

Cross-border ecological cooperation in the Guangdong-Hong Kong-Macao Greater Bay Area: Pattern, characteristics and challenges

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CITATION

Liu X, Yang Z, Li L. (2024). Cross-border ecological cooperation in the Guangdong-Hong Kong-Macao Greater Bay Area: Pattern, characteristics and challenges. *Journal of Infrastructure, Policy and Development*. 8(8): 5131. <https://doi.org/10.24294/jipd.v8i8.5131>

ARTICLE INFO

Received: 10 March 2024

Accepted: 15 April 2024

Available online: 16 August 2024

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Abstract: Cross-border ecological cooperation is always a challenging issue. Ecological cooperation in the Guangdong-Hong Kong-Macao Greater Bay Area has its own uniqueness as it is cross-border cooperation under “One Country, Two Systems”, which is different from multinational cooperation or regional collaboration within one country. This paper analyses the cooperation documents of Guangdong, Hong Kong and Macao, official reports and academic literature, and then summarises the unique pattern of ecological cooperation in the Greater Bay Area under “One Country, Two Systems”. It outlines four characteristics: different priorities in ecological management of each side, case by base cooperation, government-dominated cooperation with low public participation, and huge institutional gap between three sides. This article also identifies several problems and causes: lack of common ecological targets for each side and effective cross-border regulative measures, cumbersome coordination in cross-border cooperation. Finally, four feasible recommendations have been put forwarded: creating new institutional arrangements under the context of “One Country, Two Systems”, establishing the efficient decision-making platform for the inter-city cooperation, introducing the market-based resource allocation, and encouraging public participation in ecological monitoring.

Keywords: cross-border cooperation; ecological cooperation; the Guangdong-Hong Kong-Macao Greater Bay Area; cooperation pattern; characteristics

1. Introduction

As one of the most open and economically vibrant regions in China, the Guangdong-Hong Kong-Macao Greater Bay Area is a cross-border cooperation area promoted by the Chinese government under “One Country, Two Systems”. Regional cooperation in the Greater Bay Area has promoted the economic development, but the fruits of rapid industrial development have also brought about serious environmental pollution. Ecological problems such as air and water pollution, and alienation of biological population structure have emerged one after another, affecting the life quality of local population.

The Greater Bay Area is located in South China and encompasses nine cities in Guangdong (Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen and Zhaoqing) as well as the two Special Administrative Regions of Hong Kong and Macao. The Greater Bay Area covers an area of approximately 56,500 km², with a resident population of 86.62 million in 2023, making it the most densely populated Bay Area urban agglomeration in the world, with the highest population density exceeding 1200 people/km². Under the unique political and spatial arrangement, the Greater Bay Area belongs to one country but has borders within the region. Ratti (1993) once builds three models of borders: closed border, filtering border and opened border. The Greater Bay Area falls into the filtering border as there

are limited communication and transportation within the region. Filtering borders have a role to play in filtering out undesirable elements, thereby protecting the region's own internal economy and standard of living (Bujdosó et al., 2015; Matlovičová et al., 2015). However, cross-border cooperation facilitated communication between regions that were previously separated by borders, since regions willing to gain access and keep open to each other (Bujdosó et al., 2011). The Greater Bay Area with borders reserves the place for the central government to promote the regional cooperation among Guangdong, Hong Kong and Macao while they are at different development levels.

Rapid urbanisation and the region's well-developed manufacturing cluster have led to huge consumption of water and energy in the region. Moreover, the different stages of development and development structures of the cities in the Greater Bay Area have led to different major sources of environmental pollution, so the targets and contents of ecological regulations in these cities are not exactly the same. Cities in Guangdong are still in the middle stage of industrialisation, with the secondary industry accounting for 40.12% of GDP in 2023 (Statistics Bureau of Guangdong Province, 2024), and manufacture is still the dominant industry within the province, which results in that industrial production and fossil energy emissions are the main source of environmental pollution. Therefore, from the published carbon neutral plans of cities in Guangdong Province, the focus is still on the reform of industrial technology and the application of green technology, as well as the reduction of pollution caused by traditional transport such as vehicles. While the tertiary sector of the economy (finance, commerce, logistics and gaming, etc.) accounting for more than 90% of GDP in Hong Kong and Macao, as the post-industrial society stage, the service sector and residents' lives are the main sources of environmental pollutants (Xu and Ma, 2022).

The conventional national-based perspectives on cross-border cooperation are scarcely applicable in the Chinese context (Breslin, 2000). In February 2019, the promulgation and implementation of the Outline Development Plan for the Greater Bay Area is a landmark document for the comprehensive construction of the Greater Bay Area (The State Council, 2019). The document points out the need and necessity to strengthen the construction of ecological civilization. This policy orientation shows that ecological protection is both an important support for the construction of the Greater Bay Area, and likewise a construction goal of the Greater Bay Area (Gou et al., 2022).

