectors. In this way, ecological security, livelihood protection, and high-quality coastal economic development can be pursued jointly.

Existing research on blue finance has developed along three main strands. The first concerns innovation in blue-finance instruments. Seychelles issued the world's first sovereign blue bond in 2018 to promote marketized blue finance, and ICMA released unified industrial standards for blue project screening and information disclosure (World Bank, 2018; ICMA et al., 2023). Related innovative financial tools have gradually formed a complete supporting system (UNEP, 2024). Grants and concessional loans from the Global Environment Facility reduce financing barriers in developing

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countries, and parametric climate insurance can provide rapid post-disaster payouts to support the restoration of natural protective systems such as mangroves and coral reefs(EUSPA, 2024).A broad scholarly consensus holds that ocean projects involve high upfront costs, long investment horizons, and substantial ecological externalities; conventional lending is therefore poorly suited to their characteristics, making dedicated blue-finance instruments essential for appropriate risk pricing. The second strand addresses coastal climate resilience. Resilience theory examines how coastal social-ecological systems withstand disasters, recover autonomously, and strengthen their adaptive capacity over time· (Espinoza Córdova et al., 2024). Empirical evidence shows that ecosystem-based protective measures, such as mangroves and seagrass beds, can outperform hard seawalls when their combined benefits for risk reduction, carbon sequestration, and fisheries are considered (Zhang et al., 2025). Transformative adaptation theory for densely populated coastal cities further advocates integrating urban spatial planning, ecological corridors, and early-warning systems into hybrid networks that combine natural and engineered defenses(Cotton et al., 2024). The third strand focuses on international practice. Small island states have adopted debt-for-climate swaps that redirect debt-relief resources toward coastal ecosystem protection (Essers et al., 2021). International organizations use blended-finance structures and multilateral guarantees to mobilize private investment in coastal-resilience projects (International Finance Corporation, 2022). Communities in Europe and North America have also issued performance-linked environmental bonds that tie financial returns to measurable disaster-risk-reduction outcomes（March et al., 2023).

Nevertheless, extant blue finance literature is fragmented in analytical frameworks, lacks cross-border regional adaptability, and fails to deliver actionable policy solutions.

Against the above gaps, this paper answers three core questions:

(1) How does blue finance alleviate two types of coastal climate risks?

(2) What are the differences between global mainstream blue finance models?

(3) How to construct a localized blue finance system for China?

2 Theoretical Foundations for Blue Finance in Coastal Climate-Risk Management

2.1 Principal Theoretical Foundations

Ecosystem Service Valuation Theory. Conventional financial systems struggle to quantify the economic value of marine ecological assets such as mangroves, blue carbon, and nearshore fisheries, thereby weakening the financing appeal of ecosystem-based protection projects. Ecosystem service valuation theory converts the intangible functions of coastal ecosystems - including protection from wind and disasters, carbon sequestration, fishery replenishment, and ecotourism - into measurable and tradable cash flows. It thus provides the underlying valuation basis for blue bonds, blue credit, and ecological insurance and helps resolve the pricing challenges associ-

ated with blue projects. This theory establishes the core pricing logic for blue bonds and blue credit products.

Risk Diversification Theory. Highly localized, abrupt coastal climate catastrophes exceed the standalone risk-bearing capacity of individual governments, financial institutions and enterprises; diversified blue finance portfolios enable cross-stakeholder and cross-regional risk dispersion to mitigate localized systemic shocks. It explains multi-layer risk-sharing mechanisms for blue funds and climate insurance.

Sustainable Development Theory. Sustainable development theory requires the simultaneous pursuit of economic growth, social well-being, and ecological security. With binding proceeds allocation rules, blue finance channels capital to projects integrating disaster mitigation, carbon sequestration and livelihood improvement. This approach prevents ocean-industry growth from depleting ecological capital and supports long-term, coordinated, and sustainable development. It establishes the core screening criteria for eligible blue investment projects.

2.2 How Blue Finance Mitigates Coastal Physical and Transition Risks

Coastal climate risk comprises physical risk and transition risk. Blue finance mitigates these risks through a layered transmission mechanism, as illustrated by the conceptual model in Figure 1.

