



# Climate Change Adaptation Strategy for Sea Port Operations in Vietnam

Case study of sea level rise in the Mekong Delta

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### **Climate Change Adaptation Strategy for Sea Port Operations in Vietnam Case study of sea level rise in the Mekong Delta**

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#### **Abstract**

Rising sea levels are an increasingly dangerous threat and are receiving attention from countries in their journey to find appropriate adaptation methods. Although we still have time before the situation gets worse, establishing an adaptation approach remains a concern for many countries. Rising sea levels threaten many areas, but in this study, their impacts on port operations will be considered more carefully. The specific effects of this problem on port operations will be carefully introduced, and slightly expanded to provide a suitable vision for the topic. After enough necessary data and information are collected, an adaptation framework and adaptation actions will be planned to suit the Mekong Delta region, in Vietnam.

The author chose a qualitative research method to conduct this study. All second data in the study were screened and determined using a systematic evaluation method. Coordinate with the Benchmarking method to make the sea level rise situation of both the Netherlands and Vietnam clearer in some aspects. Next, the author chose a semi-structured interview method to better understand the real problem in the Mekong Delta region, ready for establishing adaptation ideas. The initiatives in the adaptation chapter are based on theoretical analysis and analysis of actual data from experts invited to be interviewed.

The output of the study has established an adaptation framework suitable for the Mekong Delta region in the context of sea level rise. At the same time, establish adaptive actions that can be considered in the future when short-term projects officially start. This study has a lot of valuable information that can be highly referenced for future research. The balance between theory and practice has been planned to ensure maximum validity in this article.

#### **Keywords/tags (subjects)**

Sea Level Rise, Climate Change, Seaports, Seaport Operations, Benchmarking, Systematic Literature Review, Mekong Delta, Adaptation, Vietnam, Netherlands

#### **Miscellaneous (Confidential information)**

None

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# 1 Introduction

## 1.1 Background

Climate change is a significant issue that requires global cooperation to implement policies aimed at reducing its impact. Human activity is the primary source of climate change, leading to significant negative consequences for both people and the environment, pushing the natural world's ability to adapt beyond its limits (IPCC, 2022). Climate change has had significant global impacts in recent years, including substantial losses in several regions, such as Vietnam. Vietnam is in the top 5 most susceptible nations worldwide to the impacts of climate change according to USAID (2023). Most of the population and their property are often threatened by natural catastrophes including storms, floods, and landslides. Vietnam is also at risk of experiencing substantial economic and social consequences in several locations and industries as a result of climate change.

The phenomenon of sea level rise has garnered significant scientific interest as a consequence of climate change, and an abundance of concrete scientific evidence has emerged to underscore the escalating gravity of the situation. The escalating acceleration of sea level rise can be attributed to the unprecedented increase in global temperature. Over the past few years, temperature indices have consistently established historic and unprecedented records. In addition to sea level rise, this results in numerous other repercussions, including the thermal expansion of the ocean and the thawing of ice sheets in Greenland and Western Antarctica at an unprecedented rate. A list of phenomena that require immediate resolution. In the future, sea levels are anticipated to increase substantially, wreaking havoc on coastal communities. More than 300.000 residents will be at risk of chronic inundation by 2045, according to projections (Union of Concerned Scientists, 2018).

Furthermore, port infrastructure and terminals may be among the first to be negatively impacted by climate change byproducts. Temporary or even permanent port closures may result from the dangers posed by these phenomena. In the meantime, seaports are vital to the expansion of international commerce, as the majority of annual products transported between hemispheres are transported via water. When a seaport sustains damage due to an assault from extreme phenomena, it gives rise to a dual set of risks and has the potential to disrupt the entire industry, resulting in substantial economic repercussions. And, it poses a threat to the human activities of coastal inhabitants and has adverse effects on the economy and society (e.g., health and demographic concerns).

## 1.2 Overview of the Mekong Delta Region

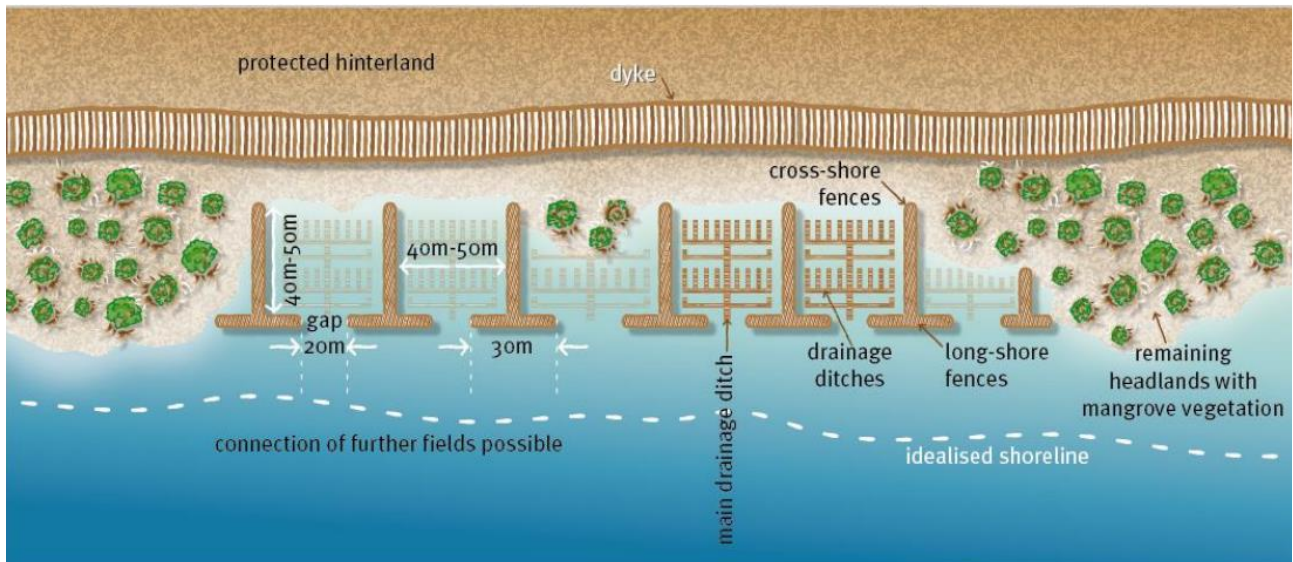
The Mekong River in Vietnam is confined to a small region known as the Mekong Delta. Nevertheless, this region is home to over 18 million individuals, constituting 19% of the nation's overall population and contributing 12% to Vietnam's Gross Domestic Product in 2020. The Mekong Delta region comprises 13 provinces, with a natural area of about 39,734 km<sup>2</sup>, which is comparable to 12.2% of the country's total area (Tạp chí Cộng Sản, 2023). The Mekong Delta is a prominent hub for cultivating rice, fruit, and seafood, establishing it as the primary location for these agricultural industries in Vietnam. Furthermore, it is acknowledged as one of the seven primary economic areas of the nation. The Mekong Delta is crucial in guaranteeing food security for the entire nation.

