

The blue economy strategies: The plans, The Visions and The Realities - Sustainable aquaculture strategy in china prospects 2030 as a model –

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Abstract:

The study aims to present the theoretical framework for blue economy strategies with diagnosing and analysing their implementation in China as a leading model, and focus on the application of aquaculture strategies. It aims to provide a clear and comprehensive overview of the most important blue economy strategies in general and China's implementation of them, with an evaluation of achievements and future potential for sustainable aquaculture in China and identifying the critical success factors and areas for improvement.

One of the most important findings after the analysis is that China's implementation of blue economy strategies is based on three pillars: targeted policies such the five-year plans (2021-2025), environmental innovation through green technology and sustainable financing, and global integration through international and regional initiatives such as the Belt and Road Initiative, In addition, China's rapid digital transformation through the use of artificial intelligence technologies to monitor water quality and sensors to predict diseases in fish farms has led to an increase in seafood production.

Keywords: Blue Economy, Sustainable Aquaculture Strategy 2030, Chinese Aquaculture

Jel Classification Codes : O13,R11, Q22,Q28,O21,H83,Q01,Q56,O13.

1. INTRODUCTION :

The term ‘blue economy’ was recently popularised by Belgian economist and businessman Gunther Pauli, who called for the sustainable use of ocean resources as a response to global environmental and economic challenges, according to the World Bank: ‘The Blue Economy generates \$83 billion for the global economy on annual base and this figure increases annually.’ The Blue Economy is a comprehensive and innovative approach to sustainable development that focuses on the responsible use and conservation of water resources and seeks to achieve a balance between economic growth, environmental protection and social justice in the seas, oceans, and coasts. The sustainable blue economy relies on the growth potential offered by the seas and oceans and encourages smart solutions to marine challenges within the framework of sustainable development because the future of humanity depends on the health of the water resources, as coastal and marine industries alone have become a major contributor to the global economy.

Research Problem: The blue economy has become a vital model for sustainable development, advocating for the efficient and ethical utilization of marine resources to harmonize economic progress, environmental preservation, and social welfare (World Bank, 2022). Although its importance is widely acknowledged, a substantial disconnect exists between the theoretical frameworks of blue economy strategies, their policy designs, long-term goals, and on-ground execution (Pauli, 2010). As a major contributor to marine-based industries, China has integrated sustainable aquaculture into its blue economy agenda, targeting improved food security, minimized environmental harm, and strengthened coastal economies by 2030 (Hishamunda, 2023). Yet, the degree to which these ambitions translate into tangible outcomes remains unclear.

Multiple obstacles are found in China’s progress toward sustainable aquaculture, such as excessive fishing, environmental contamination from farming activities, weak regulatory compliance, and tensions between profit-driven motives and ecological preservation (Song & Zhang, 2025). The effectiveness of these strategies in achieving ecological sustainability while supporting economic growth requires critical examination. This research investigates the disparities between policy objectives and practical outcomes, identifying key barriers to realizing a truly sustainable aquaculture sector within China's blue economy framework and is aiming to answer the question of “**What are the realities and prospects of implementing a sustainable aquaculture strategy in China?**”

Research Importance : The importance of the study stems from the fact that it deals with the study of a modern and important topic, which is the strategies of the blue economy, which is considered one of the challenges facing countries in general and China in particular due to our study of it as a model in applying one of the most important strategies of the sustainable blue economy, namely the strategy of sustainable aquaculture, which is considered a food policy to ensure food security and one of the pillars of sustainable environmental and social development.

This research holds substantial academic and practical value as it investigates contemporary blue economy strategies, a critical area of sustainable development that presents significant challenges for nations worldwide. Focusing specifically on China's implementation of sustainable aquaculture a pivotal component of the blue economy framework, the study offers critical insights into how this strategy serves dual objectives of ensuring national food security while advancing environmental sustainability. By examining China's approach as a case study, the research contributes to broader discussions on balancing economic growth with ecological preservation

in marine resource management, providing valuable lessons for policymakers and stakeholders engaged in sustainable ocean development.

The study's relevance extends beyond theoretical discourse, addressing pressing practical concerns in global food systems and environmental governance. As sustainable aquaculture emerges as both a food security policy and a driver of social-ecological resilience, this research systematically evaluates its implementation challenges and opportunities within China's blue economy model.

Research Objectives : The study primarily aims at providing a theoretical framework for blue economy strategies by diagnosing and analysing the reality of their application in China as a pioneering model with a focus on the application of aquaculture strategy, in addition to this main objective, there are a set of additional objectives including :

- Giving a clear and comprehensive vision of the most important blue economy strategies in general with a focus on presenting the most important concepts related to the aquaculture strategy.
- To examine China's implementation of blue economy strategies, assessing both achievements and challenges in policy execution and sectoral integration.
- To analyze current practices and future potential of sustainable aquaculture in China, identifying critical success factors and areas for improvement.

These objectives collectively aim to bridge theoretical understanding with practical insights, offering valuable perspectives for policymakers, researchers, and stakeholders engaged in sustainable marine resource management.

Research Methodology : This study employs a descriptive-analytical approach to systematically examine the theoretical foundations and practical applications of blue economy strategies, with particular emphasis on sustainable aquaculture. By synthesizing theoretical insights with empirical evidence from China's model, this study aims to derive meaningful conclusions about the effectiveness of blue economy strategies in achieving sustainable development goals. This methodological approach allows for a structured examination of both conceptual and practical dimensions, providing a balanced perspective on the opportunities and constraints in advancing sustainable aquaculture within the broader blue economy framework.

The structure of the research: To address and answer the research question, the following topics will be addressed:

- The theoretical framework for a sustainable blue economy.
- Concepts addressing sustainable aquaculture.
- China's Strategy for Sustainable Aquaculture in the Blue Economy 2030.

