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Marine Tech for Tourism Industrial Transformation in Developing Emerging Marine Tourism for Environmental Sustainability in the Greater Bay Area

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Abstract: Through case study method researching the possibility of transformating the economic development mode of the Greater Bay Area, this paper aims to find how marine technology can help the sustainable tourism development in Greater Bay Area. As part of this paper, efforts will be made to clean up tourism pollutants, educate and publicize the need to safeguard the marine environment and use coral planting to develop new ecotourism to improve the GBA's sustainable development model. By discovering the current development dilemmas faced by the Greater Bay Area, we will explore how sustainable economic development can contribute to its development. According to our preliminary findings, coral planting contributes substantially to marine ecology and has been used to maintain aquatic product quality and diversity in South Africa and Malaysia, as well as to protect coastal cities from erosion. To develop environmental sustainability in the GBA, an investigation of emerging marine tourism industries is proposed through a marine exhibition and coral planting project. Meanwhile, exploring the limitation would be met when conduct marine tech for sustainable economic development.

Keywords: Marine Tourism; Great-Bay Area; Tourism Industry; Marine Exhibition; Sustainable Development; Marine-Tech.

1. Introduction

As society has developed, pollution has become more severe, including climate change [19, 22], marine pollution, and overfishing, which have also contributed to a variety of environmental problems [48]. Biologically complex, diverse, and fragile, coral reefs are some of earth's most fragile ecosystems. It is worth noting that since the reform and opening of the Great Bay Area [18], the area has always focused more on industrial development than on tourism and cultural development [20]. In the post-pandemic period, people will be better able to understand economic activities and marine environmental protection as a result of these studies, and they will be more able to promote harmonious relationships between the marine environment and economic growth [21]. Furthermore, the GBA economies have been adversely affected by COVID-19, which has forced them to seek new methods to stimulate economic growth, such as sustainable tourism initiatives[1]. Innovation is an essential component of marine tourism development. In addition to product innovation, tourism transformation and innovation are also essential[3,42]. There has been an increase in the mainstreaming of eco-innovation, eco-efficiency, and sustainability over the years. Historically, tourism has played an inefficient role in stimulating the economic growth of the Greater Bay Area[23, 32], whereas the traditional tourism industry is currently unable to meet the increasing demands of consumers, which means that the industry needs to undergo a transformation so that it can meet these demands in the long run. In a blue ocean economy, marine resources are utilized in an innovative way within the local economy of a region [20].

1.1. Literature review

1.1.1. Economic Distribution in the Greater Bay Area

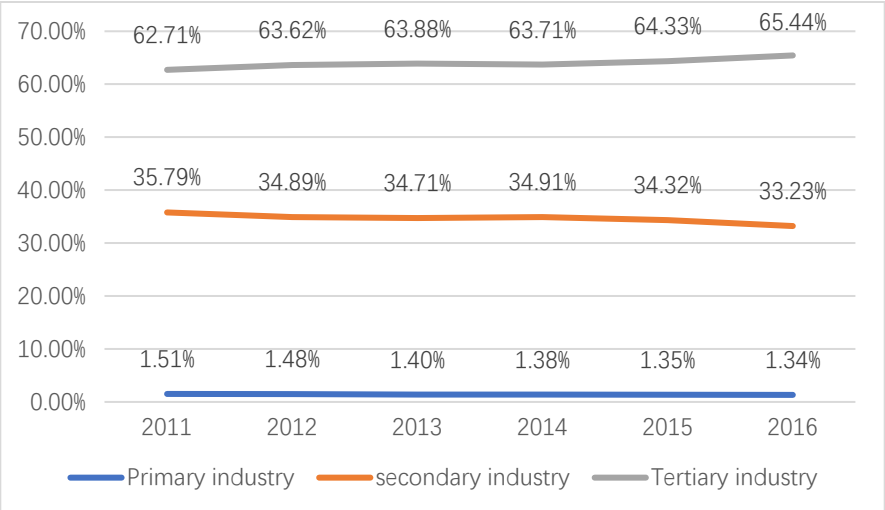

Figure 1. Proportion of industries in the Greater Bay Area *(Data resource: Guangdong Provincial Bureau of Statistics, Census and Statistics Department of the Hong Kong Government, Macao Statistics and Census Service, Yiou Think Tank)*

The Guangdong-Hong Kong-Macao Greater Bay Area is transitioning towards a service-based economy and striving for innovation. The Greater Bay Area's economy has shifted from an industrial to a service and innovation-based economy. As a result, the tertiary industry has become the largest industry, while the secondary industry has experienced a slow decline in proportion. Economic growth is now driven by the service sector rather than industry. While in Liu et,al,' paper, it is found that the deterioration of river pollution in the Greater Bay Area is consistent with economic development, and the pollutant discharge and riparian habitat destruction are concluded and other human activities are the main causes of organic matter pollution in the Dongjiang Basin. The development of the tertiary industry in the Greater Bay Area indicates that economic tourism is a contributing factor to the pollution of its banks and the ocean. Therefore, it is necessary for the tertiary industry to transform and upgrade towards sustainable economic development.