Owens 70% of Vietnam's mangrove forests and 90% of seagrass meadows. The Mekong River provides sediment and nutrients that nourish habitat conditions in this region. These circumstances have helped create the richest fishery resource in Vietnam and serve as an important defense for coastal towns against storm surges. Climate change also has other consequences in this region, including prolonged drought, rising environmental temperatures, rising sea levels, land subsidence, and slow mangrove degradation. The consequences of these impacts are the loss of economic prospects for people living in the Mekong Delta, causing disruption to daily activities, including activities in production and export.

Annually, the region incurs significant harm as a result of the repercussions of climate change. People's crops are threatened and their lives are poor, so the ports here cannot operate actively. Moreover, the bridge system and sea defense system in this region are very tangled, resulting in challenges for ships attempting to dock. One of the reasons why developing the ports here is challenging is due to the immovable defensive system, which prevents cargo ships from accessing the harbor.

Understanding the problems that climate change can cause, the Vietnamese government has made efforts to implement many plans and cooperate with many countries and organizations to support the Mekong Delta region to prevent and adapt to climate change. Many experts from European and American countries have come and built many things to help people. Long-term projects are quite rare but short-term projects have appeared. It is difficult to muster financial resources to establish a perfect water defense system for the region, so experts from many places have tried many

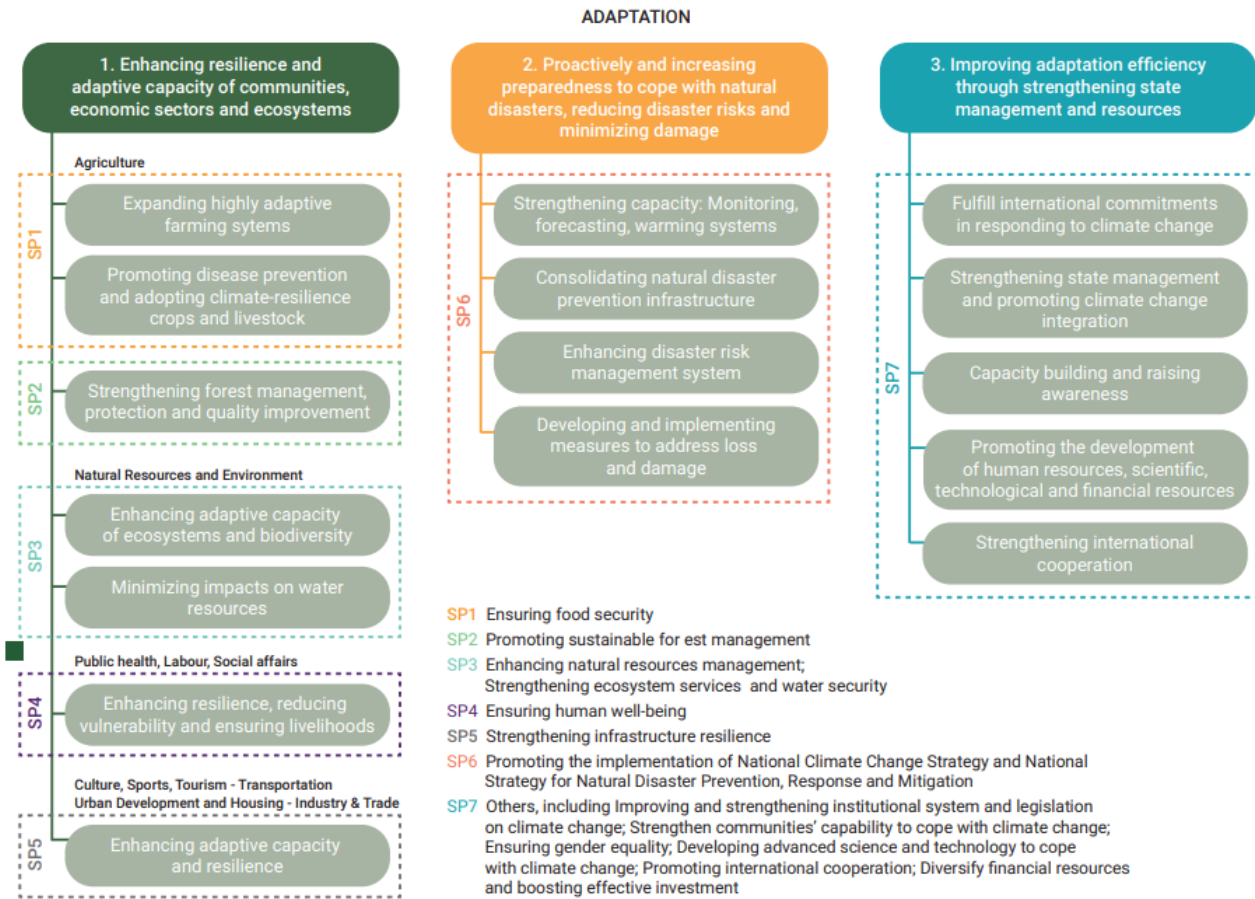
different ways from gray to green to find a solution. Typically, water-absorbent bamboo was used to build a fence to protect the land, but it collapsed within a year of being built. That is, experiments have been conducted throughout the provinces of the region to find answers, but they have shown to be imperfect and insufficient in stimulating economic growth and disrupting the movement of products.



