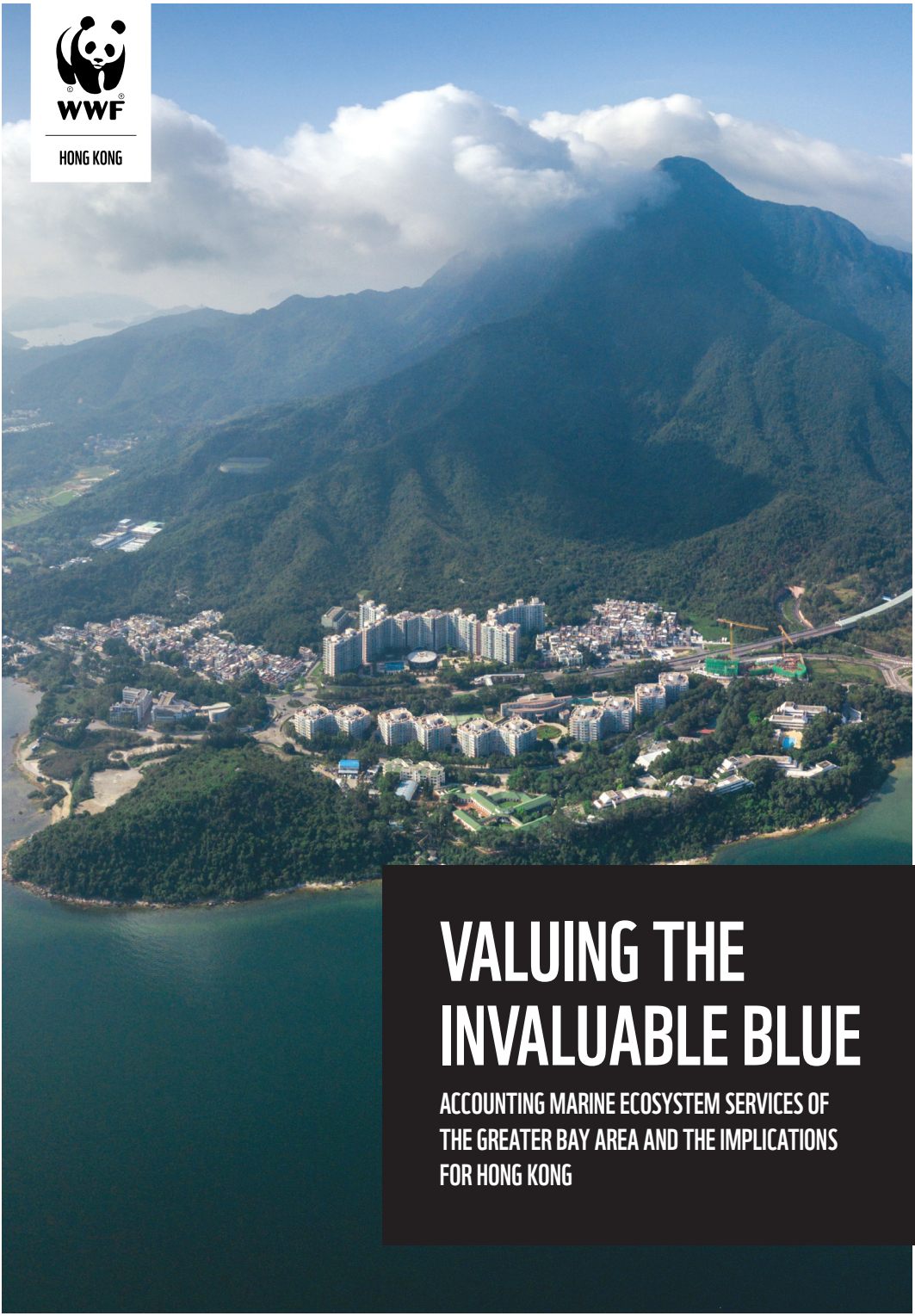


WWF

HONG KONG

VALUING THE INVALUABLE BLUE

ACCOUNTING MARINE ECOSYSTEM SERVICES OF THE GREATER BAY AREA AND THE IMPLICATIONS FOR HONG KONG

World Wide Fund for Nature (WWF)

WWF was founded in Switzerland in 1961. As one of the world's leading independent conservation organizations, WWF works in 100 countries and has over 5 million supporters globally. Over the past 60 years, WWF has been protecting the future of nature. We are working to sustain the natural world for the benefit of people and wildlife.

Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (RCEES, CAS)

RCEES, CAS was founded in 1975. With the strategic theme of "national ecological environment security and sustainable development", it gives full play to the comprehensive advantages of the three major disciplines of environmental science, environmental engineering and ecology. The RCEES closely integrates the research of international environmental science and ecology frontiers with the major needs of national environmental protection and ecological construction, continuously breaks through major scientific theories and key technologies, and makes fundamental, strategic and forward-looking scientific and technological innovation contributions to the construction of China's ecological civilization and the realization of harmonious coexistence between man and nature.

Sea for Future

The "Sea for Future III" is a flagship ocean conservation project supported by the Swire Group Charitable Trust. We aim to (1) join force with universities, communities, and the public to undertake coral and seagrass habitat restoration work; and (2) conduct an ocean accounting pilot study to promote marine spatial planning and expansion of marine protected area network.

Sponsored by:

SWIRE TRUST

Valuing the Invaluable Blue

Cover : © WWF-Hong Kong
Publisher : WWF-Hong Kong

FOREWORD

Lydia Pang, Head, Oceans Conservation at WWF-Hong Kong

The ocean is one of our most vital yet undervalued assets. As the Guangdong-Hong Kong-Macao Greater Bay Area (Greater Bay Area) faces mounting environmental and socio-economic challenges, it is increasingly clear that the health of our marine ecosystems is not only a matter of conservation—but of resilience, prosperity, and long-term sustainability.

This publication, *Valuing the Invaluable Blue*, presents the findings of a pilot study on marine ecosystem service accounting across the Greater Bay Area. While the study covers the broader region, this discussion places particular emphasis on Hong Kong—exploring how ecosystem accounting can inform local policy, planning, and sustainable development. As an early regional application of the Gross Ecosystem Product (GEP) framework in coastal urban clusters, the study provides timely insights into the quantification and integration of marine ecosystem services in decision-making. The findings highlight the significant role of marine ecosystems, which contribute over 70% of the estimated GEP in the region, particularly in climate regulation, disaster mitigation, and sustainable livelihoods.