Additionally, according to the study, the pressure on the GBA's marine economy has not been reversed over the past 20 years [13]. There is a threat to the marine ecosystem and socio-economic system due to the limitation of marine resources and the unlimited demand for tourism [4, 15]. Developing innovative seaside industries and seaside tourism projects is necessary to enhance the economic growth of the GBA in the future[38]. In view of the current analysis of the Chinese marine tourism industry, it appears that at this time there are some successful cases for the development of domestic seaside tourism that have been documented so far [8, 47], in order to better understand and analyze the transformation and development of seaside tourism in the GBA. Based on an evaluation of the development of seaside tourism in the Greater Bay Area, there is a need to further develop innovation from the perspective of tourism resources and needs[54]. Based on a thorough analysis of the seaside tourism industry in the Greater Bay Area, it has been found that there is still tremendous potential for development[32]. Chinese cities are also experiencing a problem of environmental pollution when it comes to the development of tourism by the seaside [14].

This article explores the emergence of exhibition tourism as a potentially profitable offering in the tourism industry. This rise can be attributed to the influence of the COVID-19 era and the overall growth of the tourism sector. To facilitate the transition and interconnectivity of the region's economy, an innovative development strategy for the Greater Bay Area (GBA) is noteworthy. In this era of technological advancements, artificial intelligence (AI) is being used to address various challenges, including the transformation of marine tourism. A report titled 'The science and technology that can help save the ocean' from MIT Technology Review highlights the significance of marine technology as a fresh approach to foster marine development in the Greater Bay Area [51]. AI has the potential to play a significant role in shaping the future of marine tourism in the region.

The development of AI has led to more sophisticated methods for dealing with ocean pollution, revolutionizing the way we approach environmental challenges. AI has made significant contributions to the field of ocean pollution by collecting and analysing vast amounts of data from various sources, including satellite imagery, underwater sensors, and social media platforms. Through the processing of this data, AI algorithms can identify patterns, detect pollution hotspots, and predict the movement of pollutants in the ocean. Additionally, AI-powered robots and autonomous underwater vehicles (AUVs) have been developed to assist in the cleanup of ocean pollution.

Coastal cities and sustainable development agents must consider environmental policy protection and sustainable development methods when developing marine tourism [40]. Tourism projects can protect the environment through coral planting projects [8, 39] and seaside exhibitions [41, 48]. Coastal tourism has developed a range of unique products to meet the increasing demand for coastal experiences by tourists. These products incorporate abundant resources and encompass traditional tourism, leisure vacations, and innovative experiences [13, 47]. Set Macao as an example, the figure 2 illustrates that the current single industry structure in Macau is unsuitable for future economic development. Furthermore, the concentration on the gaming industry has a negative impact on the economy, hindering the growth of other sectors. Macao's tourism industry must be developed while protecting the local sea area to create a healthier economic structure. It is important to note that the region's tertiary industry relies heavily on the gaming industry, but diversification is necessary for long-term sustainability.

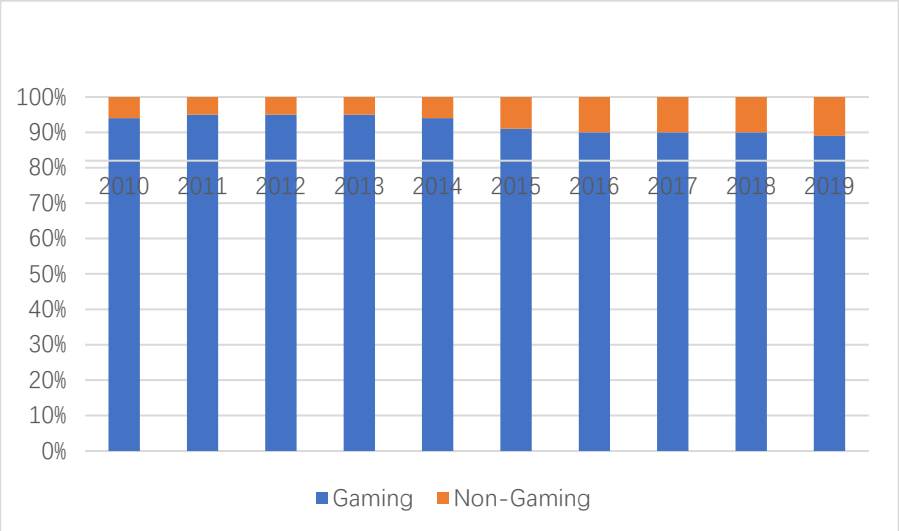

Figure 2. Revenue structure of Macao gambling companies (*figure cited from CICC Research Department*)

The development of tourism in the Greater Bay Area presents a valuable opportunity to promote economic growth and sectoral transformation across industries and regions[35, 40]. However, given the significant economic downturn experienced since the Great Depression, it is crucial for travelers to consider the potential changes to the industry's 'new normal' in light of the current situation [6]. Seaside tourism plays a vital role in the GBA's efforts to transform into more sustainable, inclusive, and visitor-centric industry, as highlighted by Hollinshead[17]. By focusing on the development of coastal areas and their tourism potential, the GBA can attract more visitors and create a more environmentally friendly and socially responsible tourism sector. In summary, the GBA is facing the challenge of reviving its economy after the epidemic outbreak. To achieve this, a significant change in the economic structure is necessary, with a focus on green economies and the development of the GBA Marine Economic Belt. The tourism sector, particularly seaside tourism, offers a promising avenue for economic development and transformation in the region.