2. The theoretical framework for a sustainable blue economy

2.1 Defining the sustainable blue economy

- 1- The term "blue economy" emerged in early 2012 at the United Nations Conference on Sustainable development (UNCSD) in Brazil (smith-godfrey, 2016, p. 59), Many definitions have been assigned to it :
 - According to the World Bank:" the Blue Economy refers to the sustainable use of ocean and other water resources for economic growth, improved wellbeing, and job creation. The activities that are undertaken need to provide social and economic benefits for current and future generations and should also aim at

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restoring, protecting, and maintaining the diversity, productivity, resilience, core functions and the intrinsic value of the marine ecosystem. Furthermore, they must be based on an economic system that emphasizes clean technologies, renewable energy, waste reduction and the recycling of materials ". (programme, 2018, p. 8)

- On the other hand, UNCTAD defines The “blue economy” or “oceans economy” comprises economic activities that directly take place in the ocean and seas or use outputs from the sea for consumption or as a source of income. At its core, however, is the idea of sustainable use of ocean resources. The blue economy has its origins in the “green economy” concept endorsed at the United Nations Conference on Sustainable Development and has been embraced by many island and coastal nations as a mechanism to realise sustainable growth". (wilkinson, 2025)
- However, OECD defined blue economy as "The ocean economy refers to the economic activities of ocean-based industries, as well as the assets, goods, and services provided by marine ecosystems. It aims to conserve and sustainably use the oceans, seas, and marine resources for sustainable development. As defined by the Sustainable Ocean for All initiative, the sustainable ocean economy emphasises the sustainable use and conservation of natural resources in the world’s oceans, seas, and coastal areas, in line with the 2030 Agenda for Sustainable Development and ocean-related SDGs". (studies, 2024, p. 15)

The blue economy is an economic system that recognizes the value of water resources while ensuring their sustainable management for future generations. Its goal is to establish a framework that enables economic development without compromising the health of marine ecosystems. Scholars have stressed the importance of incorporating sustainability principles into economic activities to balance economic expansion with ecological conservation achieving sustainability within the blue economy while this involves implementing practices that enhance marine ecosystem resilience while supporting local communities and economies. (Taufiq marwa, 2024, p. 04).

And the Blue economy is definng as a set of innovative solutions that contribute to economic and social development through the exploitation of marine resources and ensuring their sustainability and Preservation for future generations.

2.2 The Components of the Blue Economy

The Blue Economy offers a new vision of the maritime domain and the way to exploit its marine resources in order to achieve economic growth while taking into account the sustainability of the marine environment, a concept that combines economy and environmental protection, and to create a sustainable blue economy based on the following Components:

Table (01): The Components of the Blue Economy

Type of Activity	Activity Subcategories	Related Industries/Sectors	Drivers of Growth
Harvesting and trade of marine living resources	Seafood harvesting	Fisheries (primary fish production)	Demand for food and nutrition
		Secondary fisheries and related activities (e.g., processing, net and gear making, ice production and supply, boat construction and maintenance, manufacturing	Demand for food and nutrition

		of fish- processing equipment, packaging, marketing and distribution)	
		Trade of seafood products	Demand for food, nutrition, and protein
		Trade of non-edible seafood products	Demand for cosmetic, pet, and pharmaceutical products
		Aquaculture	Demand for food, nutrition, and protein
	Usage of marine living resources for pharmaceuticals and chemicals	Marine biotechnology and bioprospecting	R&D and usage for health care, cosmetic, enzyme, nutraceutical, and other industries
Extraction and use of marine non-living resources (non-renewable)	Extraction of minerals	(Seabed) mining	Demand for minerals
	Extraction of energy sources	Oil and gas	Demand for (alternative) energy sources
	Freshwater generation	Desalination	Demand for freshwater
Use of renewable non-exhaustible natural forces (wind, wave, and tidal energy)	Generation of (off-shore) renewable energy	Renewables	Demand for (alternative) energy sources
Commerce and trade in and around the oceans	Transport and trade	Shipping and shipbuilding	Growth in seaborne trade; transport demand; international regulations; Maritime transport industries (shipbuilding, scrapping, registration, seafaring, port operations, etc.)
		Maritime transport	
		Ports and related services	
	Coastal development	National planning ministries and departments, private sector	Coastal urbanization, national regulations
	Tourism and recreation	National tourism authorities, private sector, other relevant sectors	Global growth of tourism
Indirect	Carbon	Blue carbon	Climate mitigation

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contribution to economic activities and environments	sequestration		
	Coastal Protection	Habitat protection, restoration	Resilient growth
	Waste Disposal for land-based industry	Assimilation of nutrients, solid waste	Wastewater Management
	Existence of biodiversity	Protection of species, habitats	Conservation

Source: The potential of the blue economy increasing Long-term Benefits of the Sustainable Use of

Marine Resources for Small Island Developing States and Coastal Least Developed Countries p :13-14

From the table, the most important sustainable blue economy strategies can be summarised in the following points :

- **Fisheries and aquaculture:** Fisheries is a vital sector of the blue economy, contributing \$270 billion annually to global GDP, providing livelihoods for 300 million people working in the sector, meeting the nutritional needs of 3 billion people who rely on fish as an important source of protein. Many coastal states, particularly small island developing states, rely on fisheries for services such as ensuring food security, poverty alleviation and employment opportunities, and have huge potential for business opportunities. The seafood economy has reached \$140 billion, with global demand for fish rising from 50 million tonnes to 183 million tonnes, with the global demand for fish increasing from 50 million tonnes to \$183 million. (association, 2025) And The aquaculture sector is expected to be a major factor in achieving the projected growth of the water resources in the region, and the increase in the number of people in the water sector is expected to be a major factor in achieving the projected growth of the water resources in the region, which is expected to be a major factor in achieving the projected growth of the water resources in the region.
- **Sustainable Coastal & Oceanic Tourism :** After fisheries, coastal tourism is one of the most productive activities of the blue economy. It remains a vital economic resource, but it is necessary to strike a balance between the economic benefits and environmental conservation. Innovative eco-tourism models are emerging as a solution to this challenge.
- **Non-living Resources :** This includes offshore oil, natural gas, and minerals such as gravel and sand. Innovations in cleaner extraction methods are critical for reducing the environmental impact of resource extraction ; This is after the globalisation of the Middle East, where most of the world's countries have moved towards the globalisation of the fields, with the majority of the world's countries being in the process of globalisation.
- **Maritime Technology and Innovation :** Biotechnology is a vital sector in the Blue Economy, as the marine environment offers new prospects for the development of many cosmetic and pharmaceutical products and their various chemical constituents.
- **Renewable Energy :** Offshore renewable energy, including wind and wave energy, is one of the most promising sectors for innovation within the Blue Economy. The development of renewable energy sources is central to reducing reliance on fossil fuels and promoting sustainable growth.
- **Ports, Maritime Transport and Shipping :** Maritime transport plays a key role in international trade, as evidenced by the fact that 85 % of the volume of goods is transported by sea. The international maritime

transport system consists of: Ports, tanker ships, maritime navigation people, auxiliary maritime services, most importantly freight shipping.