As governments and institutions around the world move toward nature-positive development, ecosystem accounting provides a practical and science-based tool to integrate ecological values into planning, budgeting, and investment decisions. For Hong Kong, this approach offers a timely opportunity to align marine spatial planning, environmental impact assessments and blue finance with our broader sustainability goals.

WWF is proud to support this work as part of our commitment to advancing Nature-based Solutions and evidence-based policy. We are especially grateful for the generous support of the Swire Group Charitable Trust, whose contribution made this pioneering study possible. We also extend our sincere thanks to our partners at the Research Center for Eco-Environmental Sciences of the Chinese Academy of Sciences, and to our colleagues across WWF offices in Hong Kong and mainland China. We further acknowledge the many experts and stakeholders who provided valuable advice, comments, and suggestions throughout the process.

We hope this publication will serve as a useful reference for policymakers, researchers, and stakeholders working to safeguard our marine environment. By recognising the true value of nature, Hong Kong can lead the way in building a resilient, inclusive, and sustainable blue future for the Greater Bay Area and beyond.

MARINE ECOSYSTEM SERVICES

The ocean covers over 70% of the Earth's surface, serving as the livelihood and core of life for billions of people, and nurturing countless species. Natural processes in the ocean, such as photosynthesis, nutrient cycling and water circulation, enable ecosystems and biodiversity to thrive, forming the foundation of various ecosystem services.

Broadly speaking, **ecosystem services** refer to the various benefits that ecosystems provide to humans. The ocean stores a vast amount of heat, influencing weather and global climate patterns. Seagrass beds and kelp forests act as effective carbon sinks, helping to mitigate climate change. Mangroves and coral reefs protect coastlines from natural disasters like storms, floods and tsunamis, preventing loss of life and property. The ocean's fisheries resources sustain the livelihoods of fishers and meet human dietary needs. Magnificent scenery and various water activities are also services provided by marine ecosystems.

These ecosystem services are categorised into four widely recognised types - **supporting services, regulating services, provisioning services, and cultural services**[1,2].

Supporting Services:
Fundamental functions that maintain ecosystem services.

1. Nutrient cycling
2. Primary production (e.g photosynthesis)
3. Habitat provision
4. Biodiversity maintenance

Provisioning Services:
Products provided by marine ecosystems.

1. Fisheries resources
2. Energy

Regulating Services:
Functions that regulate environmental processes.

1. Climate regulation (e.g carbon absorption and storage by seagrass beds)
2. Water purification (e.g oyster reefs purify seawater)
3. Coastal protection (e.g mangroves, coral reefs)

Cultural Services:
Non-material benefits provided by marine ecosystems.

1. Recreational activities (e.g diving, canoeing)
2. Aesthetic value (e.g marine landscapes)
3. Educational and research opportunities
4. Cultural heritage and identity (e.g fishing culture)

ECOSYSTEM SERVICE ACCOUNTING

Helping Decision-Makers Better Understand Ecosystem Contributions to the Society

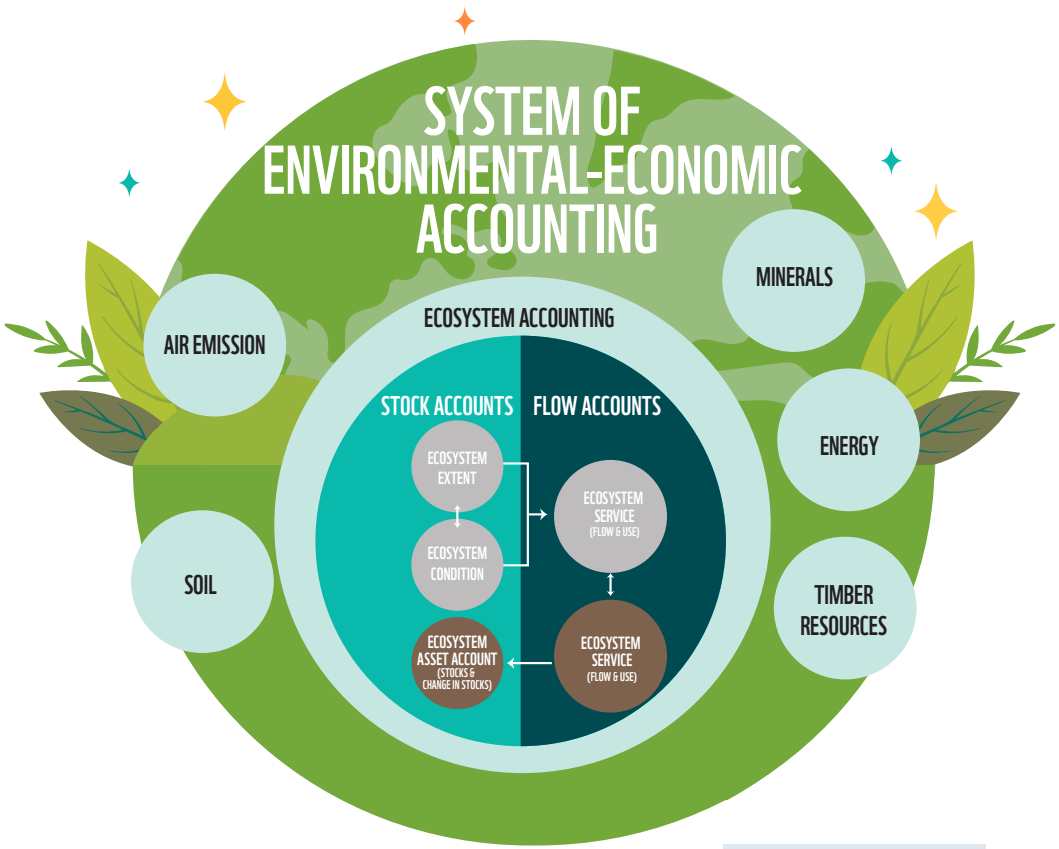
Mainstream economic indicators, such as Gross Domestic Product (GDP), are important for assessing economic development of the society, yet the crucial role of nature in economic and social progress is often overlooked. For example, if a country were to clear all its forests within a year to develop timber or livestock industries, its GDP would significantly increase due to the immediate economic benefits and job opportunities from timber or livestock. However, this would also mean the country would face enormous long-term social costs, irreversible environmental damage, biodiversity loss and catastrophic loss of natural wealth.