1.1.2. Digital and Intellectual Tourism

The pandemic has permanently changed both the supply and demand ends of the tourism industry. The tourism industry will accelerate the process of digital and intelligent transformation. On the consumer side, the convenience level of basic tourism services will grow remarkably; on the supply side, digital technology will accelerate innovation, a large number of digital and intellectual products and services will be created leading to the change of organizational form of the industrial chain[3]. Furthermore, the pandemic also changes in the relationship between domestic and international markets slowing down the process of internationalization. Therefore, the domestic tourism market becomes the focus of competition. The advantage of GBA is its vigorous development of high-tech industries in Hongkong, Macao and Shenzhen. Robotics [30], artificial intelligence, big data, and virtual reality, as the advantageous industries in the GBA, can change the existing tourism model to achieve digitization and intelligence, and optimize and expand eco-tourism. These technologies can maximize eco-tourism services, optimize resource allocation, and arrange tourism services according to user needs. To achieve this goal, our project will not only be limited to improving services and technologies but will also actively invest in academic exchanges and joint innovations with local enterprises and scientific research institutions to apply the latest information technology and intelligent technology to continuously improve service efficiency and enhance user experience.

1.1.3. Marine Tech Used for Habitat Tourism

The output of GIS [12, 36], also known as location intelligence, includes intelligent maps that visually represent spatial data. These maps display information like population density, land use patterns, and transportation networks. GIS enables spatial analysis, uncovering patterns and identifying trends. Real-time dashboards provide up-to-date information and visualizations for monitoring and tracking phenomena. During the coronavirus pandemic, GIS-based dashboards were used to track the virus spread and analyze its impact. These interactive data visualization tools help decision-makers comprehend information and make informed decisions.

In 2017, the world's first 3D ocean map was released, revolutionizing ocean-related data and sustainability solutions. It benefits various stakeholders, including scientists, environmental managers, fishermen, shippers, and citizen scientists [37, 52]. Through AI, users can virtually navigate and explore the ocean, gaining valuable insights and classifying information quickly. The use of 3D printing for artificial reefs [29] has gained attention due to its potential to address habitat loss and degradation in marine environments. This technology allows for custom-designed structures that mimic natural reef formations, providing a suitable habitat for marine organisms. Artificial reefs can be tailored to specific ecological requirements, incorporating intricate designs and features to offer shelter, protection, and foraging opportunities. Sustainable materials [1, 24], such as biodegradable polymers or recycled materials, can be used for reef production, reducing the ecological footprint. 3D printing technology streamlines the production process, reducing costs and enabling rapid deployment in multiple locations. This approach offers opportunities for large-scale reef restoration projects. Overall, 3D-printed artificial reefs contribute to habitat protection and restoration, promoting marine biodiversity and the sustainability of our oceans.

1.2. Research Areas to be Addressed

The research area of this article focuses on the transformation and upgrading of the tourism economy in the Greater Bay Area. This paper focuses on the transformation and upgrading of the tourism economy in the Greater Bay Area. It explores the role of marine science and technology in promoting this process. The Greater Bay Area, including Hong Kong, Macau, and Guangzhou, is known for its vibrant tourism industry. However, the tourism sector needs to adapt to remain competitive with technology and changing consumer demands. Marine science and technology have emerged as key drivers in this transformation. Advancements in marine science have led to sustainable tourism practices, attracting environmentally conscious tourists and preserving the natural beauty and resources of the area. Technology integration has revolutionized the visitor experience, using virtual reality and augmented reality for immersive tourism. These advancements attract more tourists and enhance their satisfaction, leading to increased economic benefits. Marine science advancements have also facilitated the development of marine-based industries, diversified the regional economy and created employment opportunities. The article highlights the significant role of marine science and technology in transforming and upgrading the tourism economy in the Greater Bay Area. Utilizing these fields can adjust to market dynamics, attract more tourists, and ensure sustainable tourism practices.

2. Research Method

2.1. Data Design

In addition to analyzing contextualized research and case studies, this study also explores the role of sustainable practices in the development of seaside tourism in the Greater Bay Area. By examining theoretical cases and experiences, the study highlights the importance of incorporating environmentally friendly approaches in coastal tourism development. It also discusses promoting responsible waste management, implementing renewable energy sources, and preserving natural habitats and ecosystems in coastal areas.

The study explores the socio-economic impact of seaside tourism in the Greater Bay Area, including job creation, economic growth, and the well-being of local communities. The study aims to provide a comprehensive understanding of the potential benefits and challenges associated with the expansion of seaside tourism in the region through examining empirical data and conducting interviews with stakeholders. The findings offer valuable insights into the possibility and necessity of developing seaside tourism in the Greater Bay Area. By considering both theoretical frameworks and practical experiences, it sheds light on the role of marine technology, sustainable practices, and socio-economic factors in shaping the future of coastal tourism in this Greater Bay Area.