The existing studies on ecological cooperation in the Greater Bay Area mainly focus on the water resources and air quality. The atmospheric pollution in Guangdong, Hong Kong and Macao shows obvious regional and compound characteristics. Excess ozone emissions and serious fine particulate matter contiguous pollution affects a wide range of areas, which exhibits that air quality in the Greater Bay Area still has a large gap compared with those well-developed countries (Xu et al., 2019). Secondly, the pollution level of polybrominated diphenyl ethers (PBDEs) in the Greater Bay Area is significantly higher than that in other international bay areas. For example, the concentration of PBDEs in the tributaries of the Pearl River ranges from 0.34 to 68 ng/L, whereas that in the coastal waters of Sweden is less than 1 pg/L (Liu et al., 2019). With the transfer of chemical and ceramic industries to areas outside the Pearl River

Delta (PRD), drinking water sources in the north of the area are also threatened by pollution (Gou and Gong, 2022). In fact, the habitat quality of the Greater Bay Area (habitat quality refers to the ability of an area for the sustainable development and survival of individuals and populations) declined steadily after 1990, manifesting the gradual contraction of high-grade habitat areas and the expansion of low- and medium-grade habitats, in particular the clustering of low-grade habitats on both the east and west sides of the Pearl River (including Hong Kong and Macao) (Zheng et al., 2023). This suggests that the ecological environment is in continuous deterioration with the constant development of the Greater Bay Area, and the spatial changes in low-grade habitats on both sides of the Pearl River also indicate the need for improved cooperation among Guangdong, Hong Kong and Macao. Other regions' experiences may expand horizons and provide lessons. Successful management of Rhine River proves the feasibility of cross-border ecological cooperation and provides experiences for the Greater Bay Area (Dieperink, 2000).

With the economic development of the Greater Bay Area, ecological protection has become the critical issue for the sustainable development in this region. This paper intends to explore the unique cross-border ecological cooperation pattern and characteristics in the Greater Bay Area under the context of "One Country, Two Systems". On the one hand, it is in dialogue with existing theories and literature on the cross-border cooperation, and on the other hand, it provides feasible policy recommendations for contemporary ecological conservation cooperation in the Greater Bay Area.

For the above purposes, we collect the ecological cooperation documents and official reports of Guangdong, Hong Kong and Macao and news reports about the ecological cooperation of the Greater Bay Area from 1990 to 2024, and academic literature on cross-border ecological cooperation as our analysis data to explore the current status, characteristics and underlying causes of the ecological cooperation. Based on the content analysis, we identify the ecological cooperation pattern, characteristics, and challenges. Finally, some feasible policy recommendations have also been proposed. During the whole process, we also dialogue with the existing theories and literature over the cross-border cooperation in the ecological protection, which contributes to better understanding the ecological cooperation in the Greater Bay Area.

The rest of this paper proceeds as follows: The second section identifies the cross-border ecological cooperation pattern of the Greater Bay Area. The third section summarizes four characteristics of the ecological cooperation. Section four explores three underlying reasons of these characteristics. Section five throws out four recommendations to improve the cross-border ecological cooperation. Finally, we have a brief conclusion.

2. Cooperation pattern of the Greater Bay Area

Ecological linkages are complex and always go beyond borders (Strübel, 1992), hence environmental issues need cross-border cooperation, in particular among governments (Scherer and Zumbusch, 2011). Thus, we have collected and collated almost all important government documents on cross-border ecological cooperation

between Hong Kong, Macao and Guangdong from 1990 to 2023 to explore their cooperation pattern (**Table 1**).

Table 1. The Guangdong-Hong Kong-Macao Ecological Cooperation Group and important documents on cross-border ecological cooperation.

Group and Document	Year	Content and Activity	Area
Hong Kong-Guangdong Environmental Protection Liaison Group	1990	1. To exchange views on environmental issues of common concern. 2. To draw up joint action plans to deal with cross-border water pollution.	Guangdong, Hong Kong.
The Hong Kong-Guangdong Joint Working Group on Sustainable Development and Environmental Protection	2000	To enhance cooperation in cross-border environmental issues.	Guangdong, Hong Kong.
The Pearl River Delta Regional Air Quality Management Plan	2003	1. A set of measures to enhance the potential of the air pollution control measures. 2. To compile a regional atmospheric emissions inventory for the two governments to evaluate the progress and effectiveness of the air pollution control measures. 3. To strengthen technical exchange and training to officers of the region with a view to enhancing their knowledge on regional air quality issues.	Guangdong, Hong Kong.
Outline of the Plan for the Reform and Development of the Pearl River Delta	2008	1. Enhancement of resource conservation and environmental protection. 2. Creation of new situation for opening-up and cooperation.	Guangdong, Hong Kong, Macao.
Regional Cooperation Plan on Building a Quality Living Area	2012	To establish long-term cooperation directions in five major areas: environment and ecology, low-carbon development, culture and people’s livelihood, optimization of regional land use, and green transportation organization.	Guangdong, Hong Kong, Macao.
Framework Agreement on Cooperation Between Guangdong and Macao	2013	To Promote cooperation between Guangdong and Macao in environmental monitoring, environmental protection industry, and environmental emergencies	Guangdong, Macao
Cooperation agreement on regional air pollution control and prevention	2014	1. Establishing a joint PRD air quality monitoring platform for Guangdong, Hong Kong and Macao; 2. Jointly release regional air quality information; 3. to take forward air pollution control and prevention measures; 4. Scientific environmental studies cooperation; 5. Fostering exchanges and promotion activities on environmental technology among the three sides.	Guangdong, Hong Kong, Macao.
Cooperation Agreement on Regional Air Pollution Control and Prevention among Hong Kong, Guangdong and Macao	2014–2017	Enhance the regional air quality monitoring network by increasing the number of monitoring stations and parameters, and releasing real-time hourly concentration of each air pollutant.	Guangdong, Hong Kong, Macao.
The 2016–2020 Cooperation Agreement between Guangdong and Hong Kong on Environmental Protection	2016	Strengthen air quality monitoring, protection of water environment and nature conservation in the region.	Guangdong, Hong Kong.
The 2017–2020 Cooperation Agreement between Guangdong and Macao on Environmental Protection	2017	To strengthen exchanges and cooperation in environmental protection planning, environmental monitoring, solid waste treatment, and environmental protection industry cooperation.	Guangdong, Macao
The Hong Kong-Guangdong Marine Environmental Management Special Panel	2017	To enhance exchange and cooperation on marine environmental issues, including marine refuse management and response actions to marine environmental incidents	Guangdong, Hong Kong.
A memorandum of cooperation	2018	To promote the development and application of retro-commissioning of buildings in the Greater Bay Area for enhancing energy saving.	Guangdong, Hong Kong, Macao.