The System of Environmental-Economic Accounting

To better "visualise" the contributions of ecosystems to human well-being, the international community established the System of Environmental-Economic Accounting: Ecosystem Accounting (SEEA EA), which was adopted by the United Nations Statistical Commission in 2021[3]. SEEA EA is an international statistical framework that integrates data on ecosystems and landscapes, quantifies changes in ecosystem services and assets, and links this information with economic and other human activities[4]. SEEA fills a significant gap in previous official statistics, allowing the contributions of nature to be more comprehensively considered in decision-making processes.

Quantifying the Ocean's Contribution to the Economy and Society

Ecosystem accounting is rapidly advancing, and many countries are beginning to adopt it in their policy development process. Currently, over 90 countries have implemented ecosystem accounting within their statistical or policy frameworks[5]. The ocean, as a crucial component of the ecosystem, should also be an essential pillar in a holistic ecosystem account[6]. As the planning and management of marine resources and spaces is relatively more complex when compared to that of terrestrial landscapes, utilising ecosystem accounting to steer marine spatial planning (MSP) could potentially be a cost-effective approach to integrate and quantify the economic and social contributions of marine resources, thereby aid in decision-making.



Gross Ecosystem Product (GEP) [7]

This concept, proposed by Chinese scholars, is a specific application of ecosystem accounting. It refers to the total monetary value of ecosystem products and services used in a specified area over a certain period (usually one year). GEP presents the contributions of ecosystems to humanity in economic and monetary terms, allowing the value of ecosystem assets and services to be integrated into decision-making processes, thereby enhancing the protection of ecosystem assets.

EVOLUTION OF CHINA'S OCEAN ACCOUNTING POLICIES AND LOCAL PRACTICES

China has rapidly developed policies in the field of ecosystem accounting. Guided by the policies delivered by the Central People's Government, there have been numerous cases of local implementation of ecosystem accounting across the country.

From Concept to Institutional Application

Foundation: In 2015, the "Integrated Reform Plan for Promoting Ecological Progress" [8] first proposed the incorporation of ecological benefits into the evaluation system for socio-economic development, providing a legal basis for ecosystem accounting.

Promoting Application: The 2021 "Opinions on Establishing and Improving the Mechanism for Realizing the Value of Ecological Products" [9] called for the formulation of a unified national standard for ecological product value accounting and promoted the application of GEP in areas such as ecological compensation, marking the transition from theoretical research to institutional practice.

Combining "Dual Carbon" Goals: The 2024 "Work Plan for Improving the Carbon Emission Statistics and Accounting System" [10] integrates ecosystem service accounting with the goals of reaching "Carbon Peaking" by 2030 and achieving "Carbon Neutrality" by 2060.

Aligning with the UN SEEA EA Framework and Introducing Technical Standards

Terrestrial Accounting: In 2020, the "Technical Guidelines for the Accounting of Gross Ecosystem Product of Terrestrial Ecosystems" [11] was released, followed by the trial implementation of the "Guidelines for the Accounting of Gross Ecosystem Product" [12] in 2022.

Ocean Accounting: In January 2025, the First Institute of Oceanography under the Ministry of Natural Resources led the compilation of the "Technical Guidelines for the Accounting of Gross Ecosystem Product of Marine Ecosystems" [13], which was open for public consultation. This marked the entry of China's ocean GEP accounting into a new phase of national standardisation. The Guidelines categorise ocean services into four major types: provisioning, regulating, cultural, and supporting, and for the first time quantifies unique indicators such as "coastal protection" and "carbon sequestration and oxygen release", providing a unified framework for ocean GEP accounting in mainland China.

Local Practices: Differentiated Exploration and Innovation

Shenzhen: In 2021, Shenzhen pioneered the GEP accounting system for highly urbanised areas and applied the results in planning and decision-making. In February 2025, Shenzhen released the "Technical Specification for Accounting Natural Resource Assets of Marine Ecosystems (Draft for Comments)," [14] providing localised technical support for "blue carbon" trading.

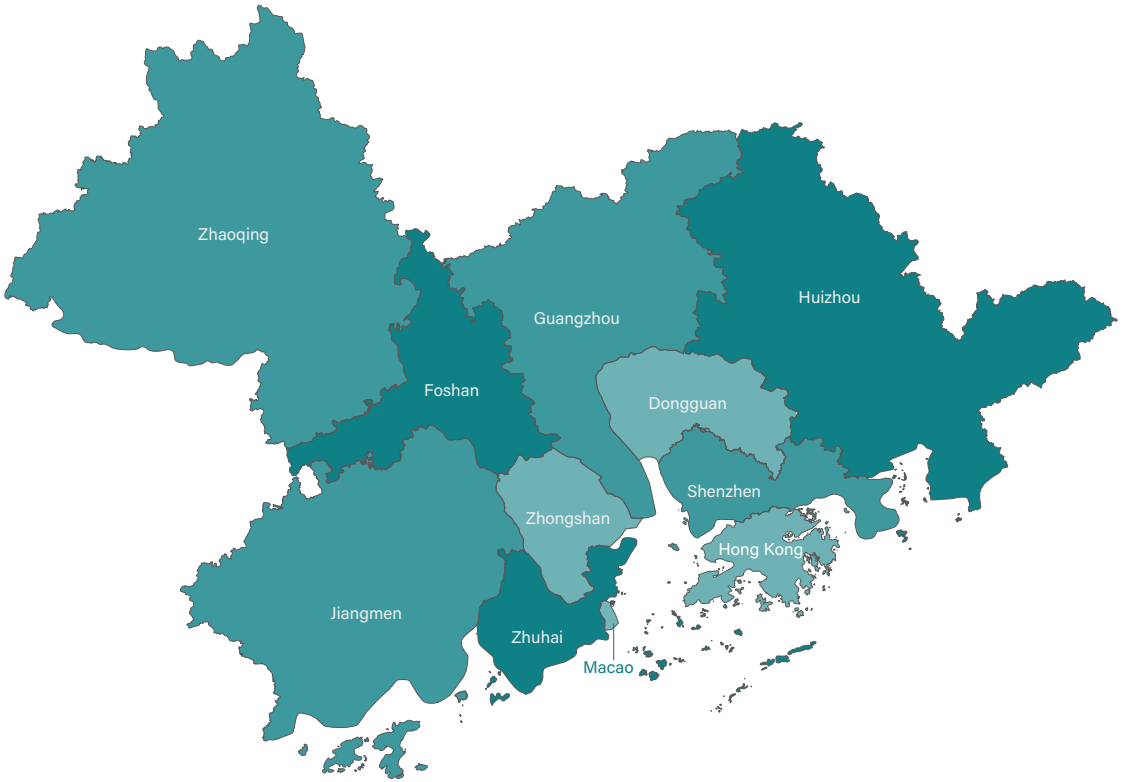
Zhoushan: In 2024, Zhoushan introduced the nation's first GEP accounting standard for specific marine areas, covering both terrestrial and marine regions, and promoted the application of green finance.