- **Shipbuilding and Repair** : The shipbuilding industry is embracing innovations aimed at reducing environmental footprints, such as the development of greener fuels and technologies that improve energy efficiency in vessels.
- **Maritime Mineral** : The seas and oceans contain mineral deposits of economic value, including gold, copper and iron, where after the gain of countries suffering from a shortage of minerals on land.

3. Concepts about a sustainable aquaculture

3.1 Definition and Benefits of Aquaculture:

Aquaculture, commonly linked to fish farming, encompasses the cultivation of various aquatic organisms, including fish, crustaceans, molluscs, and seaweed, among others (FAO, 2022, p. 46). This practice offers numerous benefits, such as maximizing fish production to meet global food demands (Bostock et al., 2010, p. 7). Additionally, aquaculture provides high-income employment opportunities, supporting economic growth in coastal and rural communities (World Bank, 2013). A key advantage is its ability to fulfill market demands consistently, overcoming seasonal limitations inherent in wild fisheries (Tveterås et al., 2012, p. 24). Harvesting in aquaculture systems is more controlled and efficient compared to traditional fishing methods, reducing operational challenges (Asche et al., 2018, p.59). Furthermore, aquaculture facilitates the productive use of non-arable lands, including wastelands and desert areas, by utilizing innovative water-recirculating systems (Diana et al., 2013, p.256). This allows for the provision of fresh fish in regions with limited access to natural water bodies, enhancing food security (Belton & Thilsted, 2014, p.60). Aquaculture also promotes sustainability by producing high-quality fish with significant export value while alleviating pressure on overexploited wild fisheries (Naylor et al., 2021, p. 553). By reducing dependence on natural aquatic resources, aquaculture helps mitigate ecological stress, contributing to the conservation of marine biodiversity (Troell et al., 2014, p.8) .

3.2 Sustainable aquaculture theory : Sustainable aquaculture theory emphasizes the importance of balancing economic productivity, environmental sustainability, and positive social impacts in aquaculture practices. In this context, aquaculture is not only seen as a way to increase seafood production but also as a strategy to maintain ecosystem balance and support the livelihoods of coastal communities. Amidst the growing global demand for animal protein, especially fish. Sustainable aquaculture also involves the adoption of environmentally friendly technologies and farming practices that minimize negative impacts on nature, such as effective waste management, efficient use of water resources, and prudent handling of feed and chemical use. Economically, aquaculture creates opportunities for industry players and local communities to engage in broader supply chains. Technological developments in fish farming can reduce production costs, increase efficiency, and foster innovation. (Zainul wasik, 2025, p. 1039)

3.3 Types of Aquaculture :

The types of aquaculture are varied and differ depending on the type of water, the type of marine life, and the system used. Below is a comprehensive categorisation of the most important types of aquaculture :

3.3.1 Classifying aquaculture by water quality : The following chart lists several technologies specific to the three sub-sectors of the aquaculture industry : brackish water, fresh water, and marine water aquaculture.

Table (02): Classifying aquaculture by water quality

Brackish water aquaculture	Fresh Water Aquaculture	Marine Water (Mariculture)
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Fish Farms	Fish Farms	Hatchery Construction
Pond Design	Cage Construction	Cage Construction
Dike Construction	Fish Tank Construction	Recirculation Systems
Hatchery Construction	Water Filtration Systems	Multi-Trophic Aquaculture
	Oxygenation	Hatcheries
	Temperature Regulation	ROVs / AUVs
	Hatcheries	Remotely Operated Vehicles (ROVs)/Ultra Aquatic Vehicles (UAVs)

Source : <https://www.trade.gov/aquaculture-industry-summary>, see 23june2025.

3.3.2 Aquaculture by production technique : Based on the production techniques used, aquaculture can be categorised into four types :

- **Extensive aquaculture (traditional or extensive breeding system):** A non-intensive fish farming system that takes place in semi-natural environments where fish are stocked in ponds or earthen ponds of large areas with low population density, without any feed or supplementary food, as the organisms depend on the natural food available in the pond water and is the least productive aquaculture system.
- **Intensive aquaculture :** A large number of organisms are raised in a small space, with artificial feeding and close monitoring. Example : Concrete ponds or floating cages in seas or rivers where the fish are completely dependent on artificial feeds, which requires expertise and a high degree of control and a high degree of risk.
- **Semi-intensive aquaculture :** Aquaculture is done in controlled environments, medium-sized ponds with irrigation and drainage, and relies on natural food growth through plankton, fertilisation and supplementation with limited use of feed and technology.

3.3.3 Aquaculture according to the type of hatchery : Three types of hatcheries are outlined here :

- **Fish cages :** It is one of the means of raising fish in their natural environment using a cage or a floating box consisting of a wooden frame, net and yarn containing fry suitable for the type of water, whether fresh or salty.
- **Fish farms :** They are basins in which fish fry are placed inside the water suitable for their living may be concrete or earthen bottom These basins allow controlling the entry and exit of water and providing them during the stages of breeding and growth with appropriate nutrition and care for the number of fish.
- **Fish terrariums :** These are submerged areas, with a water height of no more than 150 cm, often adjacent to lakes for easy submergence of the land with water and work to supply it with fish fry, renewable water and add fertilisers to increase its fertility These marinas depend on marine fish farming because the salt content of the lakes is high and not suitable for freshwater fish.