**Figure 1. Protect the land with bamboo fences along the shore and across the shore.**

Source: Albers et al, (2013)

Although Vietnam has an adaptation policy, first published in 2012 and most recently updated in 2020 - National Adaptation Plan (UNDP, 2023). The problem lies in the specific segment, specific policies for the Mekong Delta region are still vague, and policies in terms of supporting seaport activities are also not specific. There needs to be a specific division to support localities and departments in each sector from public to private to implement and apply. Vietnam demonstrates a receptive attitude towards addressing climate change, and this is also true for the Mekong Delta. However, there is a need for greater precision and clarity in the current situation. The objective is to attract additional investment and support from international organizations to enhance the region's stability and enhance the well-being of its inhabitants.



**Figure 2. Key strategies in Vietnam's adaptation policy**

Source: Nguyen et al, 2023

### 1.3 Research Objectives and Questions

The objective of this research is to conduct a comprehensive analysis of the underlying factors and consequences of climate change, with a special focus on the occurrence of sea level rise in the Mekong Delta region. The magnitude of the risk posed by this occurrence is substantial, as it impacts the whole living environment of individuals, the economic activity of the region, the entire country, and disrupts the flow of products at ports in the affected area. An extensive examination will be carried out on the literature pertaining to the current state of sea level rise and its effects on seaports in the region. Next, conduct an assessment and comparison process with other nations to acquire relevant results and draw lessons from prior successful initiatives. Outline key concepts for developing an adaptation framework that is appropriate for addressing the present circumstances of sea level rise in the Mekong Delta.



This subject of research holds significant importance due to its fixed effects on the local population's living environment, the economic situation of the affected region, and even the entire nation's populace. Since the dangers associated with this phenomenon have almost certainly materialized and are escalating daily, this research should be conducted. It is crucial to analyze extant plans, as only a limited number of locations have developed specific strategies to adapt to sea level rise. Develop adaptation strategies that possess a significant probability of tangible implementation by integrating up-to-date information with spatial specificity. This research contributes to our understanding of a domain that has substantial practical implications for a crisis characterized by considerable hazards.

To serve this research, two main research questions were established by the author:

- What are the most significant dangers that climate change may pose to Vietnamese port operations today and in the future?
- In pursuit of enhancing self-defense capabilities, how can a framework be constructed to facilitate adaptation to sea level rise for the benefit of Mekong Delta seaports?

#### 1.4 Research methods

The specific research methods used to answer the research questions are presented in the Table 1. According to the information in the table provided below, this study is based on a combination of research methods benchmarking, and qualitative methods. Each method is presented in detail in this section.

**Table 1. Methods employed in the research**

Questions	Research methods
1	Systematic literature review
2	Benchmarking, qualitative research, semi-structured interviews

### **Systematic literature review**

This academic approach aims to aid the researcher in locating and assessing all the relevant literature pertaining to the study's issue, enabling the formulation of conclusions that address the research problems at hand. Systematic literature reviews provide a methodical and precise evaluation of reliable and authoritative material to address a well-defined subject (Dewey, A. & Drahotka, A. 2016). This search was thorough and transparent, including several reliable databases and literature sources that have been utilized by other researchers in their studies.

### **Qualitative research method**

Qualitative research methods are of great importance to research because literature reviews and interviews contribute to answering the main questions the research is trying to address. First, a systematic literature search is essential to begin answering the research questions in depth. This is because such a systematic review helps avoid duplication of research and can allow authors to extract the necessary information in the least possible time.

Secondly, semi-structured interviews were selected as the method of gathering data from participants who possessed the ability to converse orally. To effectively construct questions and guide the conversation, the author must conduct prior research on the respondents and their expertise. This will allow for the convenient alignment of questions with the respondents' areas of knowledge, while also maintaining control over the path of the interview as needed (Bryman, 2008).

### **Benchmarking**

The objective of this study is to provide a standard that can assess the efficacy of adaptation measures in response to sea level rise. This strategy serves as both a complement to the research question and a means of contrasting the disparities between the Netherlands and the Mekong Delta. After that, it is feasible to construct a flexible framework that is appropriate for the specific situation in which this issue aims to be investigated. Benchmarks primarily concentrate on a period beyond 20 years (2000 - 2023), often starting from 2010, to gain a deeper comprehension of long-term patterns and advancements in innovation. This standard specifically addresses the operational

efficiency factors and dangers that ports encounter. Assists the author in constructing a well-suited framework for adaptation, mitigating hazards, and suggesting acceptable measures for innovation endeavors.

## **2 Literature Review**

### **2.1 Climate Change and SLR impacts on Sea Ports**

By 2100, rising temperatures are projected to cause a sea level rise of 110 cm, which is 12 cm greater than their 2014 forecast (IPCC 2019). Concurrently, they have cautioned that in the year 2050, extreme weather phenomena, which have been infrequent in past times, are likely to manifest more frequently and in a greater number of regions worldwide.

There has been an abundance of scientific evidence regarding the concealed dangers of extreme weather and sea level rise as a result of climate change's effects for many years. These alerts are widely disseminated within the scientific community and have the potential to affect a substantial portion of the global population. Constant warnings throughout the years and the evident changes in the natural world in recent years have instilled fear in governments and individuals worldwide. Sea level rise is predominantly a consequence of global warming. However, the issue receives little attention if it only increases by a few centimeters per century (Pham, 2012). Notwithstanding the transient reduction in emissions attributed to the COVID-19 pandemic, the most recent emissions gap report from the United Nations Environment Programme (UNEP) suggests that global temperature escalations surpassing 3°C remain imminent in the twenty-first century (UNCTAD, 2021).

This matter is particularly significant and necessitates a prompt solution due to the pivotal role that ports play in global commerce. The transportation of over 80% of the world's products relies on marine routes, making ports crucial infrastructure for the global supply chain and a potential catalyst for future growth. Many regions worldwide have experienced economic losses as a result of infrastructure damage and interruptions in global supply systems caused by tropical storms, increasing sea levels, or floods. Without prompt adaptation and preventative efforts, it is projected that the entire value of assets impacted by coastal flooding might rise by 12 - 20% of world GDP by 2100, according to UNCTAD (2021). In developing nations, port infrastructure is meticulously planned, but they often fail to account for the potential consequences of rising sea levels when

projecting the lifespan of the port. Also in Vietnam, there are several ports of moderate to small sizes that have been constructed with little vertical distance between the water level and the port structure, as compared to the typical sea level (Pham, 2012).