Table 1. (Continued).

Group and Document	Year	Content and Activity	Area
The Hong Kong-Guangdong Joint Working Group on Environmental Protection and Combating Climate Change	2019	<ol style="list-style-type: none"> 1. to improve regional air quality in the Pearl River Delta; 2. to jointly protect the water environment; 3. Strengthen cooperation in forestry care; 4. to care for marine resources; 5. to respond to climate change and study the causes of ozone formation to reduce regional ozone pollution. 	Guangdong, Hong Kong.
the Meteorological Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area (2020–2035)	2020	<ol style="list-style-type: none"> 1. Further strengthening meteorological cooperation among Guangdong, Hong Kong and Macao; 2. Involving areas such as meteorological data sharing; 3. Meteorological scientific research and innovation, and training of meteorological personnel. 	Guangdong, Hong Kong, Macao.
The Hong Kong-Shenzhen Task Force	2021	To deepen cooperation and jointly take forward various cooperation items including further improvement of water quality of Shenzhen River	Guangdong (Shenzhen), Hong Kong.
The Joint Study on Post-2020 Regional Air Pollutants Emission Reduction Targets and Concentration Levels	2022	To continue to work together on ozone reduction and control.	Guangdong, Hong Kong.
Cooperation Arrangement on Carrying Out Marine Ecological and Environmental Protection Work	2023	<p>Strengthening technical exchange and cooperation in following areas:</p> <ol style="list-style-type: none"> 1. water quality monitoring; 2. smart technology application; 3. and marine pollution emergency response and impact assessment. 	Mainland China, Hong Kong.
Framework Agreement on Cooperation in the Conservation of Wetlands in Shenzhen Bay (Deep Bay)	2023	<ol style="list-style-type: none"> 1. Exchange in the areas of simultaneous survey and intelligent monitoring of waterbirds (black-faced spoonbill); 2. Control of alien species such as Mulberry and Mulberry petalless; 3. Conservation of key habitats and foraging grounds in waterbird flyways; 4. Ecological baseline surveys, and nature education activities 	Guangdong (Shenzhen), Hong Kong.

Sources: Based on government documents and news reports.

The ecological cooperation in the Greater Bay Area is the cross-border regional collaboration under the background of “One Country, Two Systems”. The Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area states that it is necessary to strengthen cooperation in ecological protection among Guangdong, Hong Kong and Macao to jointly improve the ecological systems; to strengthen the protection and restoration of wetlands, to comprehensively protect the internationally and nationally important wetlands in the region, and to carry out cross-border joint protection of coastal wetlands (The State Council, 2019). Ecological protection cooperation in the Greater Bay Area is dominated by city-to-city cooperation as well as government and business cooperation within cities, but relatively little multi-city cooperation (Wang et al., 2021). Regarding the cooperation direction, ecological cooperation in the Greater Bay Area mainly focuses upon the protection of air and water resources. In terms of the cooperation targets, the vast majority of city-level cooperation within Guangdong Province occurs between neighbouring cities such as Guangzhou and Foshan, Shenzhen and Dongguan within the PRD (Xu and Ma, 2020). Among cross-border cooperation, Hong Kong and Guangdong are more active, with extensive and in-depth cooperation since the central government proposed the construction of a beautiful China in 2012, while Macao was not so active. Guangdong, Hong Kong and Macao have gradually established a collaborative governance mechanism based on an administrative agreement as the top-level design, and cooperation joint meetings and task forces (Cheng et al., 2022).

Since 1990, Hong Kong and Macao have tried to reach an exchange of views on cooperation with the bordering governments out of their own needs. The Outline of the Plan for the Reform and Development of the PRD, a seminal programme document of the central government to formally plan for the future development of the PRD, was released in 2009. Since then, a number of cooperation talks have been held between Guangdong, Hong Kong and Macao to find the appropriate cooperation mechanism. In 2014 the signing of the “Agreement on Regional Air Pollution Prevention and Joint Control Cooperation”, was the first official cross-border ecological cooperation among the Greater Bay Area. Since then, the frequency of cross-border ecological cooperation in the Greater Bay Area has gradually increased. In 2016, Guangdong and Hong Kong signed the Agreement on Hong Kong-Guangdong Cooperation in Environmental Protection for 2016–2020 to promote Hong Kong-Guangdong cooperation in the areas of air, water, environmental monitoring, scientific research on environmental protection, environmental protection industry, and notification of environmental emergencies and incidents. The environmental authorities of Guangdong and Macao signed the “Framework Agreement on Environmental Cooperation between Guangdong and Macao” and the “Agreement on Environmental Cooperation between Guangdong and Macao for the Period of 2017–2020” in 2013 and 2017 respectively to promote cooperation between Guangdong and Macao in the areas of environmental monitoring, environmental protection industry, and notification of accidents and incidents of environmental emergencies, which also served as the foundation documents for Macao and Guangdong to discuss the relevant eco-cooperation thereafter. On 12 December 2019, the Hong Kong-Guangdong Joint Working Group on Sustainable Development and Environmental Protection and the Hong Kong-Guangdong Liaison and Coordinating Group on Climate Change were merged to the Hong Kong-Guangdong Joint Working Group on Environmental Protection and Climate Change. At the fifth meeting of the new Hong Kong-Guangdong Joint Working Group in 2023, Hong Kong and Guangdong governments expressed their willingness to maintain close cooperation to improve air quality, protect the water environment, enhance forestry care, marine resources care and address climate change in the Pearl River Delta region. In addition, the Joint Working Group has endorsed a work plan for 2024, under which Hong Kong and Guangdong will continue to promote and enhance cooperation as well as scientific research on climate change mitigation, adaptation and resilience. The Pearl River Delta Regional Air Quality Management Plan has been actively implemented. Hong Kong and Guangdong will continue to take forward the inclusion of routine monitoring of volatile organic compounds (VOCs). Guangdong and Hong Kong will also strengthen exchanges and cooperation in areas such as staff training and publicity and education.