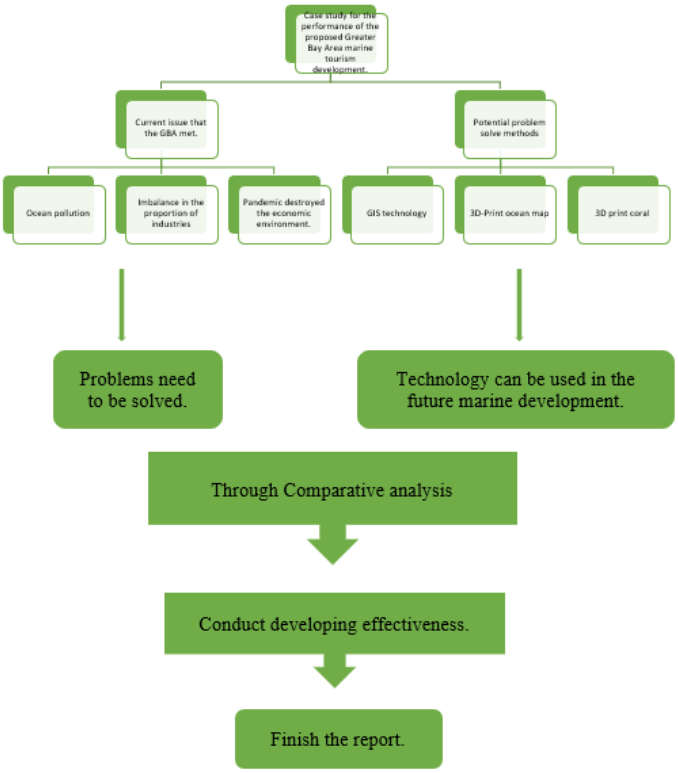

Figure 3. Research Framework

2.2. Collection

Apply qualitative research methods to conduct in-depth and detailed research. In this study, we will apply qualitative research methods to study the topic through three aspects. And we conduct the three aspects to three research questions:

RQ 1: What are the main reasons that the Greater Bay Area search for a new economic transformation.

RQ 2: How can the marine exhibition industry help popularize marine environmental protection knowledge to tourists to achieve sustainable development of the GBA through coral planting tourism project and some other habitats projects.

RQ 3: How Marine-Tech used for ocean economic sustainable development in Greater Bay Area.

Table 1. Research methods that used

Research methods	Research point	Advantages
Historical research	• Fact-finding, evaluation, organization, and analysis of past investigator method for habitats economic development. • Through the research of marine tourism industry and Marine-Tech, find a new way for Greater Bay Area development.	• Provides an important reference. • Helps to diversify the research methods and theories.
Empirical research	• Understand the potential of marine technology for economic development and pollution control. • Focusing on the "what" of the Greater Bay Area economic transformation itself.	• Enhance the credibility of the study.
Comparative research	• Analyze the similarity or different degrees of marine economic. • Provide a comparative reference for researching artificial intelligence (AI) used in different industries, especially in the marine tourism industry.	• Analyze the similarity or different degrees of different development methods. • Provide more specific analysis
Case Study	• Examine the current development trends and challenges facing the Greater Bay Area. • Identify future economic transformation in the region and development trends.	• Help clarify research questions. • Help conduct the research flow.

The qualitative research method is suitable for this research because we use historical research [9, 16], empirical research, and comparative research to conduct in-depth and detailed research on sustainable tourism projects in the GBA in a natural environment and the major projects that have already used in the marginal tourism industry in Macau. In addition, the paper will try to carry on the transformation of tourism enterprises by lessening the pollution brought by tourists. The specific steps are show in Table 1.

2.3. Practice Data Analysis and Result

Promote sustainable development of coastal cities by using marine exhibitions. In order to solve the research questions, the method of promoting the development of marine exhibition will be adopted to promote the sustainable development of coastal cities. This process will include the following aspects:

(1) Find the relationship and implication between tourism industry development and habitats pollution.

The rapid development of the economy, the intensive establishment of enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area, and the expansion of cities and towns have resulted in a series of severe water pollution problems. The economic prosperity of the Greater Bay Area has been marred by the negative consequences of water pollution. This pollution has not only disrupted the ecological environment but also hindered the development of economic construction. It is important to address this issue to ensure sustainable growth. The establishment of densely populated production enterprises and the continuous expansion of urban areas have resulted in the convergence of various types of production and domestic sewage[27, 49], ultimately leading to large-scale water pollution. This pollution spreads from point to area, making the task of treating water pollution in the Greater Bay Area more complex and arduous. To address this issue, it is necessary to implement effective measures to control and reduce water pollution. According to the Communiqué on the State of the Marine Environment of Guangdong Province, the Guangzhou section of the Pearl River, the Shenzhen River, the Dongguan Canal, the Longgang River and the Pingshan River have been severely polluted throughout the year and have not shown significant improvement in the past decade. The excessive levels of inorganic nitrogen and reactive phosphate are the main reasons for the deterioration of water quality. These can lead to eutrophication of seawater quality, resulting in the overgrowth of algae plants and the mass death of other marine organisms due to a lack of oxygen. According to Wang Juying, director of the National Marine Environmental Monitoring Center, there are still four types of poor water quality in coastal waters. The main indicators that exceed the standard are inorganic nitrogen and active phosphate. Nitrogen and phosphorus in coastal waters primarily originate from river input, agricultural non-point source pollution, urban industrial wastewater and domestic sewage discharge, marine aquaculture activities, and marine atmospheric deposition. The economic and tourism development of the Greater Bay Area is unstoppable. However, it has also caused pollution in the Bay Area due to industrial and population pressures. It is important to address these issues to ensure sustainable growth.