Seaports are, in essence, constructed to withstand and recover from the diverse array of pressures that transpire during their operational lifespan. Even so, they are susceptible to damage from extreme weather phenomena. An escalating number of ports are anticipated to be threatened by extreme weather events as a result of the observable progression of climate change. It is anticipated that the frequency and intensity of severe storms, rising sea levels, and other extreme weather phenomena will escalate (Vousdoukas et al. 2017). This could potentially hasten the decline of port infrastructure and result in substantial repercussions for supply chains, logistics, and port administration. Furthermore, the port infrastructure will be adversely affected by severe weather, resulting in substantial material losses and further adverse effects on port operations. A significant loss of funds and a postponement of the transportation of products will ensue as soon as port operations are disrupted.

Global supply chains will also be disrupted as a result of economic losses caused by direct damage to port infrastructure and disruptions in the flow of products between ports. Significant financial losses may ensue as a consequence of delayed or canceled production and orders, in addition to revenue and market share depletion. Coastal inundation is projected to cause property losses and expenses amounting to 12–20% of the global GDP by 2100 if nations do not initiate preventative measures immediately. Simultaneously, it is projected that ports sustain \$7.6 billion in annual harm due to climate-related hazards (University of Oxford, 2023).

## **2.2 Sea level rise scenarios of Vietnam**

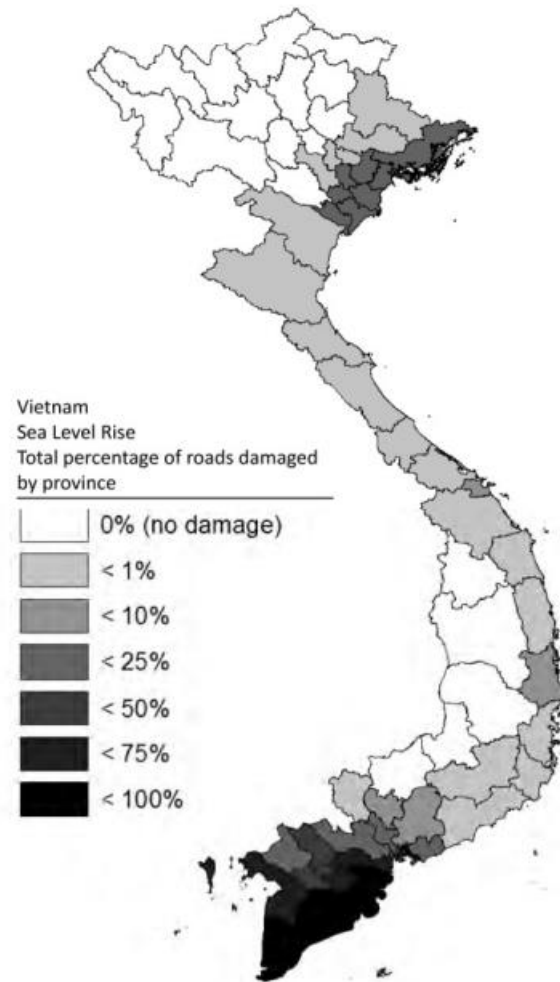
Vietnam is exceptionally susceptible to a variety of natural disasters caused by extreme weather phenomena that evolve over time, as a result of its geographical location. The Sea of Japan, which the majority of the nation's 1,800-mile coastline confronts, is the annual epicenter of numerous tropical cyclones. The northern mountainous regions are susceptible to landslides and sudden flooding, whereas the southern Mekong Delta, which is flat, is the most flood-prone area on earth. Elevated sea levels are a concern (Tatarski, 2018). In the absence of prompt implementation of ad-

adaptation strategies and resolute governmental intervention, an approximate twelve million individuals will be exposed to irreversible inundation. A further 2.4% of Vietnam's gross domestic product is vulnerable to the effects of frequent inundation. The coastal protection efforts of the central and provincial administrations of Vietnam are predominantly focused on concrete infrastructure, with some instances also incorporating mangrove restoration techniques. The determination of the most suitable measures for the preservation of the Mekong Delta remains a subject of ongoing discourse (World Bank, 2021).

In 2009, Vietnam's Ministry of Natural Resources and Environment developed a scenario to assess the impact of climate change and sea level rise in Vietnam for the first time. Vietnam is currently experiencing a substantial regional climate transition. "Compared to the average temperature recorded from 1980 to 1999, Vietnam is predicted to have an average temperature increase of 2.3°C by the end of the 21st century" (Ministry of Natural Resources and Environment of Vietnam, 2009, p.13).

A significant portion of the increase in sea level is attributed to thermal expansion and the melting of glaciers and ice caps. Vietnam's sea level increase aligns with the global trend of rising sea levels. The Ministry of Natural Resources and Environment of Vietnam's latest climate change scenario, Vietnam Climate Change Scenario 2020, predicts an increase in sea levels leading to a significant danger of floods. The average sea level along the whole coast might rise by 73cm by the end of this century. With a 100cm increase in sea level, the danger of flooding will surpass a permanent threshold in the following areas: Mekong Delta (47.3%), Red River Delta (13.2%), Quang Ninh province (1.9%), Central coastal provinces (1.5%), Ho Chi Minh City (17.2%), and Ba Ria - Vung Tau province (4.8%).

By 2050, Vietnam is expected to see a coastline sea level increase that exceeds the world average. The sea level of the East Sea is projected to rise between 24 and 28cm by 2050, and is anticipated to further climb between 56 and 77cm by 2100. The average sea level increase in the southern coastal provinces would be larger than in the northern regions, according to the Vietnam Ministry of Natural Resources and Environment (2020). In recent years, several studies have cautioned that the Mekong Delta, located in the southern area and inhabited by over 20 million people, is slowly subsiding and is in risk of disappearing. perished during the next century.