At the initial stage of ecological cooperation, Guangdong, Hong Kong and Macao had their own economic development pressures and air pollution control was their respective responsibilities. The Hong Kong and Macao government reduced air pollutant emissions, while Guangdong focused on energy reforms. In 2014, the three governments signed the Guangdong-Hong Kong-Macao Regional Air Pollution Prevention and Control Cooperation Agreement, which included the need for air quality protection as one of the regional development indicators, and the cooperation in the management of air pollution problems has been effectively implemented and

regulated (the Environmental Protection Department of Hong Kong, 2014). By early 2024, air quality in the Greater Bay Area has improved significantly, with more than 60 per cent of cities achieving 100 per cent air quality excellence and 80 per cent of cities and regions achieving 95 per cent air quality excellence.

With the gradual improvement of the development policies of the Greater Bay Area, new cooperation approaches between Guangdong, Hong Kong and Macao have emerged. Guangdong Province Government issued the “Implementation Plan for the Development of Green Finance in Guangdong Province to Support the Carbon Peak Initiative” on 24 June 2022, which contains new plans for cooperation between Guangdong, Hong Kong and Macao in green financing, cross-border transfer of green financial assets and disclosure of green industry information and standard recognition (Guangdong Province Government, 2022). In the Carbon Peak Implementation Programmes of Jiangmen, Zhuhai and Foshan in 2023, policies and plans are proposed to establish long-lasting green investment projects with Hong Kong and Macao, while Shenzhen proposing the establishment of national cooperation platforms, such as a big data service platform of ecological protection for the whole country, including Hong Kong and Macao (General Affairs Office of Foshan Municipal People’s Government, 2023; General Affairs Office of Guangzhou Municipal People’s Government, 2023; General Affairs Office of Zhuhai Municipal People’s Government, 2023; Jiangmen Municipal Financial Supervision and Administration Bureau, 2023; Shenzhen Municipal People’s Government, 2023).

3. Characteristics of Guangdong-Hong Kong-Macao ecological cooperation

Cross-border ecological cooperation in the Greater Bay Area faces the challenge of three different political structures within the region. The different levels of economic development of Guangdong, Hong Kong and Macao also determines the different pollution sources respectively. The complexity of politics, the different stages of economic development at varied cities, and the unique cultures and customs of Guangdong, Hong Kong and Macao have led to the cooperation features unique to other regions. Some observed cooperation characteristics will be discussed in this section (the Standing Committee of Guangdong Provincial People’s Congress, 2024).

3.1. Different priorities in ecological management of the Greater Bay Area

Guangdong, Hong Kong, and Macao exhibit different levels of economic development, resulting in varying sources of environmental pollution. In the mid-industrialisation stage, current pollution mainly comes from industrial production and fossil fuel usage in Guangdong Province. Those coal-dominated or energy-production cities (i.e., Zhuhai, Zhongshan, and Zhaoqing) at the mid-term industrialisation stage, are experiencing soaring increase of total emissions (Zhou et al., 2018). Since 2017 Guangdong Province has developed a comprehensive plan to achieve carbon peaking that is tailored to its unique characteristics. The plan includes promoting green technological innovation, strengthening the green manufacturing system, improving the energy structure, reducing the use of fossil fuels, promoting green transportation

and buildings, and strictly protecting forests, oceans, and wetlands (General Affairs Office of Guangzhou Municipal People's Government, 2017). The green policy of Guangdong Province has three main features: optimization of the manufacturing system, energy saving and emission reduction, and environment protection. The policy aims to significantly reduce energy consumption and pollutant emissions in the manufacturing industry, while also encouraging public participation in environmental protection. It is important to note that Hong Kong and Macao have already entered the post-industrial era, while Guangdong Province is taking bold steps towards a more sustainable future.

In the 21st century, the major polluters that once existed in Hong Kong and Macao have disappeared, and the tertiary industry now accounts for over 90% of the total (Xu and Ma, 2022). Transportation and daily living remain significant sources of environmental pollution, as energy sources such as electricity, oil, and gas are not locally produced. In 2022, the Secretary for the Environment and Ecology of Hong Kong highlighted the bureau's focus on addressing waste recycling, noise pollution, new energy bus operations, cross-border eco-corridor construction with Shenzhen, air quality regulation cooperation in the Greater Bay Area (the Environmental Protection Department of Hong Kong, 2022). The Macao Environmental Protection Bureau is committed to enhancing Macao's environmental management system through the development of relevant laws and regulations. The bureau recognizes the environmental conditions of Macao, the high impact on residents, and concerns from the community (Macao Environmental Protection Bureau, 2021). Measures to improve air quality, control noise pollution, and enhance waste management are among the bureau's top priorities. Both Hong Kong and Macao prioritize the regulation of pollution sources in their policies, since they can have a direct impact on residents, such as restrictions on traffic pollution. They also strengthen the joint management of neighbouring ecological zones with Guangdong, so as to reduce pollution from domestic activities as well as water resources and air pollution that have a clear dispersion effect.