Implications and Opportunities for the Greater Bay Area

China's new advancements in ocean GEP accounting offer collaboration opportunities for the Greater Bay Area. Hong Kong can refer to mainland China's experiences in policy design, technical standards and local practices, and adjust the framework according to local conditions. The Greater Bay Area can also introduce quantitative indicators in areas such as blue finance, coastal protection and water purification to support regional MSP and sustainable development goals.

THE UNIQUENESS OF THE GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

The Guangdong-Hong Kong-Macao Greater Bay Area (Greater Bay Area) comprises the two Special Administrative Regions of Hong Kong and Macao, and the nine municipalities of Guangdong Province. It is one of the most densely populated and economically vibrant coastal urban clusters in the world.



POPULATION

87 million (2024)[15]

GDP

RMB 14 trillion
(≈USD 1.99 trillion) (2023)[16]

COASTLINE LENGTH

3,201 kilometres[17]

MARINE-RELATED INDUSTRIES

Shipping & ports, capture fisheries, aquaculture, eco-tourism, recreational diving, etc.

Economically, the Greater Bay Area thrives on the synergistic development of its technology, manufacturing, and financial sectors, forming a regional competitive edge with huge potential. **Ecologically**, it hosts rich subtropical marine ecosystems-including coral communities, seagrass beds, oyster reefs, rocky shores and mangroves-that serve as natural buffers for water purification, coastal protection and disaster mitigation. Notably, the Pearl River Estuary is home to the world's largest population of Chinese White Dolphins, a vulnerable species whose survival is of global concern. The Estuary's population is often regarded as the "last hope" for conservation of this cetacean species.

However, the Greater Bay Area faces severe ecological challenges due to high-density urbanisation and industrial development. Over 60% of the natural coastline has been heavily modified, and habitats such as coral reefs, seagrass beds, oyster reefs and mangroves have drastically reduced in size and become fragmented[18]. The biodiversity in the Pearl River Estuary has significantly declined, compounded by cross-border water eutrophication and climate risks like typhoons, exacerbating the conflict between ecological carrying capacity and economic growth.

In this context, ocean accounting is one of the crucial tools to address this conflict. By quantifying the value of marine ecosystem services, governments and enterprises can formulate effective policies and Nature-based Solutions (NbS), for instance, more precise ecological compensation policies and exploring sustainable financial systems, to achieve balance and strong synergy between ecological protection and economic development in the Greater Bay Area. In the future, as ocean accounting continues to advance, the Greater Bay Area is expected to promote regional economic prosperity while achieving ecological restoration and long-term sustainable management, setting an example to other coastal urban clusters.

ACCOUNTING THE VALUE OF GUANGDONG-HONG KONG-MACAO GREATER BAY AREA COASTAL ZONE ECOSYSTEM SERVICE

Background

To evaluate the feasibility and potential policy contributions of ocean ecosystem service accounting in the Greater Bay Area (especially Hong Kong), WWF commissioned a pilot study by the Research Center for Eco-Environmental Sciences (RCEES) of the Chinese Academy of Sciences. The study, titled "**Guangdong-Hong Kong-Macao Greater Bay Area Coastal Zone Ecosystem Service Accounting Pilot Study**", was conducted using the technical framework of Guidelines for the Accounting of Gross Ecosystem Product. The pilot study included a selection of marine-related ecosystem service accounting indicators to estimate the GEP of the Greater Bay Area's coastal zone(see Appendix 1). This study was generously supported by the Swire Group Charitable Trust.

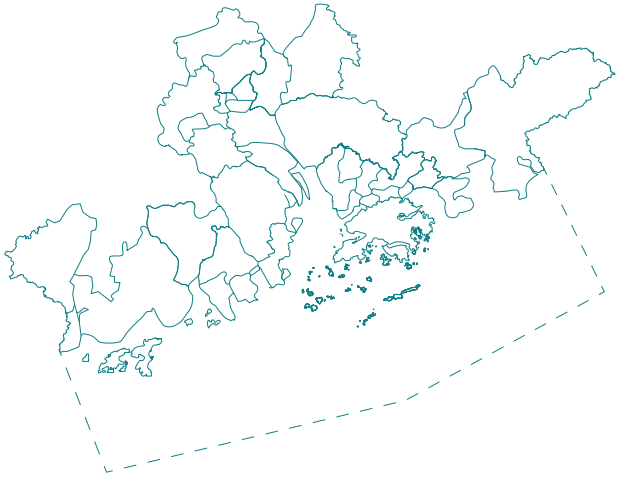


Figure 1: Research Area Scope

The total area of the research scope is approximately 51,500 square kilometres, with remote sensing data used to analyse the area of various ecosystem types. The marine ecosystem accounts for 47% of the total area.

As this pilot study was intended to focus on ecosystem services relevant to the marine environment, the definition of "coastal zone of the Greater Bay Area" in this study does not completely correspond to the administrative boundaries of the Guangdong-Hong Kong-Macao Greater Bay Area. For details, see the Technical Description section (Page 19).

In ecosystem accounting and value assessment, ecosystem services are typically quantified and expressed using "flow accounts" (e.g., the annual amount of food produced, carbon sequestered, or visitor arrivals). This study focused on the monetary valuation of ecosystem service flows, while the "stock" of ecosystems was mainly consolidated based on their current conditions and changes, such as ecosystem extent and other quantifiable indicators. The monetary valuation of ecosystem assets and habitat support services was not included in this stage of the study.