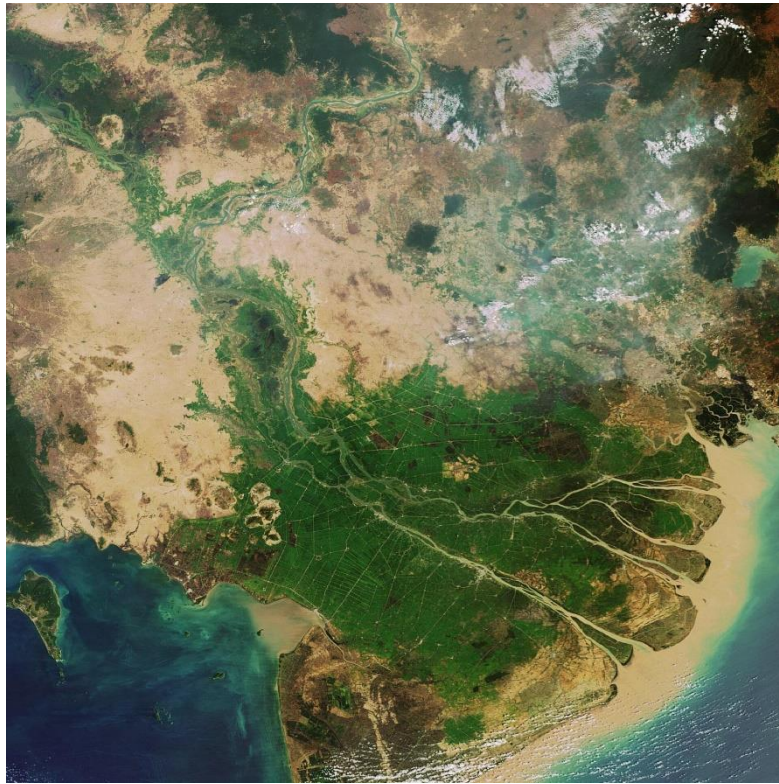
**Figure 3. Damage due to SLR is calculated as a percentage of damage for all provinces in Vietnam**

Source: Ministry of Planning and Investment (2012) and IRF (2009)

### **2.3 Topography of the Mekong Delta and Vulnerability due to the impact of SLR**

The Mekong River, one of the largest rivers in the world, is a gift that nature has bestowed upon Vietnam. The Mekong River flows through many countries, including Vietnam. When the river enters Vietnam, it is referred to as Cuu Long, since it discharges into the sea through 9 outlets in the Mekong Delta area. The Mekong Delta is characterized by its many rivers and canals, making it the most prominent geographical feature of the region. There are 101 inland waterway routes through rivers and canals with a total length of 3,186.3 km. Hence, the government must construct a multitude of bridges to provide seamless interprovincial connectivity and establish efficient road transportation networks. Simultaneously, the excessive ownership of bridges has resulted in

several challenges for canal traffic in the region. This issue will be further examined in the next section.



**Figure 4. Vietnam's 'nine-tailed dragon'**

Source: European Space Agency (2007)

Regarding the problem of rising sea levels, the Asia-Pacific region has attracted global attention, including Vietnam and the Mekong Delta region. Important scientific research has proven that the Mekong Delta will be the region most severely affected by rising sea levels. With an average altitude of 0.7 - 1.2 meters above sea level and flat terrain, the Mekong Delta is a place that easily suffers natural disasters when sea levels tend to lower. Other formulations related to the most important activities of this issue that also frequently affect the region include high arc tidal inundation, salinity intrusion, and erosion (Anthony et al., 2015). Furthermore, the Ministry of Natural Resources and Environment (2016) predicts that by 2100, sea level in this area may increase by 1 meter, submerging 40% of the Mekong Delta area.

Elevating sea levels can provide a potential hazard of overtopping and rupturing coastal barriers, even in the absence of significant storms. Furthermore, alterations in coastal current patterns will also contribute to the erosion of banks, in addition to the increase in sea levels. Rising sea levels reduce the drainage capacity of dyke and embankment systems, leading to higher river levels and increased upstream flows. Exacerbating the severity of port flooding, thereby significantly endangering the integrity of dikes and embankments. The combination of large waves and rising sea levels has adverse impacts on many aspects of the southern region of Vietnam, especially the Mekong Delta region. This includes damage to ports, protective structures, infrastructure, equipment, cargo, waterway traffic, port operations, maintenance, services, and overall capacity of waterways and ports.

At the same time, storm surge requires special consideration. Recorded data shows that storm surge height is likely to increase from 2m to 4m and spread inland through the river. Therefore, the use of ships will lead to a reduction in freeboard as well as a reduction in the capacity of ports and waterways. In addition, the design configuration of the majority of seaports, warehouses, port access roads, and breakwaters in Vietnam does not take into account the adverse impacts of rising sea levels, leading to significant damage. In the event of a 1m sea level rise and a storm surge, most seaports in the Mekong Delta are likely to be flooded.

## **2.4 Rising Sea Levels impact Seaports in the Mekong Delta Region**

The Mekong Delta is not only one of the largest deltas globally but also one of Vietnam's seven significant economic areas. This location offers abundant prospects for both agriculture and aquaculture. This area accounts for 56% of rice production, equivalent to 24.5 million tons. It also contributes to 98% of seafood production, amounting to 1.41 million tons, and 60% of the country's fruit production, totaling 4.3 million tons. In addition, it is also responsible for providing 95% of Vietnam's rice export output and 60% of Vietnam's seafood export output. This region is deemed to possess significant prospects for growth. Nevertheless, it is encountering several difficulties arising from the detrimental impacts of climate change (Bộ Nông Nghiệp và Phát Triển Nông Thôn, 2023).

Climate change has a direct influence on the port and its infrastructure, in addition to its susceptible location. Port activities may be constrained if there is flooding due to sea level rise. Port operations, including the handling of cargo, ship schedules, and warehousing systems, will be instantly disrupted



in the event of a natural assault. Furthermore, these facilities may sustain damage, rendering it infeasible to resume port operations after the sea level subsides. While sea level rise benefits the passage of large ships away from the shore, it poses a challenge for ships to enter ports. The inadequate elevation of ports and port infrastructure poses a concern as sea levels rise since it increases the risk of coastal flooding due to bow waves. This, in turn, endangers the essential departments operating at the port.