(2) The coastal exhibition project will create a good improvement for environment and tourism development of GBA.

A series of exchanges were conducted at the "2022 Asian Ocean Tourism Conference" held in Ningbo by experts and scholars from around the world regarding the development of marine tourism resources and the measures that should be taken to promote its development. It provides an excellent platform for Asia to conduct maritime tourism exchanges. Communication between experts and scholars can lead to the development of many new ideas. Also, the expert seminar and on-site research activities contributed to the development of coastal tourism in GBA of Guangdong, Hong Kong, and Macao, in order for GBA to achieve a win-win situation with the surrounding countries and regions.

A coastal exhibition will contribute significantly to the development of coastal tourism in the GBA and provide a powerful impetus for GBA's transformation into a new type of tourism while promoting sustainable development. Despite the fact that coral has been cultivated for a long time in other countries with good results, it remains a relatively new concept in China. Globally, coral reef ecological environments are deteriorating and disappearing. Throughout China, coral reefs have suffered serious ecological degradation, and the government and the GBA are paying close attention to the restoration of coral reefs. In the coastal exhibition area, a group of relevant personnel will demonstrate the degradation of coral reefs in the GBA and explain the importance of coral reefs to the marine environment. While showing the successful precedents of coral planting around the world, it can also encourage us to cultivate coral. As a result of knowing the concept of blue growth[10], people will be more concerned with protecting blue resources and reducing marine pollution when participating in coastal tourism projects. Additionally, they will be more enthusiastic about protecting coral growth environments and participating in coral planting projects. Communicate and exchange with other provinces, cities or countries through coastal exhibitions.

2.4. Conclude the Data

Advocating the sustainability, economic value and compatibility with the lifestyle in the GBA by implementing the coral planting project. Considering the GBA's ecology, marine science, economy, and human geography, coral planting is an example of a pilot project that promotes the transformation of the tourism industry in the GBA. The project's primary objective is to add value to coral plating with a minimum impact on the environment or economy. A proper and precise repositioning of coral planting in the GBA will result in the transformation of the tourism industry from traditional tourism to ecotourism. For the purpose of enhancing sustainability, economic value, and lifestyle compatibility, the project employs the following four methodologies.

3. Findings

The Greater Bay Area for Sustainable Marine Development can promote local ecological conservation advocacy and achieve sustainable development goals through coral planting. The Okinawa Prefecture Government in Japan has already undertaken a large-scale coral transplantation project in 2022 to restore the coral reef ecosystem. This project demonstrates the importance of coral cultivation for both humans and the ecology. Planting coral seedlings is an empowerment program for coastal communities that aims to restore the ecological

function of coral reef resources through conservation and rehabilitation activities carried out by participatory community groups[11]. This highlights the significance of coral cultivation for both humans and the ecology. Planting coral seedlings is a program that empowers coastal communities to restore the ecological function of coral reef resources through conservation and rehabilitation activities. The program aims to achieve this by planting coral seedlings. Planting coral seedlings is an empowerment program for coastal communities aimed at restoring the ecological function of coral reef resources through conservation and rehabilitation activities.

This activity is one of the closest to marine ecological protection and allows people to act together to protect the marine ecology. This is consistent with the initial speculation that coral can restore the ecosystem. Studies have shown that this area of the Greater Bay was once rich in coral populations. The Greater Bay Area (GBA) in China's southern Guangdong Province is situated within the South China Sea (SCS), approximately 700 km from the Coral Triangle, which harbours the greatest coral diversity in the world [8, 44]. This finding supports the feasibility of the coral planting project, as coral colonies exist to demonstrate that the water quality conditions are suitable for implementation. We chose to plant coral to restore the marine ecology because it is fragile and easily affected by human interference. By protecting the coral and increasing the area of coral planting, we can help restore the survival and reproduction of other organisms in the marine environment. Additionally, the state of coral can be used as an indicator of the health of the marine ecology in the future[31, 33]. Coral planting is a step towards transitioning from traditional tourism to ecotourism. It is offered free of charge to visitors who participate in the recreational diving program. NASA data indicates that there is an overlap between the locations of coral reef damage and GBA scuba diving sites. Therefore, we will analyze the extent of coral damage to estimate the number of divers available for controlled planting and other protective measures to reduce coral damage.