4. China's Strategy for Sustainable Aquaculture in the Blue Economy 2030 :

4.1 China's blue economy between reality and expectations :

The blue economy contributes about 9% of China's GDP (equivalent to 1.25 trillion dollars), with expectations of this percentage rising to 15.84% by the end of 2025. This results from China's sound planning for various blue economy strategies such as marine aquaculture, offshore oil and gas industry, ports and maritime shipping,

shipbuilding, and marine engineering equipment manufacturing. China has achieved advanced positions in global value chains in these sectors. The following presents some of these plans :

4.1.1. Coastal and Marine Tourism :China's total marine economy value exceeded 10 trillion yuan (1.4 trillion US dollars) in 2024, according to the National Development and Reform Commission. This figure includes marine tourism as one of its main pillars, with coastal tourism representing a vital component of China's overall tourism market - projected to achieve a compound annual growth rate of 5.67% until 2029.

Hainan Island stands as China's premier tourist destination, welcoming millions of visitors annually through its luxury coastal resort hotels. Activities such as diving and marine tours generate substantial revenue, alongside destinations like Qingdao and Xiamen which attract tourists with their beaches and cultural festivals.

Regarding government strategies, China will focus on marketing secondary coastal cities (e.g., Yangzhou and Qinhuaogdao) through social media, also supporting investment in major tourism projects like Hainan's "Marine Amusement City", in addition to enhancing service quality to attract foreign tourists (currently comprising 69.8% of visitors, mainly from Hong Kong and Macau) with a projected total tourism revenue reaching 554.4 billion dollars by 2029.

4.1.2. Marine Renewable Energy :China has emerged as the global leader in offshore wind energy, with its operational capacity reaching 42.9 GW by mid-2025 - accounting for half of the world's total offshore wind capacity. Currently, China has an additional 67 GW of offshore wind projects under development. Among the most notable innovations is the world's first Tension Leg Platform (TLP) developed by COOEC, designed to stabilize wind turbines in deep waters up to 136 meters in the South China Sea. This groundbreaking technology improves turbine stability while reducing steel consumption by 20%.

In January 2025, CRRC installed a massive 20 MW floating wind turbine standing 151 meters tall with a 260-meter rotor diameter. A single rotation of this turbine generates enough electricity to power a typical household for four days, while its annual operation reduces carbon emissions by 62,000 tons. The Guangdong offshore wind fleet, with its 11.4 GW capacity, prevents 23 million tons of CO2 emissions annually - equivalent to eliminating the burning of 8.7 million tons of coal.

China is pioneering an ambitious Integrated Energy Island project in the South China Sea, combining offshore wind, floating solar power, desalination, and green hydrogen production. This "Green Power Project" will supply clean fuel to the mainland while serving as a model for sustainable marine energy development. The country projects global offshore wind capacity will reach 244 GW by 2030.

To support these initiatives financially, China has implemented innovative blue finance mechanisms. The Shenzhen Stock Exchange launched the CNI Blue Index, the world's first stock index tracking blue economy companies. Additionally, China has issued specialized "Blue Bonds" to attract investment for marine conservation projects.

Complementing these technological advances, China has implemented ecological innovations such as introducing mosquito fish (*Gambusia*) for natural pest control and developing biofermentation processes to convert marine sediment into agricultural fertilizer. These approaches demonstrate China's comprehensive strategy for sustainable marine resource utilization.

4.1.3. Ports and Maritime Transport in China : Global Leadership and Future Strategies

China has established it self as the undisputed global leader in maritime shipping, operating the world's largest and most advanced port network. This extensive system comprises 34 major ports and over 2,000 secondary ports

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strategically distributed along China's 18,000 km coastline, all supported by state-of-the-art infrastructure. (Ports, 2023)

The Shanghai Port stands as the crown jewel of this network, having handled a record 47 million TEUs in 2021. This represents 25% of China's total foreign trade volume, with the port specializing in bulk commodities including coal, minerals, oil, and steel. Not far behind, the Ningbo-Zhoushan Port processed 28.7 million TEUs in 2020 while maintaining connections to 560 international ports. Its specialized facilities can accommodate massive 250,000-ton crude oil tankers and handle sensitive liquid chemical shipments. Meanwhile, Shenzhen Port serves as a crucial hub for containerized electronics and textiles, linking to 230 international shipping routes. (Ports, 2023)

Technological innovation drives China's port efficiency, with artificial intelligence systems optimizing container management and robotic automation revolutionizing loading/unloading operations - particularly visible in Shanghai and Ningbo. This technological edge supports China's vast global shipping network, connecting to 180 countries through maritime giants like COSCO and Sinotrans. Qingdao Port alone maintains links with 450 international ports, contributing to China's dominant position controlling 33% of global shipping volume and 50% of the world's shipbuilding and offshore equipment market.

Looking ahead, China's maritime strategy emphasizes sustainable development through ambitious initiatives. The Maritime Silk Road program has already directed \$23 billions into modernizing African and Asian ports, strengthening global supply chain connectivity. Domestically, ports are transitioning to clean energy, exemplified by Guangdong's offshore wind projects that power port operations while reducing emissions. Infrastructure expansion continues with deep-water projects like Rizhao's new terminals capable of handling next-generation 24,000-TEU mega-container ships.

4.2 China's Aquaculture Strategy 2030 -The Sustainable Transformation

China's aquaculture sector has undergone a remarkable transformation, evolving into a global leader that produces 52.2 million tons annually - representing 57% of worldwide output. The sector's total value has experienced exponential growth, skyrocketing from 0.95 trillion yuan in 2001 to 9.9 trillion yuan in 2023, reflecting China's successful transition toward high-quality, sustainable development.

The 2030 strategy builds on this foundation through three key pillars : technological innovation, environmental sustainability, and market expansion. Cutting-edge offshore aquaculture systems now complement traditional operations, while smart farming technologies leverage AI and IoT for precision management. The implementation of comprehensive ecological certification systems ensures product quality while protecting marine ecosystems.

China's vision for 2030 focuses on doubling sustainable production capacity through groundbreaking approaches. Integrated multi-trophic aquaculture systems create symbiotic environments that maximize resource efficiency. Advanced monitoring platforms provide real-time data on water quality and stock health, while research into alternative feeds reduces reliance on wild fish stocks. Stringent new environmental regulations complete this holistic approach, ensuring China's aquaculture sector continues to lead the global transition toward sustainable blue food production.