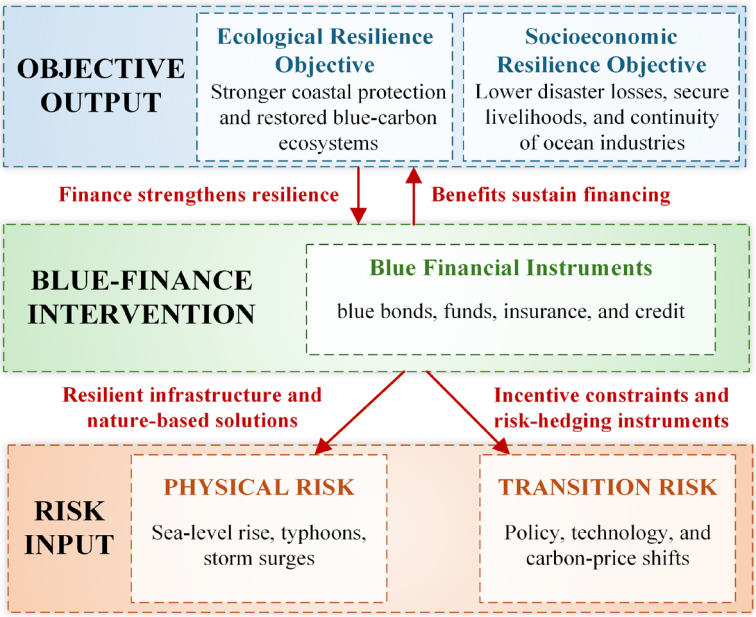


Fig. 1. Conceptual model of blue finance-enabled coastal climate-risk management

Physical-Risk Mitigation Mechanism. Physical risk refers to asset damage and economic losses directly caused by sea-level rise, typhoons, and storm surges. Coastal climate disasters incur annual losses over 580 billion RMB, with fiscal relief covering 30% of disaster costs. Blue finance mitigates this risk through both ex ante protection and ex post compensation. For example, long-term and low-cost capital from blue bonds and blue funds supports two types of resilient investment: hard infrastructure, including seawall reinforcement, flood-resilient port upgrades, and urban sponge-city drainage networks; and nature-based infrastructure, including mangrove and seagrass restoration and the construction of nearshore shelterbelts. Seawalls cost 2–5 ten thousand RMB per meter with zero ecological gains, while mangrove restoration yields 3–10 times long-term comprehensive benefits per unit investment. These investments reduce disaster exposure at its source. Ex post, blue parametric climate insurance converts large, one-off disaster-relief expenditures into smaller, recurring premiums; annual premium spending is merely 17% of one-time fiscal rescue funds, and triggered compensation arrives within 7 days. Rapid payouts following a trigger event can finance equipment repair, reconstruction of aquaculture facilities, and coastal ecosystem replanting. This mechanism relieves pressure on public disaster-relief budgets and helps prevent cycles in which disasters cause or recreate poverty.

Transition-Risk Management Mechanism. Transition risk refers to asset impairment and operating losses in ocean industries caused by tighter environmental policies, advances in low-carbon technology, and carbon-market volatility during the transition to a low-carbon and sustainable economy. Blue finance manages this risk through incentive constraints and financial hedging. Under the incentive mechanism, differentiated blue credit applies tiered interest rates: offshore wind, green shipping, sustainable aquaculture, and other low-carbon industries receive loan rates 10–30 BP lower and maturities extended 2–5 years, while polluting coastal industries face 100+ BP higher financing costs. Three-year blue bond coupons stay at 1.87%–2.60%, 100 BP cheaper than equal-grade ordinary industrial bonds; blue marine loans rose 25.6% year-on-year in 2024, 13 points above common industrial loans. These incentives accelerate the green transformation of traditional ocean industries. Under the hedging mechanism, innovative instruments such as blue-carbon futures and credit-asset securitization help port-based enterprises offset 60%–75% of carbon price swings. At the same time, early-stage finance for marine biotechnology, blue-carbon trading, and other emerging blue industries creates new growth engines that offset the risks associated with the decline of traditional sectors.

2.3 Four Core Components of a Blue-Finance Model

A complete and operational blue-finance support model requires coordination among four core components: financing actors, use of proceeds, risk sharing, and monitoring and evaluation.

Financing Actors: Government Guidance, Market Leadership, and Social Participation. On the government side, coastal development and reform commissions, ocean authorities, and finance departments should introduce interest subsidies, tax relief, and guarantee-compensation policies; establish blue-finance risk reserve funds; create a unified national pipeline of blue-finance projects; and aggregate fragmented adaptation needs among micro and small entities. On the financial side, commercial banks should provide medium- and long-term blue credit, insurers should develop parametric climate insurance, fund managers should establish cross-regional blue-industry funds, and securities firms should issue blue bonds and asset-backed securities (ABS). These institutions form the core of market-based capital supply. On the social side, fishers' cooperatives, community organizations, and nonprofit institutions should participate in project screening and local oversight, while inclusive microfinance should reach small-scale actors and ensure that projects address the actual needs of coastal residents.