The Greater Bay Area for Sustainable Marine Development can promote local ecological conservation advocacy and achieve sustainable development goals through coral planting. The Okinawa Prefecture Government in Japan has already undertaken a large-scale coral transplantation project in 2022 to restore the coral reef ecosystem. This project demonstrates the importance of coral cultivation for both humans and the ecology. Planting coral seedlings is an empowerment program for coastal communities that aims to restore the ecological function of coral reef resources through conservation and rehabilitation activities carried out by participatory community groups[11]. This highlights the significance of coral cultivation for both humans and the ecology. Planting coral seedlings is a program that empowers coastal communities to restore the ecological function of coral reef resources through conservation and rehabilitation activities. The program aims to achieve this by planting coral seedlings. Planting coral seedlings is an empowerment program for coastal communities aimed at restoring the ecological function of coral reef resources through conservation and rehabilitation activities.

In line with our paper's theme, we are promoting a sustainable development goal. The discharge of harmful water in the city is a significant factor in the lack of coral. Therefore, the development of marine sustainability in the Greater Bay Area can transform national tourism into ecotourism. This transformation can help restore the ecology in the marine and reduce sewage discharge and pollution caused by human activity. Coral planting aims to implement proactive measures to achieve the goal of transitioning from traditional tourism to ecotourism, thereby reducing the negative impact of business activities on the environment and society[5]. The proposed method of evaluation will be Sustainable Business Models. The concept of value proposition is advocated to create a value logic that integrates the value needs of multiple stakeholders. This approach not only creates value for segmented customers, as emphasized in the traditional business model, but also brings benefits to all stakeholders. A sustainable business model integrates a company's economic goals with those of sustainability while simultaneously pursuing the interests of all stakeholders. There is a contradiction between the current state of marine tourism resource development and the demand for marine tourism in the Greater Bay Area. The Sustainable Ecological Model can help find business solutions that achieve both economic and sustainability goals while considering various stakeholders in the development of marine tourism resources.

3.1. Environment-friendly Sustainable Tour Services

In order to carry out the transformation from traditional tourism to ecotourism, renewable energy and eco-friendly technology will be utilized to provide sustainability for all the replaceable services including entertainment, transport, and manufacturing. There are two benefits of developing ecotourism with green energy[2] and technology:

(1) Renewable energy including solar, wind, tidal and biomass energies have been consistently drawing increasing attention due to their feasibility to regulate CO_2 emission and produce value added products with lower exhaust, less or no pollution, and more reasonable approaches of energy sources and consumption. The fuel of seaborne vehicles and underwater heating systems are expected to consume renewable energy to avoid oil leakage or heavy metal pollution.

(2) Green technology applies environmental science, green chemistry, marine engineering and electronic devices to coral planting and related human activities. The objective is to curb the negative impacts of human involvement. Currently, the transplant coral reefs are fixed using proxy putty and cement. Petroleum-based plastics remain underwater for centuries before they can be completely biodegraded. Therefore, the highlight of the project is to focus on the eco-friendlier approaches to serve and guide tourists in the utilization of green energy resources including biodegradable materials and less hazardous pesticide/nutrients [7].

The evaluable of sustainable tour services will be conducted by quantifying the overall interests of the environment-friendly sustainable tour services from an economic point of view and compared with those using traditional fuel and technologies. The evaluation is expected to consider the entire lifecycles of the tour services from manufacturing to waste disposal.

3.2. Local Ecosphere Oriented Marine Economics

Coral planting tourism aims to farm and reattach broken coral pieces in the diverse marine ecosystems of the GBA. It also aims to construct stronger and more resilient ocean

ecosystems. The text should be clear, concise, and objective, following academic structure and formatting with a formal register and precise word choice. The blueprint proposes making coral planting the focal point of dive ecotourism, aquaculture, and fishery. The coral ecosphere is formed by a transplanted reef-building coral species and a distinct microbial environment, providing a habitat for marine life. This ecosystem offers long-term economic benefits by protecting coastlines, providing food and medicines, and having potential economic value through fishing, diving, and snorkelling on and near reefs. Therefore, a strategy to transplant coral will be implemented to restore and conserve the ecosystem, including associated fish stocks and marine ecosystems. Factors such as seawater temperature, salinity, marine species, underwater landforms, and sea activities of residents will be considered to study the relationship between marine resources and human activities in the GBA.

3.3. Educational Tourism and Publicity

When constructing ecotourism projects, it's crucial to recognize the importance of local people and receive local policy support. Engaging with educational institutions can effectively increase project exposure and promote the concept of marine ecological protection to the public. Collaboration with educational institutions can take various forms, such as organizing workshops and seminars to educate students and the local community about sustainable tourism and environmental conservation. Policies at the city and government levels aim to support environmentally friendly businesses and technologies. By aligning with these policies, the ecotourism project can benefit from existing infrastructure and resources in the region. Collaboration with local communities is proposed to preserve natural resources, protect the environment, and promote sustainable tourism. This collaboration may involve engaging local residents in conservation efforts, such as beach clean-ups and reforestation projects. Involving the community fosters a sense of responsibility and enhances the tourism experience for visitors. By acknowledging the significance of local people, receiving local policy support, and collaborating with educational institutions and communities, the ecotourism project can promote sustainable development in the GBA while conserving the region's natural beauty and cultural heritage.