3.2. Case by base cooperation mechanism

Current cross-border ecological cooperation among Guangdong, Hong Kong and Macao is characterised by "one issue at a time or case by case". From the documents signed by Guangdong, Hong Kong and/or Macao, the actual cooperation is limited to a specific issue (Zhang et al., 2021). The Ecological Cooperation Working Group has been tasked with exploring cross-border cooperation on specific issues. While cross-border institutions in other regions (such as Europe Union) are in charge of the multinational collaboration rather than working as the mouthpiece as the working group, which have exhibited good results (Blatter, 2003), thus, it is valuable to explore the possibility to apply the multi-tiered system of governance in the Greater Bay Area (Leibfried and Pierson, 1995).

The overall regional environmental strategy is confined to the Guangdong Province, and does not form the overall cooperation in the Greater Bay Area that the central government hope for in the document (National Development and Reform Commission, 2017). The Carbon Neutral Implementation Plan for Guangdong

Province in 2022 and 2023 did not involve any planning for Hong Kong and Macao. From the perspective of “One Country, Two Systems”, the action programme respects the administrative autonomy of the Hong Kong and Macao. Apart from the “Implementation Opinions on Implementing the Outline Development Plan for Guangdong, Hong Kong and Macao” issued by the central government, there is no effective and sustainable regional environmental policy with an overall plan for the Greater Bay Area to cope with regional environmental development. This has directly led to a lack of forward-looking ecological cooperation in the Greater Bay Area and a slow response to new environmental issues. The Greater Bay Area urgently needs a multi-scale platform that can effectively coordinate the three regions on a long-term basis in order to expand the diversity of cooperation (The State Council, 2019).

3.3. Government-dominated cooperation with low public participation

Public participation is the important factor in promoting the ecological protection, thus the government should foster public interest of stakeholders to participate in the environment protection activities (Reed et al., 2018). However, the ecological cooperation of the Greater Bay Area has been dominated by the governments, but lacked the sufficient public participation. Data on the results of the cooperation between Guangdong, Hong Kong and Macao were not publicly available, government-related work was not transparent, and information related to policy implementation was difficult to access. Both Hong Kong and Guangdong lacked the tools to engage the public in discussions, as evidenced by the secrecy of the content of the meetings (Hopkinson and Stern, 2002). Research on environmental protection cooperation in the Greater Bay Area is mainly conducted through indirect data studies including (policy texts, weather data, pollution data, public data of the Hong Kong Government, etc.) (The Environmental Protection Department of Hong Kong, 2023). Prior to the release of the “Agreement on Cooperation in Joint Prevention and Control of Air Pollution in Guangdong, Hong Kong and Macao” in 2014, the governments of Guangdong, Hong Kong and Macao did not disclose the data of their governmental meetings. In 2014, air quality monitoring stations of Guangdong, Hong Kong and Macao began to be operated and provide public information on air quality. Since then, the three governments have started to share real-time air quality data, which is considered as a successful case of ecological cooperation in the Greater Bay Area (the Environmental Protection Department of Hong Kong, 2014).

Through non-governmental organisations (NGOs), ordinary people in Europe can participate in monitoring the issues they care about. At the same time, European NGOs can collect public opinion by mail and telephone, and use the media, scientific research and political lobbying to provide feedback on government policies (Richards and Heard, 2005; Dür and Bièvre, 2007). However, few NGOs in the Greater Bay Area carried out environmental activities (Cheng et al., 2022). The staff involved in the environmental cooperation and education in the three places are government employees, and the implementation sector is a working group appointed by the governments (Zheng and Zhang, 2014). By collating the official meetings and activities of the ecological governance websites of Guangdong, Hong Kong and Macao, the existing activities and meetings are all led by the two or three governments.

3.4. Huge institutional gap

Although the people living in the Greater Bay Area within one country share the same aspirations for the ecological environment and close ecological and cultural ideologies, different ideologies and administrative systems in the region, as well as differences in cultural thinking challenge the cross-border ecological cooperation (Li, 2017). Hong Kong and Macao have relatively independent legislature and judicial system to oversee the government, as they enjoy high level of autonomy with their own jurisdiction. The governments of Hong Kong and Macao are respectively accountable to local people, and therefore the two places have a more proactive desire to cooperate on environmental issues that directly affect the people's life experience. While Hong Kong and Macao only has one level of government, Guangdong has four levels of government, which is more complex in policy making and implementation (Yang et al., 2022).

Geographically, Guangdong Province is much larger than Hong Kong and Macao and is located upstream of Hong Kong and Macao, thus, Guangdong holds a dominant position in ecological cooperation. Hong Kong and Macao do not have the capacity to solve water and air pollution on their own. Guangdong Province considers whether the ecological cooperation with Hong Kong and Macao is in line with its own policy target, resulting in its passive and conservative behaviour in cooperation (Li, 2017). Moreover, the current laws of Hong Kong and Macao do not require consideration of the impacts of environmental projects on regions outside of Hong Kong and Macao, resulting in a serious tendency of localism in the policies of the three regions and a predicament of "zero-sum game" (Mao, 2018; Yang, 2006).

