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Article

**Connecting the World Through Canals:
An Analysis of the Role of Water Infrastructure in Diplomacy, Economy and Sustainable
Development**

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Abstract: Canals have played a significant role in shaping world civilisation, not only as water infrastructure but also as a symbol of diplomatic, economic and sustainable development that transcends geopolitical boundaries. This article examines the strategic role of canals in connecting global societies, strengthening international trade, and contributing to cultural exchange from a historical and contemporary perspective. By integrating a qualitative approach, this study highlights the role of canals such as the Suez Canal, the Panama Canal, the Kra Canal and others as both physical and symbolic mediums that support social, economic, and political integration. The findings indicate that canals have accelerated global mobility, formed a major maritime trade network, and served as instruments of economic diplomacy. However, challenges such as geopolitical tensions, economic benefit imbalances, and ecological risks continue to hinder the potential of canals as catalysts for global unity. This article highlights the need for ecological monitoring and a more inclusive framework for international cooperation to address these challenges. By focusing on the future of canals in the context of climate change and sustainable development, this article offers a new perspective on water infrastructure as an element of global integration that can support social, economic, and ecological integration at the international level, thereby making a significant contribution to academic literature.

Keywords: Canal, Water Infrastructure, Diplomacy, Economy, Sustainable Development

Introduction

In examining the role of canals in forming a global network, one striking reality is that these infrastructures are not merely physical channels for trade or irrigation, but also symbols of diplomatic, economic and sustainable development relations that go beyond geopolitical boundaries. Canals have long played an important role in shaping the history of human civilization, serving as routes that not only connect people and regions but also stimulate economic growth, trade, and cultural exchange. From the Grand Canal in China, which has connected the northern and southern parts of the country since the Sui Dynasty, to the Corinth Canal in Greece, which reduces maritime travel distances in the Mediterranean region, canals have become a symbol

of innovation and human endurance in adapting to geographical challenges (Yan, 2021; Hopper, 1955). However, behind the benefits it brings, the canal also highlights the gap in resource management, economic justice, and geopolitical tensions. The Suez and Panama Canals are examples of how water infrastructure is used as a tool to strengthen the economic and political position of major powers. The Suez Canal, which connects the Mediterranean Sea and the Red Sea, is not only an important route for European and Asian trade but also has sparked conflicts as parties sought to control it. The Suez Crisis in 1956 illustrated the strategic importance of this canal, with Egypt asserting full control and opposing the dominance of Western powers (Boughton, 2001). Likewise, the Panama Canal, which connects the Atlantic and Pacific Oceans, has shortened the time and cost of international maritime travel, but also became a symbol of U.S. hegemony until it was finally handed over to Panama in 1999 (Conniff, 2012).

However, the role of the canal is not only limited to global trade routes. In a regional context, canals are often the backbone of economic and social development. In Asia, the Fuchu Irrigation Canal in Japan functions to reduce flooding and increase logistic efficiency (Okazaki & Saito, 1989). Meanwhile, in India, the Indira Gandhi Canal has become a savior for the arid areas of Rajasthan, supporting agricultural activities and stabilising the lives of local residents (Gardiner, 1987). However, canal construction often brings ecological challenges that require careful management to ensure a balance between development and sustainability. Additionally, canals also play an important role in regional integration and diplomatic relations. The Kiel Canal in Germany, which connects the North Sea and Baltic Sea, has become an important element in uniting the economy of Northern Europe (Heine, 2014). In a broader context, new canal projects such as the Nicaraguan Canal aims to compete with the Panama Canal, highlighting how water infrastructure continues to be the centre of attention in international relations and economic development (Keasbey, 1896; Yip & Wong, 2015). However, criticisms regarding potential ecological and social impacts shows that the canal is not only a tool for development but also arenas for debate between economic needs and ecological responsibility. In many cases, the development of canals also reflects changes in technology and human innovation. For example, the Amsterdam-Rhine Canal in the Netherlands is an example of modern engineering that increases trade between the German interior and international ports in the Netherlands. This canal not only supports the regional economy but also symbolises innovation in water resource management (Van deer Veen, 1985). Likewise, in Egypt, the plan to build the Toshka Canal aims to bring the water of the Nile River to vast desert areas, demonstrating how canals can transform the economic and social landscape of the region (Malterre-Barthes, 2016).