	Selected Indicators		Analysis
Ecosystem Stock			
Extent and Condition	Area of Ecosystems	Number of Species	Integrated Spatial Distribution of Overall Quality
	Terrestrial Vegetation Space	Seawater Quality	
Ecosystem Flow			
Supporting Services	Number of Threatened Species		Integrated Scoring and Spatial Analysis
Regulating Services	Climate Regulation	Flood Regulation	Converted into Monetary Value
	Carbon Sequestration	Water Conservation	
	Air Purification	Soil Retention	
	Water Quality Purification	Coastal Protection	
Provisioning Services	Value-added Contributions of Marine Fishery Products		
Cultural Services	Natural Landscape Tourism		
	Natural Landscape Premium		

Table 1:Indicators and Main Analyses Covered in the Guangdong-Hong Kong-Macao Greater Bay Area Coastal Zone Ecosystem Service Accounting Pilot Study

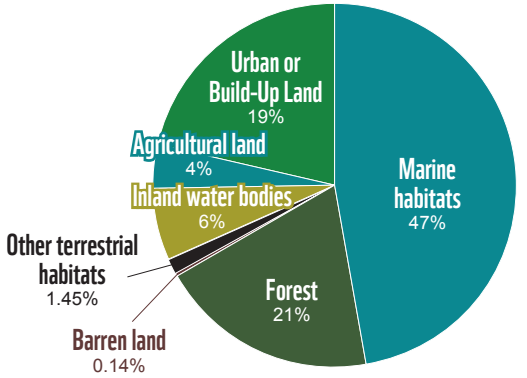


Figure 2: Area Proportion of the Coastal Zone Ecosystems of the Greater Bay Area

Results Highlights and Analysis

According to estimates by the RCEES, the total GEP of the coastal zone of the GBA in 2022 was at least about RMB 4.9 trillion (≈USD 728 billion), with marine ecosystems contributing about 73%, i.e. RMB 3.5 trillion (≈USD 527 billion) , mainly reflected in services such as climate regulation and water purification.

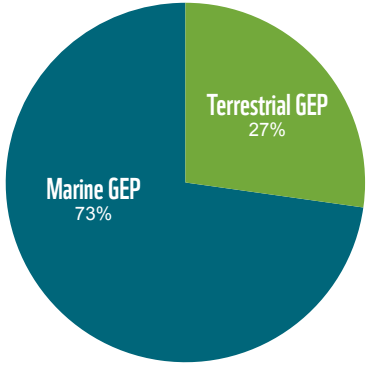


Figure 3: Proportion of Marine and Terrestrial Gross Ecosystem Products

Among various ecosystem services, the study estimates that the climate regulation services of the coastal zone of the GBA in 2022 accounted for the largest proportion, with a GEP as high as RMB 4.5 trillion (≈USD 668 billion). Of this, marine ecosystems contributed about 77% of the GEP of climate regulation services. Specifically, the climate regulation services provided by the ocean exceeded RMB 3.5 trillion (≈USD 520 billion), the value of carbon sequestration was about RMB 4.2 billion (≈USD 620 million), and coastal zone protection services contributed RMB 3.23 billion (≈USD 480 million). These data fully highlight the critical role of marine ecosystems in climate regulation, carbon sequestration, and coastal zone protection. In future policy-making and decision-making processes, it is essential to highly prioritise and consider the value of these key ecosystem services.

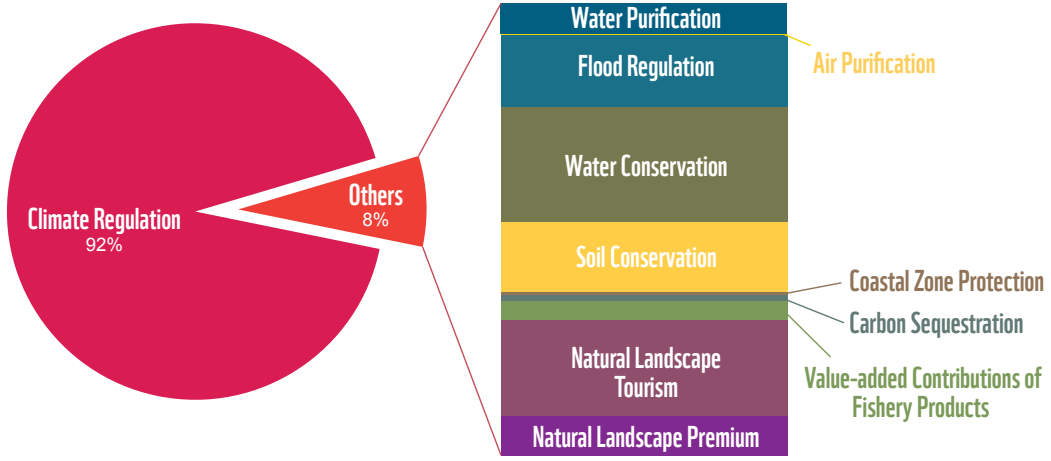


Figure 4: Proportion of Ecosystem Service Values

Ecosystem Services		GEP value (RMB 100 Million)
Regulating Services	Climate Regulation	45,000
	Water Purification	254.41
	Air Purification	3.53
	Flood Regulation	599.15
	Water Conservation	958.16
	Soil Conservation	574.1
	Coastal Zone Protection	32.3
	Carbon Sequestration	47.65
Provisioning Services	Value-added Contributions of Fishery Products	151.22
Cultural Services	Natural Landscape Tourism	804.53
	Natural Landscape Premium	325.23
Total Monetary Value		**48,750.28 (≈USD 724 billion)**

Table 2: Estimated Value of Ecosystem Services in the Coastal Zone of the Greater Bay Area


© Luna Li

In 2022, the Gross Ecosystem Product (GEP) of the coastal zone of the GBA reached at least RMB 4.9 trillion (≈USD 727 billion), equivalent to over 35% of the Greater Bay Area's GDP of RMB 13 trillion (≈USD 1.93 trillion) for the same period. In the coastal zone of the Greater Bay Area, the economic value per unit area of marine ecosystems is significantly higher than that of terrestrial ecosystems— terrestrial habitat contributes approximately RMB 54.4 million (≈USD 8 million) per square kilometre in GEP, while **marine habitat contributes as much as RMB 131 million (≈USD 19 million) per square kilometre**, which is 2.4 times higher. This disparity highlights the efficient service capabilities of marine ecosystems in climate regulation, carbon storage, and disaster buffering, providing critical support for the sustainable development of the Greater Bay Area.

Regarding **ecosystem stock**, the study evaluates four types of indicators listed in Table 1 and conducts spatial distribution analysis. For habitat support services, threatened species are used as indicators, with corresponding scores based on their endangered status and spatial distribution analysis. Areas with high habitat supporting service values are mainly distributed along **the coastal areas of the Pearl River Estuary, Daya Bay, and Dapeng Bay** (See Appendix 2).