Use of Proceeds: Binding Allocation to Climate Adaptation and Post-Disaster Recovery. Funds should be restricted to two categories of use. The first is climate-adaptation investment, including resilient infrastructure, coastal ecosystem restoration, climate-risk early-warning systems, and low-carbon ocean industries. The second is compensation for disaster losses, with industrial recovery and ecosystem restoration advanced in parallel. Quarterly disclosure of fund flows and third-party audits by accounting firms should be required to prevent misappropriation and bluewashing.

Risk Sharing: A Multilayered Mechanism to Lower Investment Barriers. At the government level, blue-finance guarantee funds and premium subsidies can absorb part of the credit-default risk borne by micro, small, and medium-sized entities. At the financial-institution level, reinsurance and asset securitization can transfer risk to capital markets. At the project-operation level, PPPs and community joint ventures can share disaster losses in proportion to capital contributions. Binding multiple parties to both risks and returns strengthens incentives for proactive risk control throughout the system.

Monitoring and Evaluation: A Long-Term Framework. The Sustainable Blue Economy Finance Principles should serve as a common eligibility standard. A multidimensional quantitative evaluation system should then be established. Environmental indicators should use remote sensing to measure additional blue-carbon sequestration, coral and mangrove coverage, and shoreline stability. Social indicators should track the number of beneficiaries and green jobs created. Economic indicators should estimate avoided disaster losses and long-term incremental industry revenues. Annual impact reports should be issued routinely, with transparent disclosure throughout the project life cycle to facilitate investor and public oversight.

3 Representative Blue-Finance Models in China and Abroad

Three differentiated blue-finance models have emerged in coastal regions worldwide, each suited to particular economic institutions, levels of financial-market maturity, and industrial structures.

3.1 Overview of Representative Cases

Shenzhen, China: A Policy-Driven Regional Blue-Finance Model. Shenzhen's model is driven by top-level local-government policy. Financing for marine climate resilience is incorporated into regulatory assessments of banks and insurers. The model's strengths are rapid policy implementation and a high degree of pilot standardization. Its limitations include strong dependence on public finance, insufficient incentives for voluntary private investment, and an underdeveloped professional climate-risk assessment system. The model is best suited to first-tier coastal cities with strong financial foundations and high levels of urbanization. It features small-scale pilot projects, fiscal-led risk sharing, relatively high public financing costs and mature local marine governance.

Rotterdam, the Netherlands: A Port-Cluster-Driven PPP Market Model. With the port authority serving as the investment and financing hub, Rotterdam's model focuses on port decarbonization, the circular ocean economy, and offshore renewable energy. The model benefits from mature market-based instruments and a strong capacity to finance large resilient infrastructure. However, high investment thresholds and stringent requirements for environmental monitoring and public consultation may generate conflicts over community interests. The model is most appropriate for large, internationally connected port economies. It targets large port infrastructure, adopts market multi-agent risk sharing, with low private capital cost and complete industrial governance systems.

Coastal Southeast Asia: A Finance-Community Blended Model. In this model, multilateral institutions such as the Asian Development Bank provide concessional loans and financing guarantees, while debt-for-climate swaps mobilize private capital. The model is highly inclusive and generates substantial ecological and social benefits. Its limitations are weak domestic financial systems, inconsistent environmental, social, and governance (ESG) standards, relatively high financing costs, and limited capacity to undertake major coastal infrastructure. It is best suited to developing coastal regions with underdeveloped financial markets and dense fishing communities. It features tiny community ecological projects, multilateral blended risk-sharing, elevated overall capital expenditure and inadequate local financial governance capacity.

3.2 Similarities and Differences among the Three Models

All three models target enhanced coastal ecological and climate resilience through multi-stakeholder coordination, standardized risk-sharing and systematic impact evaluation. They diverge along four core comparative dimensions: capital source, project magnitude, community engagement intensity and adaptive regional economic conditions. Specifically, Shenzhen deploys fiscal funds for medium urban pilots with limited resident participation; Rotterdam leverages private capital for large port infrastructure with moderate local involvement; Southeast Asia draws on multilateral finance for micro community ecological projects with deep resident engagement. No universal model exists; mixed localized adaptation is necessary for real-world practice.

4 Blue-Finance Models for China's Coast

4.1 Localized Blue-Finance Models

Based on differences in fiscal capacity, industrial structure, and financial development among China's eastern, southern, and northern coastal cities, four differentiated models are proposed.

Government-Led Public-Financing Model. Applicable contexts include large public coastal disaster-prevention projects. Funding should come from special blue bonds issued by local governments and officially sponsored blue-development funds. Public fiscal backing can support projects with long investment horizons and low short-term returns, thereby providing systemic protection against large-scale physical risks such as sea-level rise and widespread storm surges. This model matches the Bohai Rim’s demand for large cross-regional coastal defense projects.