Nevertheless, canals also reflect geopolitical challenges and tensions. For example, the Iran-Russia Canal, which was designed to connect the Caspian Sea with the Indian Ocean through Iran, is an example of how the canal could be a tool to reorganise geopolitical dynamics. This project sparked a discussion about how it will affect traditional trade routes such as the Suez Canal and the world's dependence on those passages (Kameneva, Lukyanova & Tavberidze, 2018). In this case, it is clear that the canals are not only the physical infrastructure but also tools that shape and challenge the balance of global power. Apart from the economic and political importance, the canals also have a significant cultural dimension. In Venice, Italy, the canal is part of the city's identity, attracting tourists from all over the world and supporting the local economy (Van Der Borg, 2017). The Rideau Canal in Canada, which was originally built for military purposes is now recognised as a world heritage site and tourist destination (Donohoe, 2012). This dimension shows that the canal not only brings practical benefits but also holds symbolic and cultural value for society.

However, the role of the canals as a catalyst for unity is often limited by the unbalanced management challenges. Issues such as water pollution, lack of international cooperation, and the inability to adapt to climate change pose risks to the effectiveness of the canal in supporting social and economic integration. Therefore, this study aims to explore the role of the canal as a strategic element that goes beyond its basic function as a transportation route. This study will examine how canals contribute to global integration through three main dimensions: diplomacy, economy, and sustainable development. By focussing on examples of

canals across history and geography, this study will also examine the challenges faced by this infrastructure in the modern era, including geopolitical issues, ecological sustainability, and unequal distribution of benefits. Through this approach, this study aims to provide a new perspective on the role of canals and hopes to contribute to the academic discussions on sustainable water infrastructure, while proposing recommendations to ensure that the benefits of canals are distributed more equitably. By understanding the strategic importance of canals in a global context, this study is expected to help shape fairer and more sustainable policies for water infrastructure management.

Research Methodology

This study uses a qualitative approach that combines theoretical analysis, case studies, and international comparisons to understand the strategic role of canals in global trade, diplomacy, and sustainable development. The world-systems theory is used as the primary analytical framework, allowing this study to assess how canals function in global economic and political systems, reflecting the hierarchy of power and imbalances in the distribution of economic benefits (Chirot & Hall, 1982). This theory also helps to explore the relationship between structural global changes, such as the rise of international trade and climate change, with the role of canals as instruments of integration.

Data collection was conducted through secondary literature review and case study analysis. This literature provides data on the history of canal development, its role in global trade, and the ecological and geopolitical challenges it faces. The collected data are analysed through thematic analysis, international comparisons, and theory-empirical approach. Thematic analysis is used to identify main themes such as economic integration, geopolitical management, and ecological sustainability. International comparisons examined similarities and differences between canals to identify lessons applicable to future canal development. The theory-empirical approach integrated world-systems theory with empirical data, linking theoretical analysis with real-world cases to produce more comprehensive and practical understanding. This approach aims to ensure that this study is able to provide answers to the main question about how canals remain relevant as instruments of economic integration, diplomacy, and sustainable development. This study also aims to make a significant contribution to academic literature.

Literature Review

This literature reviews examines the role of canals as a strategic element in geopolitical relations, economics and sustainable development. Overall, previous studies have discussed the role of canals such as the Suez Canal, the Panama Canal, the Istanbul Canal and others in reshaping maritime trade routes, improving logistical efficiency, and supporting regional economic growth. However, there is a significant gap in understanding the imbalance of economic benefits, sustainable management challenges, and the more complex geopolitical impacts within the context of current global changes, including climate change and increasing pressure of water resources. This study aims to fill that gap by examining the economic, ecological, and geopolitical dimensions of the canals in both historical and contemporary contexts.