In addition to the overall GEP amount, understanding the composition of various ecosystem services in the study area helps identify regional advantages and characteristics, providing important references for policy-making. Among regulating services, marine ecosystems dominate in climate regulation, water purification, coastal zone protection and carbon sequestration functions; terrestrial ecosystems dominate in air purification, flood regulation and soil conservation services. Provisioning services mainly account for the value of fishing and aquaculture within the region, estimated at approximately RMB 15.1 billion (≈USD 2.2 billion). Cultural services involve various economic activities, and due to the limitations of this pilot study, only some indicators were preliminarily estimated for investigating the feasibility assessment and potential contribution to policy-making, which will be further refined and improved in the future.

Advantages/Opportunities	Challenges	Recommendations
Framework and Model for Physical and Value Accounting		
Although marine GEP is still in its early stages, the GEP framework has extensive application experience in accounting for terrestrial ecosystem services in mainland China. With localised parameters, calculation models and accounting software platforms, the framework demonstrates strong applicability, comparability, and policy relevance. With the forthcoming update of the national standard "Technical Guidelines for the Accounting of Gross Ecosystem Product of Marine Ecosystems", marine GEP accounting is expected to see broader adoption and application.	When estimating physical and value quantities with localised parameters, due to the current lack of relevant parameters in Hong Kong, other regional parameters were used as substitutes, which may cause accuracy differences.	Comprehensive accounting of marine ecosystem services enable comparison of value proportions across different spatial distributions and facilitate analysis of changes over time, making them widely applicable for supporting policy-making. Developing localised parameters and accounting software platforms is highly feasible. It is recommended to divide ecosystem service performance based on the characteristics of marine ecosystems in different regions, replacing substitutional data.
Establishment of Data and Accounting Scope		
Practically, once the accounting framework is established, most data collection sources mainly involve in remote sensing technology, geographic information system analysis, international and local authoritative monitoring data and official statistical yearbooks, which are generally highly accessible.	Due to differences in statistical methods and data completeness among Hong Kong, Macao, and mainland cities, inconsistencies arise in cross-border comparisons. To ensure data consistency and comparability across the study area, lower resolution data (e.g., species numbers) may be used as a unified standard, affecting the overall accuracy and detail of the estimation results.	When accounting for marine ecosystem services, the scope and resolution established need to closely align with policy needs to balance the accuracy of estimation results with practical requirements. Additionally, remote sensing data can effectively analyse the areas of terrestrial ecosystems, while detailed classification of marine ecosystems may require supplementary field survey data to improve accuracy.
Local stakeholders in Hong Kong already possess a very rich data foundation, with government departments, academic and professional groups and non-governmental organisations able to collaborate and contribute.	The cross-administrative nature of the Greater Bay Area presents coordination challenges in data collection and cooperation mechanisms among different regions.	Strengthen data collaboration and establish a regional data platform in long term, unify statistical standards and promote cross-border data sharing and collaborative management among Guangdong, Hong Kong, and Macao.

Table 3: Review on Advantages, Challenges, and Recommendations regarding the pilot study

POTENTIAL APPLICATIONS OF MARINE ECOSYSTEM ACCOUNTING IN HONG KONG

Robust Policy and Scientific Foundation

Local experts and academic groups have conducted multifaceted research on Hong Kong's ecosystem services, such as the "Hong Kong Biodiversity Strategy and Action Plan (BSAP) 2016-2021," which has monetarily and non-monetarily estimation towards the aesthetic value of country parks and the air regulation services of terrestrial plants[19]. Conducting marine ecosystem service accounting can strengthen the realisation of related action goals and seamlessly connect with the next stage of BSAP.

Currently, there are eight marine parks and one marine reserve designated in Hong Kong, with approximately 78,000 visitors to marine parks in 2024[20]. As marine-related recreational activities (such as leisure diving, water sports, island tours) become increasingly popular among residents and tourists, and the government mentions sustainable tourism development in the " Development Blueprint for Hong Kong's Tourism Industry 2.0"[21], it is evident that a healthy marine environment is a key factor supporting the sustainable development of the local tourism economy. In the future, it is advisable to conduct more comprehensive and in-depth integration of cultural services in eco-tourism, including surveys on the number of participants, time spent, and consumption in marine parks and other marine ecological hotspots in Hong Kong, incorporating the contribution of marine cultural services into decision-making considerations.

In 2024, the total output of marine aquaculture fisheries is estimated at 626 tonnes, valued at approximately HKD 66 million (≈USD 8.4 million); in the same year, the catch from Hong Kong's fishing industry is about 92,000 tonnes, valued at approximately HKD 2.4 billion (≈USD 300 million)[22]. The "Blueprint for the Sustainable Development of Agriculture and Fisheries" policy aims to double the annual output of locally farmed marine fish to 1,200 tonnes within five years and further increase to about 6,000 tonnes within 15 years[23]. Marine GEP accounting can quantify sustainable development potential and integrate it into macro quantifiable indicators, providing momentum for policy promotion.

1 Guidance for Local MSP Policy Formulation

Comprehensive marine ecosystem service accounting can compare value distributions across different spatial distributions and analyse changes at different time points, providing scientific basis and decision-making references for Hong Kong's MSP[24]. By quantifying the economic and social contributions of ecosystem services (such as fishery resources, climate regulation, biodiversity), policymakers can more effectively delineate marine protected areas, balance conservation and development needs, and reduce conflicts between different marine activities. For example, MSP can help allocate marine space, ensuring important habitats are protected while leaving appropriate space for fisheries, tourism and infrastructure activities. This ecosystem-based planning model helps maintain marine ecological health, improve management efficiency and promote participation and consensus across society.

2 Macro Reference for Government Budget and Corporate Investment Resource Allocation

Ecosystem service accounting can quantify the economic and social contributions of marine ecosystems, bridging conservation and decision-making and investment. When the benefits of sustainable initiatives such as marine protected area efforts, habitat restoration and Nature-based Solutions are concretely quantified, decision-makers, investors, stakeholders and the public can better understand their long-term returns and risk management value, thereby enhancing support and willingness to invest in related conservation work (such as government budget allocation or corporate investment) [25]. For example, restoring coral community, mangroves, seagrass beds and oyster reefs not only improves biodiversity but also enhances fishery productivity, mitigates climate change impacts and brings eco-tourism benefits.