Moreover, the increasing sea levels in the region have a detrimental effect on the transportation of cargo ships and hinder their ability to dock according to the planned timetable. According to the given information, the Mekong Delta region contains several dykes to protect against seawater intrusion, and it is also characterized by the presence of several expansive bridges that connect different provinces. The increasing sea level will provide significant challenges to transportation, since it may result in ships being unable to dock according to their planned timetable due to the need to wait for the tide to subside. In addition, it is not practical to permit ships carrying substantial amounts of containers to reach the provinces due to the insufficient height of the bridges at the time of their construction. Consequently, it would be necessary to invest time in raising the bridges to create sufficient clearance for the entry and exit of ships.

## **2.5 Potentials and Challenges of Waterway Infrastructure in the Mekong Delta**

The Mekong River route is capable of serving both inland and cross-border waterway transport. And Vietnam is in the downstream area of this large river, the advantage of downstream countries being that they can navigate both inland waterway and sea transport. The economic benefits that this river brings to the countries it flows through are very potential, but with the current high frequency, the environmental and safety risks are equally great.

In the Mekong Delta region, the downstream location through which the Mekong River flows is capable of receiving a larger number of ships than areas in other countries through which this river also flows. It is capable of handling 78% of annual cargo volume and 89% of passenger traffic on the Mekong. In contrast, the upstream section of the river between China and Cambodia is only navigable by smaller vessels carrying less than 250 tons. The middle section from Thailand to Cambodia via Laos can accommodate large ships that can carry more than 300 tons.

The Mekong Delta region is favored with more than 30,000 km of rivers and canals, but the port infrastructure here often operates below capacity. The lack of connection between the inland waterway, port and road networks has limited the capacity and capacity it can deliver. The Mekong Delta has 7 seaports, 31 ports and 57 inland waterway ports. Despite this, about 80% of goods are still transported by road to seaports in the region (Dezan Shira and Associates, 2018).

Recent estimates show that Vietnam has the largest market share with 5.1 billion USD, followed by Cambodia (1.1 billion USD), Laos (0.4 billion USD) and Thailand (0.2 billion USD) (MRC, 2017). Vietnam's waterways account for a very high share of national freight transport (nearly 19% on a ton-km basis) compared to other leading IWT regions (China, the United States and the European Union each account for 5-8%).

The logistics industry's capacity in this particular regional market remains significantly constrained. As a result of the absence of warehouses and yards in major agricultural production regions and the construction of border crossings with Cambodia and the Gulf of Thailand, the logistics expenses associated with Vietnamese agricultural products escalate. is extraordinarily elevated. Logistics expenses in Vietnam are notably more expensive than those worldwide. Certain ASEAN nations, including Singapore and Thailand, have reduced their logistics expenses, whereas Vietnam's expenses continue to be prohibitively expensive, impeding its ability to compete. The World Bank estimates that logistics expenses (storage, transportation, customs clearance, etc.) in Vietnam comprise between 20.9% and 25% of GDP. This expense is three times that of Singapore, 12% that of Malaysia, and 6% that of Thailand. As reported by the International Monetary Fund (IMF), the mean expenditure on logistics comprises 12% of the global gross domestic product. Logistics costs for enterprises can vary significantly, surpassing 30% of revenue. In Vietnam, logistics expenses comprise approximately 25% of the country's gross domestic product, with transportation accounting for an additional 50%-60%. These figures are disproportionately high in comparison to global standards.

Furthermore, the impact will extend to coastal infrastructure, resulting in a significant reduction in the resilience of port infrastructure. The increasing sea levels will lead to several issues, including extended floods and rapid erosion, which will render port infrastructure inoperable. If appropriate high-level infrastructure is not constructed, the road area within the port may remain inundated

for an extended period. Furthermore, the interruption of essential services such as power, water, and drainage would result in substantial harm not only to the local region but also to Vietnam and the global community at large.

### **3 Methodology**

This chapter describes the methodological approach used to address the research questions and achieve the research goals. This research will combine Systematic Literature Review (SLR) and Benchmarking approaches to acquire a full grasp of theoretical and practical issues. The systematic literature review aims to develop a robust theoretical basis. It is beneficial to collect viewpoints from several academic disciplines about the topic of sea level rise. An examination of scholarly literature reveals gaps in understanding the effects of sea level rise on port operations in the Mekong Delta due to its complexity. Benchmarking using actual instances helps pinpoint strengths and flaws, offering practical insights into successful strategies used in other situations. It helps assist this research by providing practical adaption techniques and frameworks. By combining both methodologies, the research can verify its findings across different approaches and enhance the reliability of the results.

#### **3.1 Systematic Literature Review (SLR) for Theoretical Framework**

By presenting the findings of prior research in a succinct manner, a systematic literature review functions as a compilation of prior studies pertaining to a particular subject (Salminen, 2011). The works published from 2000 to 2024 were the subject of a systematic review of the written literature. The sources utilized in this context comprised both academic and non-academic materials, such as industry-prepared research documents, guidance documents, and reports, to assist practitioners in their work. To locate comprehensive information pertaining to the domain of climate change and sea level rise, scholars consult pivotal research reports for academic literature. These reports also serve as sources for forecasting future sea level rise and analyzing the effects of sea level rise on port operations and the living environment. The reports considered are:

- Vietnam's climate change scenario
- Special report: special report on the ocean and cryosphere in a changing climate
- Maritime Economics & Logistics (MEL)

- Impacts of waves and sea level rise on ports due to global climate change: Viet Nam sea ports case study
- Socialist Republic of Viet Nam: Climate Change Impact and Adaptation Study in the Mekong Delta (Cofinanced by the Climate Change Fund and the Government of Australia)

For non-academic publications, newspapers articles, memoirs, websites of the following organizations were also considered:

- United Nations Conference on Trade and Development (UNCTAD)
- Mekong River Commission (MRC)
- Ministry of Natural Resources and Development

A systematic literature review was conducted for this study and the findings were used to inform the results and discussions presented in the preceding and following chapters.