In terms of sewage discharge monitoring methods, Guangdong has five monitoring methods, while Macao only refers to one of them, and Hong Kong has no explicit monitoring method. In terms of pollutant limits, the three places are also not comparable. The environmental regulatory standards set by Guangdong, Hong Kong and Macao are inconsistent. Macao's pollutant emission standards mainly make reference to standards of mainland China, Europe, the United States and Japan, but there are still differences with the standards and items of the Mainland. For example, in the emission standards for air pollutants in the cement industry, the mainland China standards distinguish between the production process and the type of equipment in a more detailed manner, while those of Macao do not make any distinction. Hong Kong's environmental regulation partly adopts international standards, and partly forms its own standards based on reference to Japanese and European standards (Xu and Ma, 2022). Because of the different regulatory regimes and the lack of uniformity of relevant laws, the cooperative organisations of the Greater Bay Area lack actual supervisory power and incentives, and penalties measures, but only play the role of ecological information and policy exchange.

4. Problems and causes of ecological cooperation in the Greater Bay Area

The current cross-border environmental governance cooperation in the Greater Bay Area is not effective due to a series of problems, including different policy objectives, different policy decision-making and implementation processes, a lack of

effective regulation, and the absence of long-term integrated and effective communication platforms and organisations in the three regions.

4.1. Lack of common ecological targets

Cross-border cooperation only works successfully if common objectives exist (Scherer and Schnell, 2002). In the case of Hong Kong's joint endeavour to combat air pollution with Guangdong, the two places had different starting points in formulating their policies from the outset. During the 10th Five-Year Plan (2001–2005), the Hong Kong government aimed to satisfy the public's demand for resolving air pollution and showed a more positive attitude at the beginning of the cooperation. Government officials in Guangdong focused on purely economic development and did not put the emphasis upon the ecological protection. During this period, sulphur dioxide emissions in Guangdong surged, and the spread of air pollution led to a significant drop in visibility in Hong Kong. The public hoped that the Hong Kong government could combat air pollution, but due to the fundamental differences in the objectives of the two governments during this period, effective cooperation could not be achieved (Kim and Gevelt, 2022). The constellation of unilateral problems shows a clear asymmetry of benefit-detriment relations between the different partner regions, which means that one region is highly dependent on the activities of the other, which is completely independent (Scherer and Zumbusch, 2011). The Hong Kong government has been under tremendous public pressure for failing to effectively improve air quality. The Hong Kong Emission Inventory Report published by the Environmental Protection Department of Hong Kong in 2010 identified that cross-border air pollution from the PRD accounted for 50%–60% of Hong Kong's average air pollution (Kim and Gevelt, 2022).

During the 11th Five-Year Plan (2006–2010), cooperation between the Hong Kong and Guangdong governments was quickly achieved since ecological protection was linked to the evaluation of local officials, which resulted in significant improvements of air quality in Hong Kong compared to the previous period. As Hong Kong's air pollution problems could not have been solved without the Guangdong's cooperation, external environmental cooperation has become an important theme in Hong Kong. However, ecological cooperation is mutual for both sides. Both sides should respect the partner's interest. When Hong Kong, out of self-interest, allowed the Tuen Mun landfill expansion project in Hong Kong to jeopardise the interests of the neighbouring Shenzhen residents, which aroused the complaints of Shenzhen residents (Mao, 2018).

4.2. Cumbersome coordination in cross-border cooperation

The presence of the central government has greatly facilitated cooperation on cross-border air pollution control in the Greater Bay Area, but it has also indirectly made the implementation and cooperation relationship weak and unsustainable (Liu et al., 2021). The cross-border ecological governance mechanism of the Greater Bay Area is an executive-led network governance under "One Country, Two Systems" (Wu, 2021). Cross-border cooperation is carried out under the guidance and coordination of the central government through the institutional framework of the

Hong Kong (Macao)/Guangdong Cooperation Joint Conference. This framework results in cross-border cooperation being carried out through the mode of “application by one government-approval and decision making by the central government-policy implementation by Guangdong, Hong Kong and (or) Macao” (Zhou and Luo, 2019). While the central government has been effective in coordinating cooperation between Guangdong, Hong Kong and (or) Macao, there has been little cooperation between local cities in the Greater Bay Area. This is different from Europe. There is no “central government” in Europe Union and their cross-border cooperation adopts a bottom-up cooperation model (Evens et al., 2020).

Cross-border cooperation in the Greater Bay Area is a top-down cooperation model. Although the central government does not directly intervene in local policies, but controls the orientation of local policies through the performance variable, especially to Guangdong (Zheng and Zhang, 2014). First, it takes a lot of time from the issuance of central documents to the introduction of specific measures by local cities. The central government has issued the “Implementation Opinions on Implementing the Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area” on 5 July 2019. Later Guangdong Province also issued the “Implementation Plan for Developing Green Finance in Guangdong Province in Support of Peak Carbon Actions” to meet the central requirement on the Greater Bay Area Outline over the ecological protection, however, till the end of January 2024, only six cities (Guangzhou, Shenzhen, Zhuhai, Jiangmen, Foshan and Zhongshan) have completed their respective peak carbon implementation plans. Hong Kong and Macao are still on the stage of collecting public opinions and it would take a long time to improve their own laws and regulations. Thus, effective cooperation in the Greater Bay Area is not easy.

Secondly, under “One Country, Two Systems”, the heterogeneous nature of environmental laws, regulations and standards in Guangdong, Hong Kong and Macao need to be articulated in order to improve the sharing of ecological and environmental information and the recognition of joint decision-making in the Greater Bay Area. Differences in the environmental impact assessment mechanisms of Guangdong, Hong Kong and Macao have led to the suspension of the construction of the Hong Kong section of the Hong Kong-Zhuhai-Macao Bridge (HZMB) due to the Environmental Impact Assessment (EIA) report, which resulted in billions of dollars of economic losses despite the subsequent refinement of the EIA report and the resumption of construction (Gou et al., 2022).