3 Incorporating Marine Ecosystem Services into Local Environmental Impact Assessments (EIA)

Traditional EIAs lack objective criteria for evaluating ecological and fishery impacts and rarely quantify ecosystem services. Incorporating marine ecosystem services into the environmental impact assessment process can more comprehensively reflect the potential social and economic impacts of development projects[26]. For example, when evaluating reclamation projects, in addition to calculating habitat loss area and biodiversity impacts, it is also necessary to consider the loss of significant climate regulating services and weakened disaster resilience. This quantitative assessment helps decision-makers weigh different options more comprehensively and objectively, choose the development path most beneficial to society as a whole and provide strong scientific basis for project implementation and the formulation of ecological compensation and restoration measures.

4 Promoting Blue Finance Development

With global emphasis on sustainable development, blue finance has become an important trend in international financial markets. As an international financial centre, Hong Kong has unique advantages in developing blue finance. Fully quantifying and demonstrating the value of local marine ecosystem services will help design and issue innovative financial products such as blue bonds and blue funds, attracting more capital into marine conservation, sustainable fisheries and marine-friendly eco-tourism[27,28]. This not only helps enhance Hong Kong's position in the global green and blue finance markets but also provides financial support for local economic transformation and ecological conservation, promoting sustainable development in the region.

5 Implementation Recommendations

Hong Kong has unique advantages and opportunities to become a pioneer in promoting marine ecosystem accounting in the Greater Bay Area and China. Currently, local data resources are abundant, providing a good foundation for localised accounting. To capitalise on these advantages, the following steps are recommended:

- Personnel training and capacity building;
- Develop a localised marine GEP accounting framework: refine Hong Kong indicators and local parameters based on international and national standards;
- Develop local marine ecosystem services accounting model software platforms;
- Form cross-departmental and cross-sectoral teams: including the Environment and Ecology Bureau (policy-making), Agriculture, Fisheries and Conservation Department (species and habitat data), Planning Department (spatial planning), Environmental Protection Department (pollution monitoring);
- Incorporate the physical and monetary values of ecosystem services into the official statistical system: Add a "Marine Ecosystem Services" section in the Census and Statistics Department's annual report and regularly publish GEP data;
- Enhance data collection and integration; and
- Public awareness and engagement

By implementing these recommendations, Hong Kong can lead the way in marine ecosystem accounting, contributing to sustainable development and environmental conservation in the Greater Bay Area and beyond.

TECHNICAL DESCRIPTION

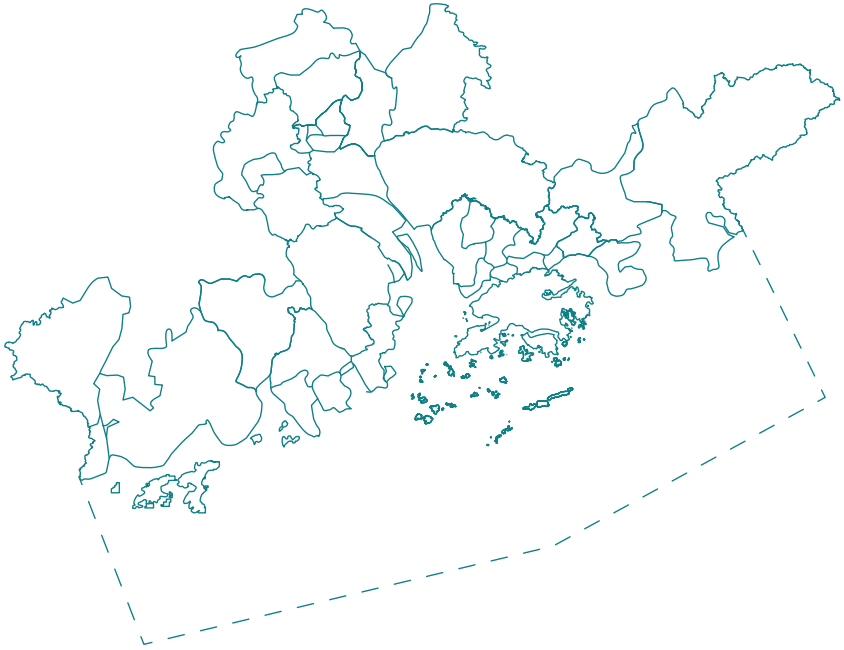
Guangdong-Hong Kong-Macao Greater Bay Area Coastal Zone Ecosystem Service Accounting Pilot Study

Study Area Scoping

1 Terrestrial scope: Land areas of coastal districts and counties in the Guangdong Province which are within the GBA, under the "Guangdong Province Coastal Zone Comprehensive Protection and Utilization Plan (Revised)"(the Plan); land areas of the Hong Kong and Macao Special Administrative Regions; and districts/ counties that are adjacent to the coast but are not coastal themselves, are included in the study area.

2 Marine scope: Since the sea boundary of the districts/ counties are unclear, this pilot study uses the southern boundary in the Plan to draw perpendicular lines to the east and west vertexes of the land boundary to delineate the sea area.

3 The total study area covers approximately 51,500 square kilometres.



Currency Exchange Rate

For consistency and international readership, all monetary values in United States dollar (USD) are adopted with a conversion rate dated July 2022: 1 USD ≈ 6.733 Renminbi (RMB) ≈7.849 Hong Kong dollar (HKD)

APPENDIX 1

Guangdong-Hong Kong-Macao Greater Bay Area Coastal Zone Ecosystem Service Accounting Pilot Study
Summary of indicators, data sources and accounting methods

Stock

	Indicator	Data source
Quantity	Area of various ecosystems	Esri-Sentinel 2 Geographic information system
	Number of species	Spatial data from the IUCN Red List of Threatened Species
Condition	Vegetation quality (net primary productivity)	NASA-MODIS remote sensing data
	Marine water quality (Chlorophyll)	NASA-MODIS remote sensing data