For example, the writing about the Suez Canal has focussed on its importance as the main strategic route connecting Europe and Asia. Several previous studies, such as Piquet (2004) found that the Suez Canal not only played an important role in international routes but also been a symbol of geopolitical dominance by major powers such as Britain and France before its nationalization by Egypt in 1956. However, these study often ignores an in-depth analysis of how geopolitical conflicts and post-nationalisation economic pressures affect local communities and ecosystems around the canal. This study takes a holistic approach by including social and ecological dimensions to understand the full impact of the canals on local societies and global geopolitics.

In the case of the Panama Canal, previous literature, such as by Maurer and Yu (2010) discussed a lot of technological transformation and diplomacy involved in the canal control from the United States to Panama. This study highlights how the expansion of the canal and the use of new technology, such as logistics automation has increased the efficiency of maritime routes and the increased national revenue for the host country. However, an important gap that has not been addressed is the issue of an imbalance of economic benefits among local communities, especially the social impact on indigenous populations who were displaced during the construction and expansion of the canal. This study emphasises the need to investigate how the canal can be managed sustainably to reduce inequality and ensure that their benefits are distributed more equitably.

The proposed Kra Canal development in Thailand has also drawn academic attention, but most studies have focused primarily on its economic potential without giving sufficient attention to geopolitical challenges and ecological risks. Studies such as by Duangjai and Sulong (2012) highlight how the Kra Canal could ease congestion in the Malacca Strait and enhance Thailand's role in international trade. However, issues such as potential conflicts with neighboring countries like Singapore and the impact on marine ecosystems in the region remain under-analysed. This study aims to fill this gap by focusing on multilateral approaches that could ensure that the canal's development does not trigger regional tensions or damage the environment.

The clear gap in the literature is the lack of an approach that integrates historical, economical, geopolitical, and ecological dimensions holistically. Most previous studies tend to focus on a single dimension, such as trade or geopolitics, without looking at the interaction between these dimensions. This study aims to overcome the gap by adopting an interdisciplinary analysis to provide a more comprehensive understanding of the strategic role of canals. This study is expected to make an important contribution by suggesting a sustainable framework that can be used to manage canals more effectively in the face of these challenges.

Results and Discussion

1. Canals as Global Connectors in History and Contemporary Times

We find that the canals have long served as vital connectors in trade and international relations, playing a strategic role that goes beyond its physical function as a transport channel. From ancient history to the modern times, canals such as the Grand Canal in China, the Suez Canal in Egypt, and the Panama Canal in Central America have formed a global network that supports economic integration, diplomacy, and cultural exchange. In addition, we found that Southeast Asia also has canals that play a significant role in the regional context, demonstrating the global importance of canals across various dimensions (Sulong, 2012).

The Grand Canal in China is the earliest example of how the canal can be an important connector in forming civilization. We observe that since its construction during the Sui Dynasty (7th century), the Grand Canal has played a major role in uniting northern and southern China. It facilitates the transportation of agricultural products, such as grain from productive regions to metropolitan centers such as Beijing, while supporting economic and political stability. In addition, we found that this canal is also an important route for cultural exchange, including technology and ideas to spread across regions in China. Today, the Grand Canal not only functions as an economic infrastructure but also as a symbol of cultural heritage that still affects China's national identity (Yan, 2021).

In central America, the Panama Canal plays a crucial role as a connector between the Atlantic and Pacific Oceans. We observe that this canal has accelerated maritime travel, reducing the cost and time for global trade. Although its construction in the early 20th century was marked by U.S. dominance, the transfer of control to Panama in 1999 showed how the sovereignty of a small country could be recognised over strategic assets (Haskin, 1913; Conniff, 2012). We also found that the expansion of the Panama Canal in 2016, which

allows larger container ships to pass through, reflects the importance of innovation in maintaining the relevance of waterway infrastructure in an increasingly complex global trade context (Park, Richardson & Park, 2020).

In addition to these major canals, we found that Southeast Asia also has canals that play a strategic role in regional trade. For example, the Lat Pho Canal in Thailand, which was built to reduce the risk of flooding in Bangkok, also increased the efficiency of trade logistics (Tanabe, 1977). We observe that this canal not only supports the domestic economy but also strengthens Thailand's role in Southeast Asian regional trade. Meanwhile, the construction of the Kra Canal or 'Kra Isthmus Canal', which aims to connect the Indian Ocean with the Pacific Ocean, has become a topic of debate (Monika, Baiquni & Hadi, 2020). We found that if this project is realised, it could reduce the congestion in the Strait of Malacca and have a major impact on the global trade routes. However, ecological and geopolitical challenges, including concerns of neighboring countries like Singapore highlight how canal development in Southeast Asia involves complex considerations.