4.2.1 The Historical Development of Aquaculture and the Geographical Distribution of Aquaculture Regions in China

- **History of aquaculture in China :**

China has a long history of aquaculture Fan Li's book "Treatise on Pisciculture" (Yang Yu Jing in Chinese) may be the earliest monograph on aquaculture in the world (Fan, 460 BCE) dated in 460 BCE. Pond culture of

the common carp (*Cyprinus carpio*) was described in this book, including pond conditions, how to breed fish under controlled conditions, and optimal stocking density. After gaining experience with common carp culturing, people began polyculture of grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), and black carp (*Mylopharyngodon piceus*), which have since been established as China's four major freshwater aquaculture species. From 1500, various approaches of collecting carp fry from the wild (e.g., rivers) and then culturing them in ponds were developed. Several integrated fish farming systems, including the combination of fish with sericulture, livestock, and ducks were used in culturing fish and livestock in the 17th century. From 1368, fish farmers were encouraged to trade live fish, which is still a very common practice in China to date.

Although China has a long history of farming fish, aquaculture in the country had been mainly a family-based business before the founding of the People's Republic of China (PR China) in 1949. After 1949, large-scale aquaculture was encouraged by the Chinese government. Thereafter, aquaculture has been one of the fastest-growing agricultural sectors in China. Since the country opened its market to the world and started its economic reform in 1978, Chinese aquaculture has shifted towards large-scale production. In 1990, China established a national aquaculture extension system. This system has been the main engine for growing the country's aquaculture sector since then. The total area dedicated to aquaculture practices has been increased from 3.21 million hectares (MHA) in 1978 to 7.45 MHA in 2017; the number of species used in aquaculture increased from less than 100 in 1978 to more than 800 in 2021 according to the statistics of the National Aquatic Technology Promotion Station. Accordingly, the annual aquaculture production has also increased from 4.3 MMT in 1978 to 52.24 MMT in 2020. (Yue, 2024, p. 207).

Aquaculture in China has a long and rich history, dating back thousands of years. Early records indicate that fish farming began during the Shang Dynasty (1600–1046 BCE), with more systematic practices developing during the Zhou Dynasty (1046–256 BCE) (Gui, J. 2024, p.1). Traditional Chinese aquaculture initially focused on freshwater species such as carp (*Cyprinus carpio*), with integrated farming systems combining fish, livestock, and crops emerging as early as the Tang Dynasty (618–907 CE) (Wang et al., 2020, p.3).

Modern aquaculture in China expanded rapidly in the late 20th century, driven by government policies, technological advancements, and increasing domestic and international demand for seafood (Hishamunda, 2023, p.10). Today, China is the world's largest producer of farmed aquatic species, accounting for over 60% of global aquaculture output (FAO, 2022).

Government initiatives, such as the "Blue Granary" program, have further promoted sustainable aquaculture expansion, particularly in underutilized inland and coastal zones (Ministry of Agriculture and Rural Affairs [MARA], 2021). However, challenges such as environmental degradation, disease outbreaks, and market fluctuations remain critical concerns for the sector's future growth (Cao et al., 2015, p.3).

- **Geographical Distribution of Aquaculture Zones in China :**

China's aquaculture industry is strategically distributed across diverse geographical regions, each with unique ecological characteristics and production specializations. The country's vast aquatic resources, spanning freshwater and marine environments, have enabled the development of distinct production zones that collectively contribute to China's position as the world's leading aquaculture producer.

Geographically, aquaculture in China is concentrated in several key regions :

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- a) Eastern and Southern Coastal Provinces** (e.g., Guangdong, Fujian, Zhejiang, Jiangsu, and Shandong) – These areas dominate marine and brackish-water aquaculture, producing shrimp, crabs, sea cucumbers, and various fish species (Song & Zhang, 2025, p.15).
- b) Yangtze River Basin** – A major hub for freshwater aquaculture, particularly for carp, tilapia, and catfish (Li et al., 2021, p.20).
- c) Pearl River Delta** – Known for high-intensity polyculture systems integrating fish, shrimp, and mollusks (Wang, et al., 2020, p.5).
- d) Inland Provinces** (e.g., Hubei, Hunan, Sichuan) – Focus on pond-based freshwater aquaculture, supplying domestic markets (Liu et al., 2020, p.60).

4.2.2. The development of aquaculture area in China :

Aquaculture has played a crucial role in China’s food security and economic growth, with the country being the world’s largest producer of farmed aquatic species. Over the past few decades, China has significantly expanded its aquaculture area, driven by technological advancements, government support, and increasing domestic and global demand for seafood (FAO, 2022).

Table (03) China: Aquaculture Area (Unit: hectares)

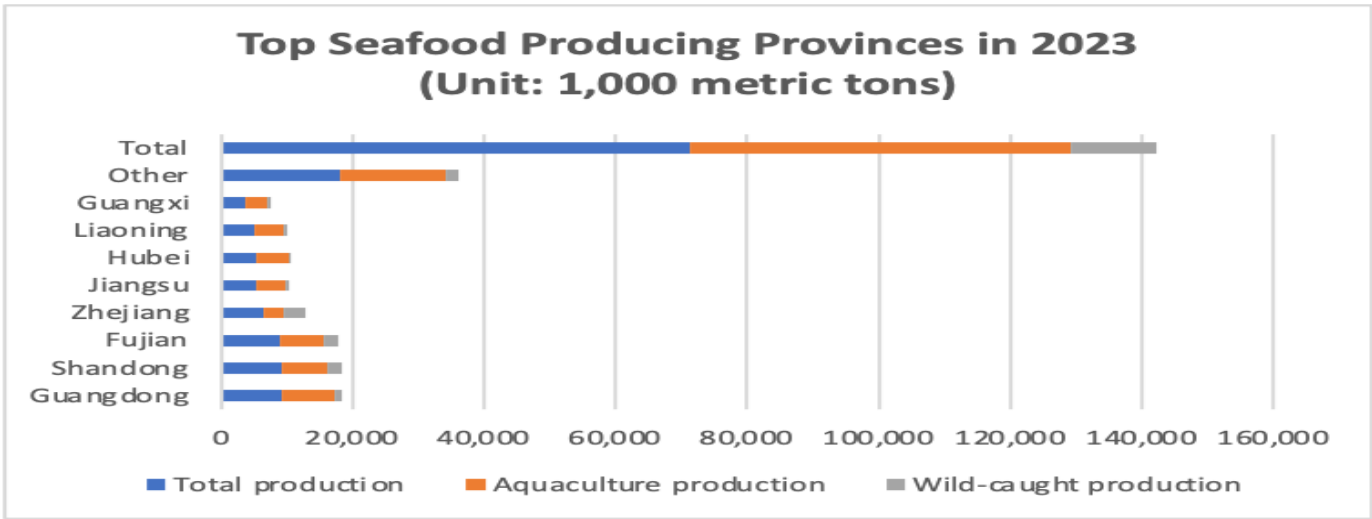
Year	Ocean	Freshwater	Total
2020	1,995,550	5,040,556	7,036,106
2021	2,025,510	4,983,870	7,009,380
2022	2,074,420	5,033,084	7,107,504
2023	2,214,870	5,409,730	7,624,600