4.3. Lack of effective regulative measures

The Lake Constance is an example of cross-border co-operation between European countries to protect the ecosystem. The German Länder Baden-Württemberg and Bavaria, the Republic of Austria, the Swiss Confederation and the Swiss Cantons of St. Gall and Thurgau signed an international agreement on water conservation and established a joint commission, which can supervise that the signatory countries comply with the strict conventions and monitor the quality of the lake water with the uniform standards (Scherer and Zumbusch, 2011). However, cross-border cooperation in the Guangdong-Hong Kong-Macao Greater Bay Area relies

mainly on the establishment of cross-border cooperation working groups, and exchanges ideas and information through meetings of the group. However, the cooperation groups themselves do not have legislative and supervisory powers, making it difficult for them to play a role in restraining and monitoring policy implementation (Wang, 2018).

The Shenzhen Bay (Deep Bay) Wetland Conservation Cooperation Framework Arrangement issued in 2023 is a good example. The Ramsar site at Mai Po Inner Deep Bay in Hong Kong is ecologically connected to the Guangdong Neilingdingdao-Futian National Nature Reserve in Shenzhen, and is an integral part of the wetland ecosystem of Shenzhen Bay (Deep Bay). The terms of environmental cooperation only point out the cooperation mechanism between the two sides—for waterbirds and their habitats in the wetland—but do not address the terms of the corresponding powers, obligations and cost of the two cities (Xinhua News Agency, 2023). This situation also applies to the ecological cooperation between Guangdong and Macao. Although it includes regional ecological contents, the “Special Plan for Building a Quality Living Area” does not put forward the overall ecological objectives of the region as well as the criteria for evaluating the progress, thus providing limited guidance for ecological cooperation in the Greater Bay Area (Housing and Urban-Rural Development Department of Guangdong Province, Environmental Protection Department of Hong Kong Special Administrative Region (SAR) Government, and Transport Bureau of Macao SAR Government, 2012).

At the same time, the policy implementation in Guangdong, Hong Kong and Macao lacks scrutiny by the public or third parties. The public need more channels to access the cross-border ecological information. Prior to 2014, Guangdong, Hong Kong and Macao did not provide channels for the public to conduct real-time monitoring and participate in cooperation discussions. Only after the first Air Pollution Index (API) measurements were completed in 2014 people could check their city’s air quality level from official websites. Until 2022, all three governments have adopted digital governance reforms to publicise the water environment, air quality and noise indices. However, the governments are still the only providers of data and information, and there is no other way to access the relevant data. At the same time, the public only plays the role of “witness” rather than “participant” in the cross-border ecological cooperation in the Greater Bay Area. At present, cross-border cooperation is still confined to government sectors, and the only way for the public to access the specific contents and results of the meetings is through the official media.

5. Measures to improve ecological cooperation in the Greater Bay Area

Ecological environmental protection is one of the important objectives of the construction of the Greater Bay Area. Cross-border ecological cooperation in the Greater Bay Area under the context of “One Country, Two Systems”, as a new practice, is a great challenge for the government and society. The effect of cross-border ecological cooperation in protection governance was not satisfactory, exposing the slow progress in regional cooperation. The underlying cause is the large differences between Guangdong, Hong Kong and Macao, such as policy objectives, development

status, policy implementation, laws and regulations, monitoring standards. The political complexity significantly creates additional work for the coordination in the Greater Bay Area. Some measures may be worth for further discussion on improving cross-border ecological cooperation.

5.1. Institutional innovation under the context of “One Country, Two Systems”

“One Country, Two Systems” is the fundamental principle in dealing with the relations between mainland China and Hong Kong and Macao. More than two decades of practice have shown that cross-border cooperation requires a balance between “one country” and “two systems” in order to achieve maximum results (The National Development and Reform Commission, 2009). Before 2003, there were very few cross-border air pollution joint agreements signed between the governments of Guangdong and Hong Kong, and air quality did not improve much. A large number of practical and effective cooperation have been reached between 2003 and 2012 when the policies emphasising Guangdong’s leading role, however, the actual results have also been encountered with obstacles and constraints due to different interests and development objectives. Cross-border ecological cooperation is a part of the “One Country, Two Systems” practice, which is easier to reach consensus as in line with the common interests of the three places. In the face of the lack of authoritative supervision and cumbersome coordination of cooperation in the Greater Bay Area, the central government should further play its role in guiding and organising cooperation among Guangdong, Hong Kong and Macao, coordinating the conflicts and rationally allocating tasks among them (Cai, 2019). It should seek the critical points where the three sides can gain the benefits together, instead of sticking to the gains and losses at a certain aspect, in order to achieve a win-win result for the Greater Bay Area.

However, the participation of the central Government in cross-border regional ecological cooperation does not mean abandoning the “two systems”. Cross-border cooperation can allow for a variety of political instruments to compensate for the shortcomings of a single political model, bringing a new dynamic to regional development. (Blatter, 2004). In fact, on the basis of the existing environmental foundation, “two systems” can satisfy the differentiated demands of the three regions to the greatest extent possible, and through mutual communication and exchange, achieve the re-innovation of cross-border ecological cooperation. At the same time, the practice of “two systems” can also broaden the scope of environmental protection (Zhang et al., 2021). Finally, the differentiated cooperation between the “two systems” is also a window for China to explore further cooperation with other countries through “seeking common ground while reserving differences”, for better global environmental governance.

5.2. To establish the efficient decision-making platform for the inter-city cooperation

Cross-border ecological cooperation among Guangdong, Hong Kong and Macao currently relies on collaborative governance teams, but they lack the power to monitor and penalize the ecological pollution behaviors. Building a beautiful and livable Pearl

River Delta is one of fundamental interests of the governments and people of the Greater Bay Area, thus, the Greater Bay Area urgently needs a higher level and more open platform for cooperation between governments and the private sectors (Wang et al., 2021).