In Malaysia, the Wan Mat Saman Canal located in Kedah and the Canal on Sanglang Road in Perlis serve as important connectors between rural areas and play an important role in supporting the suburban economy related to rice production. We can see that this canal becomes the main source of irrigation for paddy fields, as well as supporting economic stability among farmers in stated locations (Abdullah & Mohd Noor, 2020; Abdullah, Mohd Noor & Mat Enh, 2023). However, we found that water pollution and inefficient management have affected its effectiveness, reflecting the challenges faced by many canals in developing countries including Malaysia (Petah Wazzan, 2019). We also examined how canals served as not only an economic medium but also a symbol of cultural identity and integration. In Venice, Italy, the canal becomes the centre of social and economic life, in addition to being a global tourism attraction (Cowan, 2008). In the context of Southeast Asia, the Bangkok Noi Canal in Thailand has become part of Bangkok's cultural and historical landscape, reflecting the role of the canal in shaping the identity of the local community (Suphaphorn, 2015). We found that, beyond their function as trade routes, such canals also act as medium for cultural and traditional exchange, such as the famous floating market in Thailand.

The modern challenges faced by the canals, including climate change and increased maritime traffic pressure, are also the focus of our analysis. The Suez and Panama Canals, for example, are facing the issue of infrastructure implementation to accommodate the increasing demand for global trade (Ahmed et al, 2018). In Southeast Asia, the proposed Kra Canal project has raised concerns about the ecological impact, including the risk to marine biodiversity and ecosystem changes in the surrounding area (Ramadhan & Prakoso, 2024). We found that international cooperation and sustainable management approaches are important to ensure canals continue to play their strategic role without affecting environmental sustainability. In addition, we found that new canal projects such as the Istanbul Canal and the Nicaragua Canal proposal show that water infrastructure continues to be a priority in global planning. These projects, although promising great economic benefits, also trigger concerns about social and environmental impacts. For example, the Istanbul Canal is expected to reduce congestion in the Bosphorus Strait, but critics say it may threaten the stability of the Black Sea ecosystem (Kalinov, 2019). In the case of the Nicaragua Canal, this project has sparked protests from concerned local communities against displacement and loss of land (Fairchild, 2018). We conclude that canals around the world play a unique role as a physical connectors, a symbol of cultural identity, and a tool for economic diplomacy. Despite facing challenges such as economic imbalances and ecological risks, the canals continue to be an important element in supporting global trade and international relations.

2. Geopolitical Dimension and Power Conflict in Canal Control

We found that canals not only serve as a trade route but also as a geopolitical tool that reflects power conflict at the global level. As a strategic asset, the canal often becomes a field of conflict, negotiations, and renegotiations, which reflects the economic interests, sovereignty, and political stability for the country that

controls them. Key historical and contemporary examples such as the Suez Crisis in 1956, the Panama Canal conflict in 2025, the geopolitical conflict related to the Istanbul Canal and others prove how this water infrastructure plays an important role in shaping the dynamics of global power. In the context of Southeast Asia, the proposal for the construction of the Kra Canal is a symbol of how the canal continues to be the centre of strategic discussions in the region.

The Suez Crisis in 1956 was an important event in the geopolitical history of the canal. We found that the nationalisation of the Suez Canal by Gamal Abdel Nasser, the President of Egypt, triggered a major conflict involving Britain, France and Israel. This nationalisation step is seen as Egypt's effort to demand economic and political sovereignty over strategic assets controlled by colonial powers. Although the joint attack by Britain, France, and Israel was aimed at restoring control to the canal, diplomatic pressure from the United States and the Soviet Union eventually forced them to withdraw. This event underscores how canals can become flashpoints for major power conflicts, where negotiations and diplomatic pressure play an important role in determining the outcome (Smith, 2016).