### **3.2 Benchmarking for Comparative Analysis**

This study incorporates benchmarking as a procedure for identifying, comprehending, and modifying established practices regarding the effective functioning of ports with the aim of enhancing port performance through the utilization of two processes: evaluation and comparison. This methodology will serve as the cornerstone for establishing a comprehensive understanding of information exchanged between nations in order to derive the required conclusions, thus facilitating the development of a framework for adaptation to the phenomenon of sea level rise. In order to obtain practical insights and establish benchmarks, the Netherlands is an ideal partner for comparative analysis. As a consequence of the Netherlands' remarkable advancements in adjusting to the phenomenon of sea level rise and the unexpected outcomes that have stunned the international community, the standardization of ports is gaining significance and relevance in the global context.

The information will center on strategies, policies, adaptation, and mitigation measures, as the objective of this analysis is to compare and contrast the reactions of the Mekong Delta region and the Netherlands. This initiative will make extensive use of qualitative data in its benchmarking analysis, which is a relatively novel technique for comparing various sources of port information. Concurrently, selected factors for comparison will be determined in accordance with the actual

situation, the causes of sea level rise, and other pertinent levels. Established data collections pertaining to Dutch and Mekong Delta port operations will serve as the data sources.

In order to facilitate systematic comparisons, it is imperative that the project incorporates only the most accurate and pertinent information possible, such as documents, reports, or official letters obtained from reputable sources including government websites and sources with direct access to the issues at hand. When comparing measures to prevent sea level rise, numerous criteria must be considered, including economic, social, and human factors. These factors additionally contribute significantly to the exacerbation of the problem's situation. Following this, we will discuss the significance of the chosen subjects and the criteria that can be utilized to assess the performance of ports.

#### **Criteria for Comparison:**

Port infrastructure and performance will focus on the longevity and integrity of the infrastructure connecting different ports. Explore the detailed adaptation measures that ports are implementing to address the challenges posed by increasing sea levels, storm surges, and other severe weather phenomena. Furthermore, evaluate the efficiency of cargo handling procedures, vessel turnaround times, and berth usage rates.

Economic effect and financial efficiency refer to the capacity of a port to contribute to the region's economy, provide employment opportunities, operate efficiently in terms of costs and logistics, and support the financial stability of the nation.

Community engagement significantly contributes to the success of initiatives in the local area. Enhancing individuals' awareness and motivation to enhance their way of living enables the innovation process to go more easily and efficiently.

Policy and administration: adhere to policies and regulations at the national and international levels. The execution of adaptation plans necessitates authorization from various departments and stakeholders, and adherence to its own set of standards and regulations is imperative. Concurrently, investigate annual reports in an effort to increase activity transparency.

Risk management entails the evaluation of potential dangers and the adaptability to modify strategies in response to unavoidable risk scenarios.

### **3.3 Data collection**

The methods are built on two basic foundations: qualitative and quantitative methods. One, two, or a combination of these facilities may be used in research efforts. Distinguishing features characterize the data collected through qualitative and quantitative methods. Quantitative methods are often used in the collection and analysis of data involving numerical attributes, while qualitative methods are limited to non-numerical data. Indeed, research efforts sometimes require the combination and application of adaptable methods to achieve favorable results.

The qualitative approach was selected as the primary methodology for this study. A systematic literature survey reveals that the majority of research published on the subject of sea level rise impacts utilizes qualitative methodologies, including studies examining the effects of sea level rise on seaport operations and the Mekong Delta. This approach effectively presents an exhaustive overview of the port system impacted by the aforementioned climate change phenomenon, thereby enhancing the public's understanding of the pertinent sub-aspects. Nonetheless, this also highlights the necessity for additional investigation into areas that have been relatively overlooked. Such research can only be conducted via qualitative research methods, which entail a thorough examination of various individual viewpoints and opinions.

Qualitative data collected through semi-structured interviews were also examined in the present study. Interviews consist of a series of inquiries accompanied by verbal replies (Saunders, Lewis, Thornhill 2009, p. 97). Historians gather factual information pertinent to the investigation via interviews. In contrast to a rigid format requiring the interviewer to omit predetermined questions, a semi-structured interview affords greater flexibility and facilitates the generation of novel ideas in response to the interviewee's responses. During a semi-structured interview, the interviewer typically refers to a standard set of queries.

### 3.4 Data gathering, sources and availability

Data will be gathered from a diverse range of papers, which may differ based on each specific region and facet. In the Netherlands, port plans and concepts are frequently disseminated through several channels. However, acquiring precise information necessitates a comprehensive investigation and evaluation procedure. Government reports, theses, research papers, and articles provide information about the state of Dutch Harbor. Each year, a substantial quantity of research papers examining the effects of rising sea levels on the port infrastructure in the Netherlands are authored by undergraduates and postgraduate students enrolled in local educational institutions, therefore guaranteeing the verification of the information's accuracy. In addition, using numerous credible media sources, such as The New York Times, Dutch Water Sector, and Euronews, in this study will augment the information's quality.

Likewise, when it comes to the Mekong Delta, a thorough investigation will be carried out using several reliable sources. Renowned media outlets renowned for their high-quality information in Vietnam, such as Thanh Nien, Nhan Dan, and Construction Newspaper, were also taken into account. While the breadth of the information search has been broadened to meet the established criteria, the quantity of released material remains insufficient. This results in a significant amount of time being dedicated to connecting information and ensuring the precision of the obtained data. In order to resolve this issue, it is important to verify the accuracy of the information offered in the article by comparing it with other credible sources.

It is crucial to evaluate the current goals and measures for mitigating and adapting to discover distinct variations in the approach to analyzing outcomes to make comparisons. The primary goal of this project is to provide a planning proposal for the Mekong Delta region that tackles the issue of increasing sea levels. This proposal will be based on the proven and effective Dutch method but will be modified to suit the specific circumstances of the Mekong Delta region. It is crucial to thoroughly evaluate the current actions of each site and ascertain if the plan aligns well with the suggested adaption framework. Alternative methods, such as conducting interviews with people, port officials, or regional natural resources and environment agencies to get their perspectives, will not provide the same level of information as the actual execution of the plan. Hence, this technique of information collection holds immense significance for the project's success.