Public-Private Partnership (PPP) Model. This model applies to resilient industry projects with stable operating revenues. Government provides planning, supporting land arrangements, and policy guarantees, while private capital finances, constructs, and operates projects. Returns are distributed according to capital contributions, and disaster losses are shared. Market-based revenues can thus attract private investment into public climate governance. It fits the Yangtze River Delta and Pearl River Delta with mature private capital and port economies.

Market-Driven Financial-Innovation Model. This model is suited to the low-carbon transition of large ocean-related enterprises and investment in emerging ocean industries. Banks, insurers, and securities firms independently develop products such as blue credit, carbon-sink insurance, and blue asset-backed securities, with differentiated interest rates and premiums. Market-based pricing hedges industrial transition risk. It adapts to economically developed coastal cities with abundant financial institutions.

Inclusive Community and Microenterprise Participation Model. This model is designed for county-level fishing towns and villages and small coastal businesses. The model focuses on protecting the livelihoods of vulnerable groups exposed to climate risk and emphasizes the inclusive-finance dimension of blue finance. It applies to underdeveloped county-level fishing coastal zones across southern China.

4.2 Stakeholder-Specific Policy Recommendations

Recommendations for Government. First, China should establish unified national blue-finance taxonomy and eligibility standards, including a whitelist of supported projects and a negative list for highly polluting ocean industries, to eliminate blue-washing at its institutional source. Second, a fiscal-incentive system should provide interest subsidies for blue bonds, tax relief for blue credit, and risk compensation for financing guarantees, thereby reducing financing costs for market actors. Third, blue finance should be integrated into national marine spatial planning and local climate-adaptation plans. A national matching platform for blue-project supply and capital demand should be established to remove information barriers between projects and investors.

Recommendations for Financial Institutions. First, financial institutions should establish specialized blue-finance risk-management teams and quantitative climate-risk assessment models to estimate coastal disaster losses and blue-carbon revenues accurately. Second, they should develop performance-linked blue-finance products that tie lending rates and insurance payout ratios to additional blue-carbon sequestration and verified disaster-risk-reduction outcomes. Market-based incentives and constraints can thereby safeguard the effectiveness of ecological governance. Third, China should expand the secondary market for blue finance by promoting the trading of blue bonds and securitized blue-credit assets, thereby improving market liquidity.

Recommendations for Ocean-Related Enterprises. First, enterprises should incorporate climate-risk assessment into corporate strategy and project feasibility studies to anticipate and reduce climate-related losses on coastal assets. Second, they should design projects in accordance with national blue-finance standards and engage third-party institutions to obtain blue certification. This will reduce information asymmetry with financial institutions and improve access to preferential financing. Third, enterprises should develop capabilities in emerging blue sectors such as blue carbon and green shipping and use blue-finance policy incentives to build long-term core competitiveness.

4.3 A Three-Stage Implementation Pathway

Stage 1: Pilot Demonstration (From Zero to One)

Shenzhen should be selected as the core pilot city for a demonstration PPP project involving a low-carbon, climate-resilient port. The full process of project financing,

risk sharing, and three-dimensional impact evaluation should be documented to produce a standardized and replicable operating manual. The pilot would test the local feasibility of the blue-finance model and establish a national benchmark.

Stage 2: Building a National System (From One to Many)

Pilot experience should be replicated concurrently in the Yangtze River Delta, Pearl River Delta, Bohai Rim, and southeastern coastal regions. National top-level blue-finance guidance should unify rules for project eligibility, disclosure of proceeds, evaluation, and supervision. A comprehensive blue-project pipeline and an active secondary market should be developed to reduce issuance and financing costs in the primary market and complete the institutional framework.

Stage 3: Deepening and Internationalization (Routine Application and Global Replication)

Blue finance should become a routine practice, with blue credit and climate insurance incorporated into the regular business lines of financial institutions. Satellite remote sensing, big data, and artificial intelligence should be integrated to support dynamic climate-risk monitoring and intelligent benefit quantification. Through the Maritime Silk Road, China can offer blue-finance standards, technologies, and financing services to coastal developing countries in Southeast Asia and elsewhere, thereby strengthening its voice in global ocean sustainability governance.

5 Conclusion

This paper constructs a multi-dimensional analytical framework linking blue finance and coastal climate risk governance, and puts forward differentiated blue finance paths matching China's coastal conditions. The study verifies that unified standards and multi-layer risk sharing are the core guarantee of sustainable blue finance operation. Constrained by data accessibility, this paper only constructs qualitative transmission mechanisms for blue finance; subsequent research can integrate digital tools to quantitatively measure marine climate risk losses and ecological benefit returns.

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