The Panama Canal presents a different perspective on how the issue of control over the canal can develop into a symbol of sovereignty for smaller countries. This canal, which connects the Atlantic and Pacific Oceans, was built by the United States in the early 20th Century and remained under their control for almost a century. We found that throughout this period, Panama faced social and political pressure to demand regain control over the canal as a symbol of national sovereignty. The transfer of control to Panama in 1999, after an agreement between the two countries, reflects how the issue of canal control can be resolved through long-term diplomatic negotiations. However, we also observed that this process is not free from challenges, including tensions in negotiations as well as the questions about the fair distribution of canal revenues among Panamanians (Conniff, 2012).

In a contemporary context, as a strategic maritime route, the Panama Canal becomes the centre of power conflict between major countries, reflecting how the dominance of critical infrastructure can trigger geopolitical tensions. A recent statement by the U.S. President Donald Trump in 2025, expressing a desire to "take back" the Panama Canal, shows how great powers like the United States still see this canal as a strategic asset that must be controlled (Atlantic Council Experts, 2025). We see this situation as a continuation of the U.S.'s long history of intervention in Panama, including the military invasion in 1989 and the debate surrounding the 1999 handover under the Torrijos-Carter Agreement (Priestley, 2004). Although Panama has officially taken over full control, the US is still using the narrative of safety and national interests to maintain its influence on this canal. We also found that the U.S. indictment of China's influence in the Panama Canal was the main reason for increasing pressure on this country. Although Panamanian authorities insist that the canal is freely controlled without Chinese interference, the two major ports at the end of the canal owned by the Hong Kong-based company have become a basis for Washington's concerns. It illustrates how the global rivalry between the US and China translates into economic and strategic strife, with Panama as the bringing ground between these two great powers. The audit of ports and major utilities announced by the Panamanian government can be seen as an effort to ease U.S. Pressure, but it also has the potential to change the country's international trade and investment relations (Atlantic Council Experts, 2025). In a broader context, we argue that this tension raises major questions about the sovereignty of small countries in the face of pressure from great powers. Although Panama has tried to maintain its administrative autonomy, international political realities show that small countries are often forced to negotiate under unequal conditions. This situation affects not only Panama, but also the entire geopolitical stability in Latin America and the power dynamics between the US, China, and their allies. Therefore, we see this conflict as a reflection of how trade canals and routes are not just logistics infrastructure, but also the main arena for global power conflict.

Furthermore, the Istanbul Canal in Turkey is an example of how the canal continues to be a geopolitical strategy tool. We found that this project, designed to reduce the congestion in the Bosphorus Strait, has sparked

concerns among neighboring countries and the international communities. The Istanbul Canal is expected to increase Turkey's maritime trade capacity and strengthen its position as a global logistics centre (Sen et al., 2022). However, we found that this project also raises questions about ecological stability in the Black Sea and the potential negative impacts on diplomatic relations with neighbouring countries such as Russia. In this case, we see that canal development is not only related to economic benefits but also involves complex geopolitical considerations.

In Southeast Asia, the construction proposal of the Kra Canal in Thailand has become a significant topic in the regional strategic discussions. We found that if this canal were to be built, it would connect the Indian Ocean with the Pacific Ocean, while reducing dependence on the Strait of Malacca as the main route. While the project promises great economic benefits for Thailand, including increased revenue from trade and logistics, we note that it also raises geopolitical concerns. Countries such as Singapore, which depends on the Malacca strait as their economic pulse, may see the development of the Kra Canal as a threat to their strategic position (Ho, 2020). In addition, we found that issues such as population displacement, impact on the marine ecosystem, and possible conflicts with neighbouring countries add a layer of complexity to the project's planning.