4. Discussions

The Greater Bay Area (GBA) is a region bordering the South China Sea with abundant marine resources, a large population base, a high-tech talent pool, and robust economic growth. Yet, excessive urbanization and tourism development have also contributed to serious marine pollution[26, 28] . The negative impacts of human activity, such as plastic pollution[43], heavy metal emissions, and carbon emissions[25, 46], are gradually reducing the number of corals and fish in the GBA, which not only destroys biodiversity but also affects the sustainability of the marine ecosystem. The importance of marine sustainable development in the GBA is often overlooked until irreversible damage has been sustained. The development of non-polluting ecotourism services alone is clearly insufficient in this context. The marine tourism industry must be transformed into one that has a positive impact on the environment.

The paper focuses on cleaning up tourism pollutants, promoting education, and raising awareness about marine environment protection. Additionally, it proposes the use of coral planting to develop new ecotourism and improve the GBA sustainable development model. These studies aim to enhance people's understanding of economic activities and marine environmental protection and promote harmonious development between the marine environment and economic growth in the GBA during the post-pandemic period[7,21]. Our preliminary research suggests that coral planting has several benefits for marine ecology. These include preserving the quality and diversity of aquatic products in South Africa and Malaysia, as well as protecting coastal city coastlines from erosion. Walters and Samways[45] and Praveena et al. [34] suggest investigating emerging marine tourism industries in the GBA through a marine exhibition and coral planting project to promote environmental sustainability. The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) has a long coastline and numerous port clusters. However, its marine ecosystems and biodiversity are at risk, particularly due to human domestic sewage discharge. Additionally, coral reefs and other marine life face threats from global warming. While the GBA has encouraged industrial development, tourism and cultural industries have been neglected. It is important to raise awareness and promote responsible use of coastal resources[53]. A sustainable development plan for the marine environment is necessary. Transforming tourism can play a key role in promoting economic and environmental sustainability. Local tourism companies in coastal cities have negatively impacted marine ecology due to their lack of consideration for the environment. The use of Marine-Tech, such as GIS and 3D ocean maps, provides valuable data for understanding marine ecosystems and making informed decisions for conservation and resource management. The 3D Digital Ocean Map is a useful resource for environmental managers, fishermen, and shippers. It allows them to optimize their operations and reduce their impact on vulnerable ecosystems. Citizen science, facilitated by user-friendly interfaces and AI algorithms, has empowered individuals without formal scientific training to contribute to ocean research. This has led to a more comprehensive understanding of the ocean and increased public engagement in marine conservation efforts. In conclusion, the world's first 3D ocean map has revolutionized ocean-related data and sustainability solutions. The map divides the ocean into ecological ocean units and utilises AI technology to provide valuable insights for scientists, environmental managers, fishermen, shippers, and citizen scientists. It is an indispensable tool for understanding, protecting, and conserving our precious marine ecosystems.

After seeking more specific information about the ocean in the Greater Bay Area, it is convenient to explore the actual ocean zones that can be utilized for the development of the ocean tourism industry. The Greater Bay Area is known for its diverse marine ecosystems, offering a wide range of opportunities for ocean tourism enthusiasts. One of the prominent ocean zones in the area is the Pearl River Estuary, which serves as a vital gateway connecting the South China Sea to the Greater Bay Area. This estuary is not only a significant shipping route but also a rich habitat for various marine species. Exploring this zone can provide valuable insights into the region's marine biodiversity and the potential for sustainable tourism activities. Additionally, the Greater Bay Area is home to several picturesque coastal areas, such as the beaches of Shenzhen and the islands of Hong Kong,

which offer stunning landscapes and recreational activities for visitors. By delving into these ocean zones, one can gain a deeper understanding of the region's natural beauty and the immense potential for the development of the ocean tourism industry.