Source: 2024 China Fishery Statistics Report from web site <https://www.stats.gov.cn/sj/ndsj/2024/indexeh.htm>

Aquaculture will continue to be the PRC’s major means to increase domestic seafood supply. Consumer demand for high-quality seafood and changes in consumption patterns towards more processed and pre-prepared seafood are expected to continue driving growth in the industry. At the PRC’s 2024 Agriculture Outlook Conference, aquaculture production was forecast to maintain 1.1 percent yearly growth to reach 62.53 MMT in 2033 while the wild catch production will remain stable in general. The share of aquaculture production will reach 82.8 percent in total seafood production by 2033. (Report, 2025, p. 05)

China Fishery Products Report2025. March 20, 2025. FAS China Staff, Ben Boroughs.P:05

Fig.1:Top Seafood Producing Provinces in China on 2023



Source: 2025 China Fishery Products Report.from web site Depicted by the Authors,

In 2023, aquaculture accounted for over 81.6% of China's total seafood production. The table above illustrates the distribution of China's aquaculture and traditional marine fishing production areas, which are divided into: Leading Coastal Production Zones: These include Shandong (the largest producer of red tuna), Jiangsu, Zhejiang, and Fujian. These regions contribute 70% of China's marine aquaculture output, particularly in shrimp, high-value fish (such as king salmon and wolffish), and shellfish.

Inland (Freshwater) Zones: Freshwater aquaculture makes up 70% of China's total aquaculture production. It is concentrated in Henan Province, a model for inland production, with an annual output of 942,500 tons and an annual growth rate of 8.6%. Key cities include Xinyang (28.3% of production), Nanyang (11.1%), and Zhumadian (10.4%). Freshwater fish dominate 80.4% of the output, including silver carp, grass carp, and bighead carp, along with crustaceans like red swamp crayfish (accounting for 88.9% of crustacean production).

4.3 China's Sustainable Aquaculture Strategy (Four key pillars):

As the world's largest producer of aquaculture products, China has embraced a forward-thinking Sustainable Aquaculture Strategy to balance economic growth with ecological preservation. This strategy rests on four foundational pillars: transitioning to eco-friendly farming practices, integrating renewable energy, adopting cutting-edge production technologies, and implementing supportive government policies. By prioritizing innovation and sustainability, China aims to enhance food security, reduce environmental impact, and maintain its leadership in global aquaculture, setting a benchmark for responsible seafood production. The following sections explore each of these pillars in detail, highlighting China's progress and future ambitions in sustainable aquaculture

4.3.1. Strategic Shift Toward Sustainability :China integrates aquaculture into its "Blue Economy" vision to balance economic growth with ecosystem protection through:

- Recirculating Aquaculture Systems (RAS – Green Tech): Reduce water usage by 90% compared to traditional methods, used for high-value species (e.g., turbot, sea bass).
- Biofloc Technology: Converts organic waste into natural feed via bacteria, cutting reliance on synthetic feed by 30% under a circular economy model.

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- **Polyculture Systems:** Example: Integrating oyster and shrimp farming, where shrimp feed on oyster waste, boosting efficiency and reducing pollution. In Sichuan Province, farmers increased income by 35% by combining rice-fish farming, achieving ecological integration under the "Agri-Aquaculture" model. China aims for 4-6% annual growth in marine production while reducing the industry's carbon footprint by 20% by 2030.

4.3.2. Renewable Energy Adoption : To reduce the environmental footprint of aquaculture operations, China has increasingly adopted solar panels and wind turbines to power water pumps and aeration systems, significantly decreasing reliance on fossil fuels. According to Zhang et al. (2022), integrating renewable energy into aquaculture systems has led to an estimated 25% reduction in carbon emissions compared to conventional energy sources. Offshore and inland farms in provinces like Shandong and Guangdong have implemented floating solar panels on ponds, simultaneously generating clean energy and reducing water evaporation (Wang, et al 2020, p.22). Similarly, coastal aquaculture zones have incorporated small-scale wind turbines, particularly in areas with high wind potential, further enhancing energy efficiency (Song & Zhang, 2025, p.50). These innovations align with China's broader "Blue Carbon" initiative, which seeks to mitigate climate change impacts through sustainable marine and aquaculture practices (National Development and Reform Commission [NDRC], 2023). By transitioning to renewable energy, China not only lowers greenhouse gas emissions but also improves long-term economic viability, setting a model for global sustainable aquaculture development.

4.3.3. Innovative Production Models :

- **Deep-Sea Aquaculture:** Moving farms to offshore deep waters improves fish quality, reduces diseases, and supports high-value species (e.g., salmon, tuna). Example: Shandong's sustainable oyster project boosted yields by 22% while lowering nitrogen emissions through deep-sea farming.
- **Smart Aquaculture:** China employs IoT-based systems (e.g., smart water monitoring, automated aeration in Zhejiang Province) to enhance fish quality.

4.3.4. Supportive Government Policies : The Chinese government has implemented several key policies to promote sustainable aquaculture growth, aligning with its broader environmental and food security goals. A major initiative under the 14th Five-Year Plan (2021–2025) allocates \$1.2 billion to expand sustainable aquaculture, targeting a 65% share of total production by 2025 (Ministry of Agriculture and Rural Affairs [MARA], 2021). Complementary measures, such as the Marine Environmental Protection Plan and Blue Carbon Initiative, aim to reduce emissions and mitigate ecological impacts. Additionally, China has introduced green certifications, including China Green Food standards, which mandate antibiotic and hormone free production.