Additionally, we found that Southeast Asia also faces other challenges related to the canal, such as pollution and sustainable management. For example, the Wan Mat Saman Canal in Kedah, Malaysia, which has long regarded as a historical record of the state's socio-economic transformation is now facing serious maintenance and pollution problems (Petah Wazzan, 2019). We see this situation as a symbol of the failure of the Kedah State Government in protecting one of Malaysia's historical canals. Despite current Kedah Chief Minister Sunasi Md Nor's focus on water issues between Kedah and Penang, little effort has been seen protecting the canal, even though Perlis also uses Kedah water for free. However, the water dispute between Kedah and Penang appears to receive more attention (Abdullah, 2024; Abdullah et al., 2024). This issue clearly reflects how failure in canal management can affect not only the socio-economics of the population but also the loss of valuable assets such as the Wan Mat Saman Canal which has a strategic area in northern Malaysia.

We also observe that canals are often used as tools for projecting power by the countries that control it. In the case of the Suez and Panama Canal, control over the canal gives those countries a strategic advantage in international negotiations. However, we found that this process does not always lead to stability. In contrast, unfair control of canals often sparks tensions, as happened during the Suez Crisis or the protests in Panama before the transfer of control. In the context of Southeast Asia, potential conflicts surrounding the Kra Canal suggest that the planning of the new canal requires a solid diplomatic framework to avoid unnecessary tensions. From our analysis, it is clear that the canal serves as an important tool in global geopolitical strategy. Whether through direct control or international negotiations, the canal reflects the ever-changing dynamics of power. We find that to ensure that the benefits of the canal are fairly divided and conflict is avoidable, international cooperation involving all stakeholders is essential. In this case, the canal is not only physical waterways but also symbols of power, sovereignty, and global stability.

3. Economic Impact of Canals: Strategic Routes and Unequal Benefits

We found that the canal, as a strategic route, plays a crucial role in supporting global trade and accelerating economic growth. Canals such as the Suez Canal, the Panama Canal, and other canals in Southeast Asia not only shorten travel time but also reduce logistics costs, making them a critical asset in international trade networks. However, the economic benefits of these canals are often not distributed equally, causing imbalance that triggers questions about economic justice and revenue allocation.

The Suez Canal is one of the most obvious examples of the economic importance of canals in global trade. Since its opening in 1869, we have seen that this canal has become a major route for trade between

Europe and Asia, including the delivery of oil from the Middle East to global markets. By shortening maritime travel by thousands of kilometres, the Suez Canal has become a very profitable economic route for Egypt, generating significant annual income through ship transit fees (Huber, 2013). However, we also found that this income did not always directly benefit the Egyptian people, especially during the era of colonisation and domination of foreign powers such as Britain and France. The Suez crisis in 1956, when Egypt demanded control over the canal, reflected the efforts of developing countries to obtain greater economic benefits from the strategic assets in their homeland (Marston, 1988). Today, the Suez Canal continues to be the main source of income for Egypt, but the cost of maintenance, capacity expansion, and geopolitical threats such as conflicts such as regional conflicts add a layer of complexity to the economic management of this canal (Soffer, 2023).

The Panama Canal also shows how unequal economic benefits can occur when smaller countries depend on the major powers to build and operate the canal. For almost a century under the control of the United States, we found that Panama did not get a fair share of its revenue, even though this infrastructure was located within their territory. Protests and diplomatic pressure eventually led to the transfer of control to Panama in 1999, allowing the country to enjoy greater returns from the canal operations (Conniff, 2012). However, we found that this process is not free from challenges, including the debates on how canal revenues should be used for social and economic development within the country. The expansion of the Panama Canal in 2016, which increased capacity for larger container ships, shows that this canal continues to be an important strategic asset in the global economy (Pagano et al., 2016). However, we also see that this expansion increases the pressure on the infrastructure and ecosystems in the surrounding area, reflecting hidden costs that are often not equitably distributed among all stakeholders.