The coastal advantage can open up new employment opportunities in the coastal cities of the GBA. A paradigm shift in tourism, local infrastructure, and a green economy will be developed[50]. However, locals do not understand the importance of protecting marine ecosystems while developing their economies. They do not possess the specific measures needed to achieve sustainable ocean development. The government is striving to establish a sustainable economic development model for the ocean by promoting a blue economy, characterised by resource conservation and recycling. This aligns with our recommendations for the development of the tourism industry. Currently, we are analysing two possible implementation strategies based on extensive literature. As an initial measure, the restoration of coral reefs should be prioritised by modifying tourism practices and promoting the rehabilitation of marine ecosystems. Additionally, coral planting projects should be integrated into marine recreational activities, and professional teams should guide small groups of tourists in coral sightseeing and planting activities. The second program will collaborate with the Department of Cultural Propaganda to conduct exhibition visits on marine conservation, using the theme of coastal cities. The project aims to promote the local landscape, raise public awareness of the harm caused to the sea by human activity, and encourage actions to preserve the ocean. This will enhance public awareness of environmental protection and coordination of actions. Other notable developments in the field of marine conservation in the Greater Bay Area include advancements in coral reef planting through 3D printing technology. In 2016, the Hong Kong University of Science and Technology (HKUST) research team introduced a butanolide antifouling coating for vessels and fishing nets. This coating was designed to reduce the toxicity of these materials to the marine environment. The researchers aimed to address the issue of biofouling by applying an innovative antifouling coating. Biofouling occurs when marine organisms such as algae, barnacles, and mollusks attach themselves to submerged surfaces. It affects the performance of vessels and fishing nets and poses a threat to marine ecosystems by introducing invasive species and increasing pollution. The butenolide antifouling coating, developed by the HKUST research team, offers a more environmentally friendly alternative to traditional coatings. It effectively prevents the attachment of marine organisms to surfaces, reducing the need for frequent cleaning and maintenance. This improves the efficiency and lifespan of vessels and fishing nets, while also minimizing the release of harmful substances into the water[26]. The coating's introduction is a significant advancement in marine conservation efforts in the Greater Bay Area. It reduces the toxicity of materials used in maritime activities, promoting better water conservation and reduced pollution. This aligns with the region's commitment to sustainable development and environmental protection.

Also, the importance of conducting research in marine ecosystems in the greater Bay Area is discussed in the paper:

(1) Human activities have a significant impact on marine ecosystems. The marine environment is one of the most important parts of the planet. A variety of sustainable marine development plans, especially for coastal residents, are necessary in order to minimize the negative effects of human activity on the marine environment and to identify the root causes of effective problem-solving.

(2) In the field of tourism, there are various tourism models, such as mass tourism and nature tourism, all of which do not provide participation in nature protection and participation in tourism. Furthermore, they are not aware of the benefits they provide to local communities, such as the preservation of marine ecosystems. Tourism models other than ecotourism are often built without considering the welfare of local people or respecting the environment, but ecotourism seeks to minimize the environmental and social impact of its operations.

(3) Ecotourism is a new model of tourism that promotes coexistence between people and nature. As a result of promoting green activities in tourism, such as public interest marine exhibitions, people may gain a deeper understanding of marine ecosystems and become more involved in conservation by participating in other related hands-on green activities or parent-child activities related to the marine environment. Several countries around the world have implemented coral planting programs as a part of their efforts to protect the environment and restore marine ecosystems.

4.1. Implication for Innovation Management

Since the beginning of the 21st century, the Greater Bay Area's service industries have been on the cusp of a new era, thanks to technological advances and an increase in demand. In recent years, there has been a growing focus on sustainable development. This has made the Greater Bay Area an important location for reducing environmental pollution while promoting tourism. This is not only the demand of the Greater Bay Area in China, but also the common goal of the economic development of the Bay Area around the world. Attention should be paid to the innovation of management, science, and technology in the Bay Area. The implementation of the marine exhibition project and the coral planting project is a demonstration of the need for sustainable management in the modern tourism industry, not only for economic development. Industrial management in the Greater Bay Area could utilise marine technology to develop the economy in a cost-effective, environmentally friendly, and sustainable manner.

5. Conclusion and Limitation

5.1. Conclusion

According to the Greater Bay Area's development plan, it is essential to promote the region's green development, safeguard everyone's environment, and ardently promote an ecological civilization. By doing so, the idea of green development will be established, and the development of green, low-carbon production and lifestyles will be supported, as well as the sustainable growth of the region. Our proposal topic is closely related to the above content. We may be able to incorporate marine sustainability as part of the sustainable development of the Greater Bay Area, and the above policy support can assist us in transforming the national tourism industry into ecotourism in a manner that matches the government's proposed development goals. As for the convenience of transportation, the country's major tourist cities have been affected to varying degrees by the epidemic. In the Greater Bay Area, the high-speed transportation hubs

have formed a network that facilitates efficient connections between major cities and can be viewed as a place for a large number of tourists to visit during this period of gradual liberalization of the epidemic. Tourist transportation is a prerequisite for the realization of tourism activities. When the number of tourists increases, it is the best time to transform ecotourism. We can do this quickly by organizing exhibition tours and ecological promotion events. Due to policy support and increased traffic, we will be able to invite local cultural institutions to participate in exhibitions and promote maritime sustainability education and publicity. In conjunction with the local tourism unit's proposal for coral planting to restore the marine ecosystem, a series of diving programs for a fee is proposed, but coral planting is included in the diving program for free, which contributes to local economic growth.

5.2. Limitation

The proposal's limitations fall into three categories. Firstly, the sample size was not large enough to ensure representativeness of public opinion. Secondly, there is a lack of published reports on marine sustainability in the Greater Bay Area. Finally, official organizations need to provide additional data. To ensure privacy, certain data cannot be made public. Additionally, it is important to verify the authenticity of the collected data as there may have been inaccuracies in the responses provided by the respondents. The authors of these studies must pay more attention to the events and latest information related to the marine environment in the future. Additionally, they need to conduct field research in the Greater Bay Area to explore the real situation of pollution and the application of science and technology in the area. This will help them find the most suitable path for the development of the Bay Area.

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