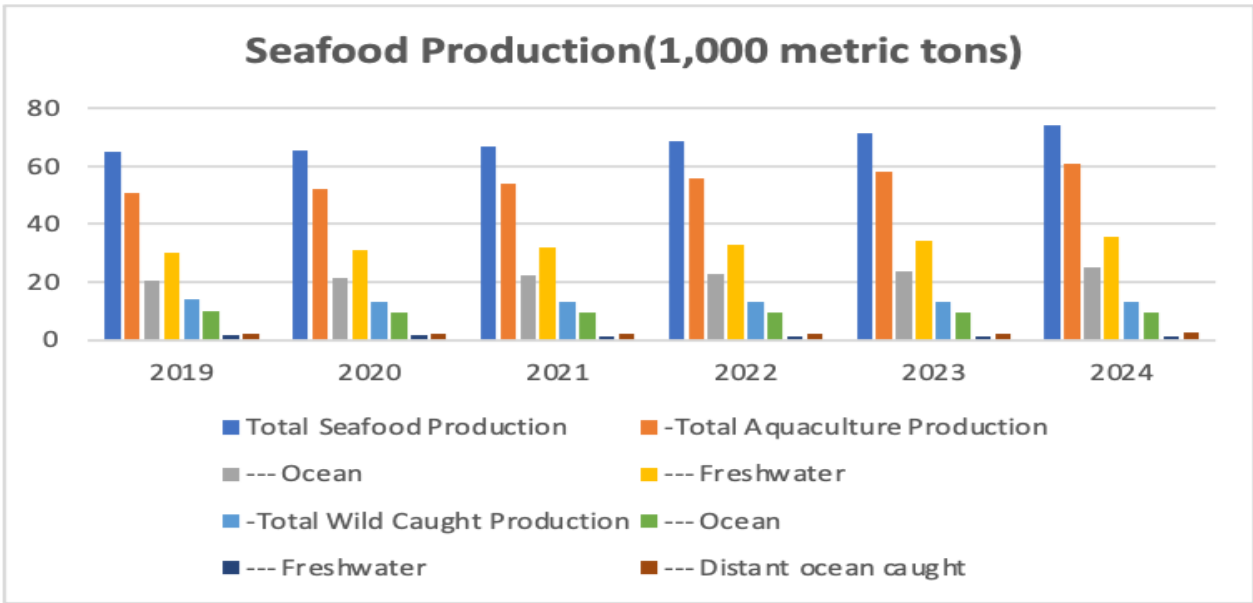
5. Annual Production and Foreign Trade of Marine Products in China (2019-2024) :

China has maintained its position as the world's largest producer of marine products, with aquaculture and capture fisheries contributing significantly to its output. Between 2019 and 2024, the country's annual production of marine products demonstrated steady growth, driven by advancements in aquaculture technology, expansion of mariculture zones, and government support for sustainable fisheries (FAO, 2023).

5.1 Annual Production of Marine Products in China

China's seafood production has demonstrated consistent growth across all categories between 2019 and 2024, with aquaculture continuing to dominate the sector. The data reveals several key trends in production patterns and their implications for China's fisheries management.

Fig.2: Seafood Production(1,000 metric tons)



Source: 2025 China Fishery Products Report.from web site Depicted by the Authors,

The total aquaculture production increased from 50.8 million metric tons in 2019 to a projected 60.8 million metric tons in 2024, representing an average annual growth rate of 3.7%. This growth was distributed across both marine and freshwater systems, with freshwater aquaculture. In contrast to the aquaculture sector, wild capture production showed relative stability with a slight decline from 14.0 million metric tons in 2019 to 13.3 million metric tons in 2024. This reflects China's implementation of fishing moratoriums and conservation measures, particularly in freshwater systems where the catch declined from 1.8 to 1.2 million metric tons. Ocean wild catch remained stable at around 9.5-9.7 million metric tons, while distant water fisheries showed modest growth from 2.2 to 2.4 million metric tons, indicating China's continued investment in its global fishing fleet. The data also highlights aquaculture's growing dominance in China's seafood production system, increasing from 78.4% of total production in 2019 to a projected 82.1% in 2024. This shift aligns with China's national policies promoting aquaculture as a more sustainable and controllable production method compared to wild fisheries. The relatively stable wild catch volumes, particularly in marine environments, suggest successful implementation of China's "zero growth" policy for domestic capture fisheries while maintaining food security through aquaculture expansion.

The data reveals an increasing reliance on aquaculture, which grew by 11.2% over four years compared to essentially flat wild catch production. This trend aligns with global patterns of aquaculture expansion but is particularly pronounced in China due to its advanced farming technologies and extensive coastal and inland water resources. The faster growth in shrimp, prawn, and crab production (compared to fish and shellfish) suggests strategic shifts toward higher-value species in response to market demands and potentially higher profit margins. The stability in wild catches may reflect both ecological limits and policy constraints, indicating that future production increases will likely continue to come from aquaculture expansion rather than wild harvests.

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5.2 Foreign Trade of Marine Products (2021-2024) :In 2024, China's revenue from aquaculture reached approximately \$154 billion, with projections indicating growth to around \$210 billion by 2030. This expansion reflects the country's dominant position in global seafood production and trade, driven by increasing domestic demand and export-oriented aquaculture development. (China aquaculture market size and outlook 2024-2030, 2025)

Table(04): China Exports of Seafood Products by Country of Destination (Unit: Million USD)

Country/Year	2021	2022	2023	2024
World	20,286	21,179	18,490	18,789
Japan	3,375	3,387	2,979	3,054
United States	2,368	2,497	1,959	2,136
South Korea	1,567	1,653	1,553	1,558
Thailand	1,510	1,664	1,298	1,016
Hong Kong	1,446	1,297	1,144	946
Malaysia	1,307	1,636	1,531	1,475
Taiwan	1,210	1,255	1,063	928
Philippines	1,013	996	731	543
Mexico	720	611	513	697
Canada	430	519	377	384
Spain	401	405	404	521
Germany	396	576	471	328
Vietnam	371	427	383	433

Source: China Fishery Statistics Yearbook2025.from web site Depicted by the Authors,

During the 2021-2024 period, several key trends emerged in China's marine product trade. The country maintained its status as the world's top exporter of aquaculture products constituting a substantial portion of shipments to major markets including the United States, European Union, Japan, and Southeast Asia (UN Comtrade, 2024). Concurrently, China's growing affluence drove a 15% annual increase in imports of premium seafood products (Song & Zhang, 2025), from Norway, Canada, and Russia (Global Trade Atlas, 2024) to satisfy rising domestic demand.