In Southeast Asia, canals also play an important role in the regional economy. We found that the Klong Lat Pho Canal in Thailand, which was built to reduce the risk of flooding in Bangkok, contributed to improving the efficiency of logistics and domestic trade (Tanabe, 1977). However, the proposal of the Kra Canal project has raised concerns about the economic imbalance in this region. If constructed, the Kra Canal has the potential to ease congestion in the Strait of Malacca and open a new route for international trade, providing great economic benefits to Thailand. However, we see that neighbouring countries such as Malaysia, which depends on the Strait of Malacca for trade, may be negatively impacted, raising questions about how the economic benefits of this canal can be distributed more equitably in the region (Abdul Rahman et al, 2016). Economic imbalance can also be seen in the context of the development of new canals such as the Istanbul Canal in Turkey and the proposed Nicaragua Canal in Central America. We found that these projects promise great economic benefits to the host country, including increased revenue from ship transit fees and job creation. However, we also see that construction costs, ecological risks, and social impacts are often not fairly shared. For example, the Istanbul Canal project is facing criticism because of the potential damage to the ecosystem of the project area. In this case, the issue of how economic benefits can be balanced with social and ecological costs becomes the main issue in canal planning (Menteşe & Tezer, 2021).

We also found that the imbalance of economic benefits from the canals often reflects the power dynamics between the country controlling the canals and the country or other party that depends on it. In the case of the Suez and Panama Canal, control over the canal provides strategic and economic advantages to certain countries, but often sacrifices the interests of the people or other parties involved. In the context of Southeast Asia, the potential for the construction of the Kra Canal reflects the same challenge, where the economic benefits to Thailand may come at a cost to neighboring countries. From our analysis, it is clear that canals play an important role as a strategic route in the global economy, but imbalances in the distribution of economic benefits continue to be a major issue. Whether in the context of daily operations or new infrastructure planning, the issue of economic justice and balance needs to be addressed through a framework that involves all interested parties. In this case, the canals are only a symbol of economic integration but also a reflection of the challenges and imbalances that present in the global economy.

4. Ecological and Sustainability Challenges in Canal Development

The construction and operation of canals, although playing important roles in supporting global trade and irrigation needs, often have an unavoidable negative impacts on the environment. Canals such as the Suez Canal, the Panama Canal, and the Wan Mat Saman Canal in Kedah, Malaysia, are examples of how this infrastructure provides great benefits, but at the same time trigger ecological challenges that require serious attention. We found that water pollution, ecosystem disruption, and biodiversity loss are key issues closely linked to the construction and maintenance of canals, and a more sustainable approach is essential.

The Suez Canal, as the main strategic route connecting the Mediterranean Sea and the Red Sea, provides a clear example of how ecological pressure can arise from intensive use. Since its opening, the Suez Canal has played an important role in accelerating trade between Europe and Asia. However, changes in water salinity due to flow between two bodies of water with different chemical compositions have led to the migration of invasive species such as lionfish and nomadic jellyfish, which disrupt local marine ecosystems (Balzani et al., 2022). In addition, the increase in ship traffic has increased the risk of oil spills and chemical pollution, which has a negative impact on marine biodiversity. The continuous use of water quality monitoring technology and the enforcement of anti-pollution laws are important steps to reduce this impact, but their effectiveness still requires greater involvement than all interested parties (Mostafa, 2004; Özkanlısoy & Akkartal, 2022).

In Southeast Asia, the challenges faced by the Wan Mat Saman Canal in Kedah, Malaysia reflect a similar issue but in the context of agricultural irrigation. This canal, which was built in the 19th century, became the backbone of the rice farming sector in Kedah, contributing to the status of this state as the Land of Rice (Hill, 2012). Despite providing great benefits to local farmers, we found that pollution caused by the use of chemical fertilisers and pesticides has adversely affected the water quality in this canal. In addition, sediment accumulation due to soil erosion has reduced the effectiveness of the irrigation system, contributing to a decrease in productivity in the agricultural sector. Restoration efforts such as the use of sustainable agricultural techniques and periodic cleaning of these canals can help reduce the negative impact on the ecosystem while maintaining its main function (Petah Wazzan, 2019).

Contemporary development projects such as the Istanbul Canal in Turkey show how ecological challenges continue to be an issue that needs to be faced in a global context. This canal, designed to reduce pressure on the Bosphorus Strait, is facing criticism for its potential adverse effects on the Black Sea and Marmara Sea ecosystems (Baba, 2020). We found that the expected changes in water flow caused by the construction of this canal could disrupt the balance of the marine ecosystem, while increased ship traffic increased the risk of oil pollution (Sözer & Ozsoy, 2017). This project reflects the need for a more integrated planning approach, including comprehensive environmental impact studies and the use of eco-friendly technology in construction and operations.