Flow

Ecosystem Service	Indicator	Quantity Accounting Method Overview	Valuation Method Overview	Data Source
Supporting Service	Species	Number and spatial distribution of threatened species	/	Spatial data from the IUCN Red List of Threatened Species
Regulating Service	Climate Regulation	The amount of energy consumption by the transpiration and evaporation of vegetation or water bodies in various ecosystems during periods when artificial temperature and humidity control is required	Alternative cost method; Valuates the local climate regulation service of urban ecosystems based on the electricity consumption cost required for manual temperature and humidity regulation	Esri-Sentinel 2 satellite data set NASA radar topographic Meteorological monitoring station data Soil physical and chemical property data Shoreline data Regional parameters
	Carbon Sequestration	Based on the net primary productivity data and NPP/NEP conversion coefficient. For marine ecosystems, it is calculated based on the carbon-fixing capacity of marine plants (phytoplankton and macroalgae)	Market price method; Valuates the carbon sequestration service based on the carbon market transaction price and total carbon sequestration amount	
	Air Purification	Based on air purification capability (Purification amount per unit area of each type of ecosystem multiplied by area)	Alternative cost method; Valuates the air purification capability of urban ecosystems based on industrial treatment cost of air pollutants such as SO2, Nox and particulate matters	
	Water Purification	Based on water purification capability (purification amount per unit area of each type of ecosystem multiplied by the area)	Alternative cost method; Valuates the water purification capability of urban ecosystems based on industrial treatment cost of water pollutant, including chemical oxygen demand, total nitrogen, total phosphorus, inorganic nitrogen, activated phosphate, etc.	
	Flood Mitigation	Based on flood storage capability (The amount of runoff reduced is calculated by using the SCS-CN method)	Alternative cost method; Valuates flood mitigation service based on reservoir construction and operating costs	
	Water Retention	Rainfall minus runoff then minus evaporation (The amount of runoff reduced is calculated by using the SCS-CN method)	Alternative cost method; Valuates the urban ecosystems' sediment reduction and diffused pollution reduction services based on the costs of pollutant treatment and reservoir dredging works	
	Soil Retention	Alternative cost method; Valuates the urban ecosystems' sediment reduction and diffused pollution reduction services based on the costs of pollutant treatment and reservoir dredging works	Alternative cost method; Valuates the urban ecosystems' sediment reduction and diffused pollution reduction services based on the costs of pollutant treatment and reservoir dredging works	
	Coastal Protection	Total length of protective natural coastline or other coastal protection constructions such as alternative seawalls	Alternative cost method; Valuates the coastal protection service of marine ecosystems based on the construction and maintenance costs of seawall protection works	
Provisioning Service	Value-added contributions of marine fishery products	Based on the value-added contribution data of fishery products of each administrative unit	Actual transaction value	Value-added contribution data of fishery products
Cultural Service	Natural Landscape Tourism	Based on tourism revenue and tourist arrivals in each administrative region data retrieved from local statistical yearbooks and online search	Total value of natural landscape tourism	Local statistical yearbooks and online search
	Natural Landscape Premium	Based on data retrieved from local statistical yearbooks and online search	Premium of rooms with natural landscape in coastal areas (within 300m from the coastline)	Local statistical yearbooks and online search

APPENDIX 2

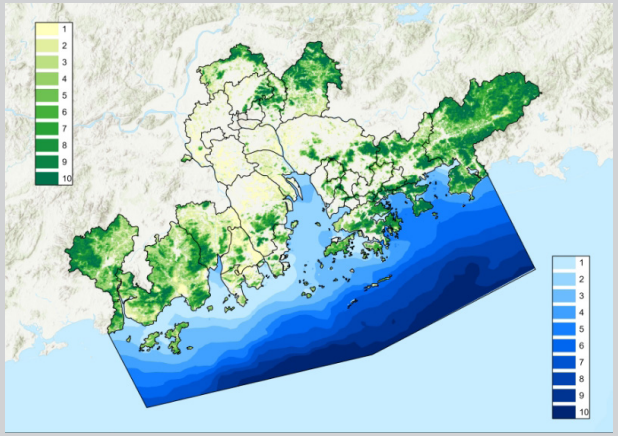


Figure 1: Comprehensive quality and spatial distribution of the study area (2023)

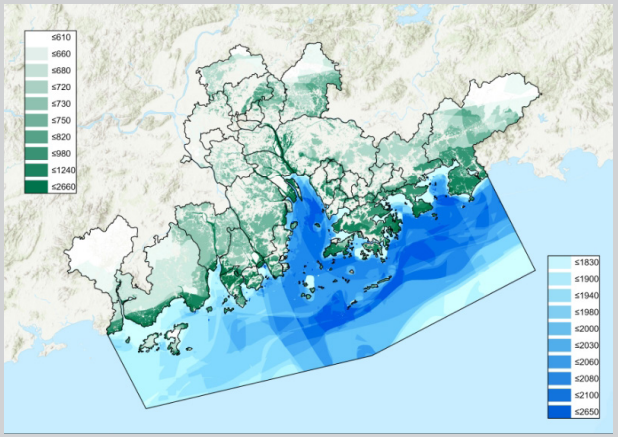


Figure 2: Scores for terrestrial and ocean ecosystem supporting services in the study area (2023)

Glossary

English Term	Chinese Term	Meaning
Blue Finance	藍色金融	Financial tools and investment strategies that support marine conservation and sustainable ocean economic development.
Coastal Zone of the Greater Bay Area	大灣區海岸帶	The geographical scope of this study
Ecosystem Service Accounting	生態系統服務核算	Quantifying the value of ecosystem services using statistical and economic methods, and integrating them into decision-making processes.
Ecosystem Asset	生態資產	Natural resource units capable of continuously providing ecosystem services, such as forests, wetlands, and oceans.
Ecosystem Flow	生態系統流量	The amount of services produced by an ecosystem over a specific period, such as carbon absorption and water purification.
Ecosystem Services	生態系統服務	Benefits provided by ecosystems to humans, including supporting, regulating, provisioning, and cultural services.
Ecosystem Stock	生態系統存量	The physical state of an ecosystem (e.g., area, biomass), representing the quantifiable basis of assets.
Environmental-Economic Accounting	環境經濟核算	Statistical methods that integrate natural resources and environmental changes into the national economic accounting system.
Guangdong-Hong Kong-Macao Greater Bay Area (GBA)	粵港澳大灣區	A regional cooperation and development area including Hong Kong, Macau, and nine cities in Guangdong Province.
Gross Ecosystem Product (GEP)	生態系統生產總值（GEP）	The total value of ecosystem products and services presented in monetary terms, reflecting nature's contribution to human well-being.
Ocean Accounting	海洋核算	Accounting methods that integrate marine ecosystem services into economic and policy analysis, quantifying their value and contributions.
Nature-based Solutions (NbS)	以自然為本的解決方案	Using natural systems or mimicking natural processes to address societal challenges, such as climate change and disaster risk.
System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA)	環境經濟核算體系 生態系統核算	A statistical framework developed by the United Nations to integrate data and values of ecosystems and economic activities.

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