A stable institutional framework to deal with conflicts will be helpful (Zumbusch and Scherer, 2015). EU provides a platform for European countries to coordinate their interests and monitor the effectiveness of implementation. In the case of forest protection, the EU Forestry Strategy Council Resolution was adopted in 1998 with the aim of establishing a sustainable framework to coordinate forest policies between member States and EU (Lazdinis et al., 2019). The establishment of a new information platform not only facilitates rapid communication between the three governments, but more importantly, further enables information flow and increases government transparency (Fu et al., 2023). At the same time, Guangdong Government has put forward the concept of green finance for the purpose of achieving carbon peaks, which is a courageous attempt to bring in private forces to participate in cross-border ecological governance. The establishment of the information and decision-making platform will facilitate the exchange of project experiences and technical research results among private green enterprises and organisations, bringing new vitality to the Greater Bay Area (Guangdong Province Government, 2022).

5.3. Introducing the market-based resource allocation

Markets have the function of efficiently regulating social resources (Pirard, 2012). Effective cross-border cooperation remains largely dependent on the governance system, with interactions between policymakers and implementers fundamentally determined by institutional design and incentives (Brunet-Jailly, 2022). As one of China's economic heartlands, the Greater Bay Area should actively encourage the sharing of environmental technologies among enterprises in the region. It is necessary to increase opportunities for private participation in cross-border cooperation and build a platform for the exchange of technology and experience among green businesses. In Europe's transition to a green economy, many new jobs have emerged, including the so-called "green jobs" (Chamusca, 2024). Markandya's research group estimated the net employment generated from this structural change at 530,000 jobs in the EU (0.24% of total employment in 2009), of which one third is due to trans-border effects within the EU (Markandya et al., 2016).

Secondly, a market-based ecological compensation mechanism and emissions trading rules should be established to increase the sustainability of cross-border cooperation (Fowlie and Muller, 2019). Finally, the rights and obligations between the various actors (enterprises and governments) should be re-delineated to increase the policies enforceability. It is foreseeable that a large market on eco-friendly related industries will be created. Cross-border eco-cooperation, which is easy to reach consensuses, can be a pioneer in promoting regional cooperation and development.

5.4. Encouraging public participation in ecological monitoring

Cross-border cooperation in the Greater Bay Area is still dominated by the government, with fewer avenues for the general public to participate, making it

difficult to give full play to the right of the public to participate in monitoring. The current tripartite governments should further conduct hearings, enrich information disclosure channels, and improve government transparency. Governments should open up channels that can provide policy advice and listen to the public's feedback on the implementation of ecological policies (Brunswicker and Chlapek, 2019; Kucera and Chlapek, 2014). In the case of the heavy metal treatment of the Rhine, where industrial and civil pollution has caused heavy metal contamination of the Rhine, the regulation is not effective even if it has a well-developed framework for monitoring responsibilities. Better results can only be achieved if people are motivated to monitor their own behaviour and the activities of companies (Bernauer and Moser, 1996; Verweij, 1999). Forming civil groups should be encouraged to enhance the cross-border exchange of residents in Guangdong, Hong Kong and Macao, since to experience different societies and cultures can promote the cross-border cooperation (Cheng et al., 2022). It is also important to enhance the popularisation of ecological knowledge and disseminate the concept of ecological co-prosperity in the Greater Bay Area, so as to reduce the tendency of regional localism, which is conducive to broadening the scope of the government's ecological cooperation policy and realising ecological cooperation on a wider scale.

6. Conclusion

While the Greater Bay Area is a crucial economic development zone in China, with a projected total economic output of over 14 trillion RMB (1.9 trillion US dollars) by 2023, accounting for approximately one-ninth of the country's total economic output, the ecological environment of the Greater Bay Area has become a significant concern for various stakeholders. This paper analyses the cooperation documents of Guangdong, Hong Kong and Macao, official reports and academic literature, and summarises the unique pattern of ecological cooperation in the Greater Bay Area under "One Country, Two Systems". It outlines four characteristics, three problems and reasons, and puts forward four feasible recommendations with targeted objectives.

The effectiveness of cross-border ecological protection cooperation has been unsatisfactory, and the slow progress of cooperation has been revealed in practice. To improve the ecological environment of the Greater Bay Area, it is necessary to fully utilize the advantages of 'One Country, Two Systems' and leverage the advantages and roles of central and local governments. Guangdong, Hong Kong, and Macao should proactively innovate and reform to generate spontaneous impetus for cooperation, while the central government should take the initiative to coordinate issues where there are divergent views and provide sufficient policy space and communication platforms for exchanges and cooperation among the three places. These attempts will create new opportunities for cross-border ecological cooperation among Guangdong, Hong Kong, and Macao. Additionally, more activities will be implemented to promote local environmental protection and effectively improve the ecological status of the Greater Bay Area.

Authors contributions: Conceptualization, XL and ZY; methodology, XL; software, XL; validation, XL, ZY and LL; formal analysis, XL; investigation, XL; resources,

ZY; data curation, XL; writing—original draft preparation, XL and LL; writing—review and editing, ZY; visualization, LL; supervision, ZY and LL; project administration, ZY; funding acquisition, ZY and LL. All authors have read and agreed to the published version of the manuscript.

Funding: This research has been funded by Macao Polytechnic University (Grant number: RP/ESCHS-01/2021).

Acknowledgments: We would like to express our deepest gratitude to Jiayuan Li's invaluable contribution to this research.

Conflict of interest: The authors declare no conflict of interest.

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