We also see that climate change adds a layer of complexity to the ecological challenges faced by the canal. Increasing global temperatures and changes in rainfall patterns have caused an imbalance of water in several major canals such as the Suez Canal and Panama. This uncertainty not only affects the daily operation of the canal but also has an impact on the water ecosystem that depends on water level stability. In this context, adaptation strategies such as the construction of water reservoirs and better flow management can help ensure that the function of the canal can be continued in increasingly unpredictable climatic conditions (Abdullah et al., 2023).

A sustainable approach in dealing with this challenge requires a combination of modern technology, a solid foundation, and multi-party cooperation. The use of automatic water quality monitoring systems, the

implementation of ship waste treatment technology, and the enforcement of anti-pollution laws are among the steps that can be taken to reduce the pressure on the ecosystem. For example, the initiative in the Suez Canal to increase the enforcement of pollution laws shows how technology and regulations can be combined to reduce the negative impact on the environment (Rodríguez-Díaz et al., 2024).

Through this analysis, it is clear that ecological challenges related to the development and management of canals require immediate attention and an integrated approach. By ensuring that the economic benefits brought by canals are not achieved at the cost of environmental destruction, canals can continue to play an important role in supporting global trade and meeting irrigation needs without affecting the stability of ecosystems that are fundamental to human and natural survival.

Conclusion

This study analyses the strategic role of canals in global trade, diplomacy, and sustainable development, focussing on economic impact, geopolitics, and ecological sustainability. The main thesis proposed is that canals, as an important water infrastructure, reflect the dynamics of power and the cross-border challenges. Although canals play a critical role in accelerating trade and supporting global economic growth, the study shows that imbalances in economic benefits, ecological risks, and geopolitical tensions are still major challenges that require an innovative and collaborative approach.

An analysis of examples such as the Suez Canal, the Panama Canal, the Kra Canal and others show that the canal not only serves as a physical route for ships but also as a tool to maintain or defy economic and political domination at the global and regional levels. In the case of the Suez Canal, its importance in connecting Europe and Asia highlights how this strategic route can be a focal point for conflict and great power negotiations. Similarly, the transition of control over the Panama Canal from the United States to Panama reflects the struggle for the economic sovereignty of developing countries against the domination of great powers. In Southeast Asia, the Kra Canal development reserves raise important questions regarding the geopolitical balance in this region, especially related to strategic competition with the Strait of Malacca.

Climate change also adds a new dimension to the management of canals. The study found that declining water levels, rising temperatures, and other ecological threats could affect the effectiveness of canal operations such as Suez and Panama. In this context, a multilateral framework that supports a holistic approach, including data-based monitoring and climate change mitigation measures, is becoming increasingly critical. Examples such as the involvement of the International Maritime Organisation (IMO) in promoting best practices in canals management show the need for global cooperation to address these challenges.

In addition, this study emphasises the need for more inclusive regional cooperation, especially in Southeast Asia. For example, the development of Kra Canal reserves requires careful negotiations between Thailand and neighbouring countries such as Singapore and Malaysia to ensure that the benefits do not trigger geopolitical tensions or affect regional stability. The study suggests that mechanisms such as ASEAN can be used to promote dialogue and ensure canal development considers shared regional interest.

This study makes an important contribution to academic literature by integrating technological, economic, and geopolitical perspectives to offer a deeper understanding of the strategic role of the canal at the global level. The findings of this study highlight that the future of the canal depends on a balance between economic development, ecological sustainability, and inclusive diplomatic relations. In this regard, this study not only offers an analysis of current challenges but also suggests a pragmatic and innovative framework to ensure the benefits of the canal can be enjoyed by future generations.

In conclusion, this study highlights the importance of canals as a critical global connector, but also suggests that the future of canals depends on how international cooperation can be integrated to address modern challenges. By emphasising the need for a more sustainable and inclusive approach, this study provides strategic guidance to ensure that canals continue to play their roles in economic integration, geopolitical stability, and ecological sustainability. In an increasingly complex global context, the canal can be a symbol of progress, but only if it is managed

canal

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