The trade landscape during this period was marked by strategic adaptations to global market conditions. Chinese exporters successfully navigated trade barriers such as U.S. anti-dumping tariffs on shrimp products (WTO, 2023) by diversifying into emerging markets across Africa, the Middle East, and Latin America (International Trade Centre, 2024). Simultaneously, the industry responded to evolving international standards by implementing eco-certification programs and enhancing supply chain traceability measures to meet global sustainability requirements

Table (05) : China Imports of Seafood Products by Country of Origin (Unit: Million USD)

Country/Year	2021	2022	2023	2024
World	13,835	18,705	18,781	17,746
Ecuador	2,187	3,562	3,562	3,117
Russia	1,861	2,762	2,891	2,741

Canada	1,063	1,209	1,324	1,266
United States	976	1,138	1,155	1,098
India	961	1,264	1,253	1,147
Norway	726	914	958	984
Vietnam	717	1,680	794	1,200
Indonesia	685	761	828	1,011
New Zealand	465	498	451	453
Thailand	414	424	461	420
Japan	401	546	339	0
Peru	321	190	507	155

Source: 2025 China Fishery Products Report.from web site Depicted by the Authors,

Total worldwide exports declined from 20,286 thousand metric tons in 2021 to 18,789 thousand metric tons in 2024, representing a 7.4% decrease, with particularly notable contractions occurring in 2023 (FAO, 2024). This overall reduction suggests potential challenges including global market volatility, trade policy changes, and supply chain disruptions in the post-pandemic period (World Bank, 2023)

Japan remained China's largest seafood export destination throughout the period, though volumes decreased from 3,375 to 3,054 thousand metric tons (-9.5%). The United States showed greater volatility, peaking at 2,497 thousand metric tons in 2022 before declining sharply in 2023, then partially recovering to 2,136 thousand metric tons in 2024 (UN Comtrade, 2024). Southeast Asian markets demonstrated mixed trends - while South Korea maintained stable imports around 1,550-1,650 thousand metric tons, Thailand and the Philippines experienced significant reductions of 32.7% and 46.4% respectively (ASEAN Statistical Yearbook, 2024).

6. CONCLUSION

This study has demonstrated that China's blue economy rests on three interdependent pillars - economic, social, and environmental - which operate synergistically to advance sustainable development. Through our examination of China's key blue economy strategies, with particular focus on the 2030 Sustainable Aquaculture Strategy, several critical findings emerge that address our central research question: What are the realities and prospects of implementing a sustainable aquaculture strategy in China?

Our analysis reveals that China's strategic implementation framework combines policy direction (particularly through Five-Year Plans), environmental innovation via green technologies, sustainable financing mechanisms, and global integration through initiatives like the Belt and Road. Despite operational challenges, including the 20% higher costs associated with energy-intensive Recirculating Aquaculture Systems (RAS) and persistent environmental concerns - successful models in Shandong and Guolian demonstrate China's steady progress toward dominating the global sustainable seafood value chain, maintaining a consistent 6% annual growth trajectory toward 2030 targets.

Three transformative trends particularly stand out in addressing the research problem of policy-practice gaps: First, the rapid digital transformation incorporating AI-driven water quality monitoring and predictive disease sensors is bridging theoretical efficiency goals with practical implementation. Second, the circular economy applications converting aquaculture waste into biofuel and recycled feed represent tangible solutions to the

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ecological contamination issues identified in prior literature. Third, the environmental vision focusing on emission reductions (with 244 GW renewable energy targets by 2030) directly confronts the tension between production growth and ecological preservation that Song & Zhang, 2025 highlighted.

The research confirms China's unique position as both the world's largest producer and consumer of marine products, with aquaculture now supplying over 60% of domestic seafood consumption, a critical achievement for food security given its 1.4 billion population. The development of 34 major fishing ports supporting \$7.7 billion in annual export revenue further demonstrates how infrastructure investment translates policy into economic reality.

These findings carry significant implications for both academic discourse and practical policymaking. They suggest that while challenges persist in regulatory compliance and cost management, China's multifaceted approach, combining technological innovation, circular practices, and global market integration, provides a replicable model for implementing blue economy strategies. The study particularly contributes to understanding how major economies can navigate the delicate balance between marine resource utilization and conservation, offering valuable insights for other nations developing sustainable aquaculture frameworks. Future research should monitor the long-term viability of these strategies as China progresses toward its 2030 carbon neutrality and food security goals.

Results also revealed China's implementation of blue economy strategies which demonstrates significant achievements in policy execution and sectoral integration, though notable challenges persist. The country has successfully aligned its national development agenda with sustainable marine resource management through comprehensive five-year plans, technological innovation, and global partnerships like the Belt and Road Initiative. Key accomplishments include the expansion of sustainable aquaculture, which now supplies over 60% of China's seafood demand while reducing pressure on wild fisheries, and the adoption of digital technologies (e.g., AI-driven monitoring) to enhance efficiency. However, challenges such as high operational costs in Recirculating Aquaculture Systems (RAS), regional disparities in enforcement, and the need for stronger circular economy integration highlight gaps between policy ambitions and on-the-ground realities.

Looking ahead, China's sustainable aquaculture sector holds substantial potential, particularly through advancements in renewable energy adoption, waste-to-resource innovations, and export market diversification. Critical success factors include continued investment in green technologies, stricter regulatory oversight, and enhanced stakeholder collaboration across the value chain. Areas for improvement focus on scaling cost-effective RAS solutions, improving small-scale farmer participation in sustainability initiatives, and strengthening international certification compliance to meet global market standards. By addressing these dimensions, China can solidify its leadership in the blue economy while offering replicable models for sustainable aquaculture development worldwide. This analysis underscores that China's progress, while impressive, requires ongoing refinement to fully realize its 2030 vision of ecological and economic balance in marine resource utilization.

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