## 4 Benchmarking

Netherlands – Living below sea level

### *Community involvement*

The Netherlands is a compact nation located in Northwest Europe, sharing physical features and a history of discovery that are notably comparable to the Mekong Delta area of Vietnam. This nation must always adapt to coexist with seawater. In recent decades, this country has increasingly come to accept this occurrence as an inherent aspect of its life, acknowledging that it cannot be avoided without human intervention. In recent decades, the Netherlands has consistently astounded the global community with its capacity to save the nation from inundation by seawater. Water concerns have been a prominent factor for the Dutch, who have progressively adapted to living with this occurrence and now consider it a core part of their national character. Rather than opposing the natural environment, the Dutch opted to adjust to water and coexist with it. This message also serves as a demonstration of their effective adaptation to the phenomena of increasing sea levels, which they present to the outside world.

### *Infrastructure*

Two projects have contributed to the Netherlands' ongoing efforts to transform the challenge of climate change into a chance for progress: the renowned sea dike system at Delta Works in the southwest of the Netherlands, and the dam and drainage system at Zuiderzee Works in the northwest. The construction of a dyke system that is suitable for the Dutch context has significantly contributed to the prevention of coastal inundation and flooding in this nation. The perimeter barrier of this nation has proven to be an effective means of safeguarding Europe's most vital ports and the surrounding infrastructure. In addition, numerous suitable plans have been developed by this nation in anticipation of severe sea level rise scenarios within the coming years. The calculation for constructing ports and terminals typically requires a location 3–6 meters above sea level; this serves to reduce the impact on the port system over the next decade (Port of Rotterdam, 2021). In addition, the barrier will close automatically in the event that the water level is expected to rise by three meters or more. This barrier system has a maximum operational lifecycle of one hundred years and can withstand five-meter sea level rises.



Although the Netherlands has a very solid system and engineers have also calculated in advance scenarios of sudden high water levels caused by climate change. "In reality, we have closed twice in 25 years. We expect to be closing more often in the future of course... We accounted for around 50 cm of sea level rise. But of course, we cannot predict the future exactly, so we expect we will need to make possible alterations sometime between 2060 and 2090," (Euronews, 2023).



**Figure 5: Dutch Delta Works**

Source: DMC and tour operator Rotterdam

### *Economic effect*

The Dutch ports are situated in the North Sea region, which serves as the gateway to the European market. These main ports in the Netherlands facilitate the circulation of a wide range of items, from raw materials to finished goods, for export. The country's primary ports are ideally positioned along the coastline and at the estuaries of three significant European rivers: the Rhine, Maas, and Scheldt. The ports located in the estuaries of the Rhine and Meuse rivers provide a significant contribution of around 34 billion euros to the overall export value of Dutch exports (Port of Rotterdam, 2022). The Rotterdam port in the Netherlands is the preeminent port in Europe, with over 500 links to more than 1.000 ports globally. These connections include deep sea, short sea, transshipment, and RoRo Liner services. In addition, several prominent shipping corporations consistently use Rotterdam as their initial port of call to optimize both time and cost efficiency for their subsequent

shipping ventures to other European nations. The appealing capacity of the Rotterdam port has not only provided numerous work prospects for the Dutch population but has also made a significant contribution to the nation's economy. In 2013, the marine cluster, comprising over 12.000 enterprises, employed around 224.000 individuals and generated a total added value of 21 billion euros, which accounted for 3.3% of the Dutch Gross National Product (GNP). Furthermore, when including the port sector cluster and port-related transportation, the percentage will increase to 7.3% according to the Government of the Netherlands in 2015.

### *Policy and administration*

The Netherlands is situated in the North Sea region, sharing this geographical area with Norway, Scotland, England, France, Belgium, Germany, and Denmark, among others. Consequently, these nations must formulate policies concerning this common sea region. Priority is given in the internationally recognized route system of the North Sea to ensure the secure and uninterrupted passage of commercial shipping, superseding alternative uses such as fishing, recreation, or construction in regions powered by renewable energy. In light of the critical nature of water transportation safety, the policy analysis of the Netherlands has incorporated climate change scenarios (Ministerie van Verkeer en Waterstaat, 2000).

However, there are often distinctions between national policy and regional policy. As the leader of the Delta Works program, which assisted the Netherlands in the establishment of secure maritime transport and port systems, among other initiatives. In cases where regional interests do not seem to be in conflict, it is critical to prioritize national interests when combining them. Rather than flood risk, regional interests frequently center on housing development in flood-prone areas, regional economic concerns, or local ecological issues. Simply because local consensus exists among institutional bodies does not mean that regional issues should be accepted. Concerning the provision of solutions to national issues, the regional perspective is the most critical.

### *Risk management*

Even though the Netherlands has developed an exceptionally effective defense system and is admired globally, hazards must be taken into account. Many factors, including climate change and

its byproducts such as rising sea levels, are beyond precise prediction. Other significant determinants of sea level rise include the rate of glacier thawing, the occurrence of floods, and extreme weather phenomena. The potential sea level rise of three to five meters will necessitate the upkeep and modernization of the Dutch defense system, according to the scenario. Although it is still quite sometime before sea levels reach an alarming level, maintenance and enhancements must be scheduled as soon as possible. As the completion of the Netherlands' vast flood and sea level rise prevention works (Delta Works) required many years, maintenance time must also be taken into account. Furthermore, mitigating the water crisis extends beyond the mere prevention of sea level rise; the Dutch defense system exhibits deficiencies such as the inconvenient and pump-intensive process of releasing river water into the sea. Additionally, this is one of the factors necessitating the Dutch government and engineers to expeditiously develop strategies to ensure secure circulation.

Mekong Delta region - Opportunities from sea level rise

#### *Community involvement*

The Mekong Delta region is the only one capable of providing Vietnam with agricultural security. Moreover, the export volume of agricultural and aquatic products from this region is particularly robust each year. Local farmers in this region can generate a respectable living by cultivating crops and rearing livestock in a manner that is suitable for the harsh natural environment. Experts and researchers from around the globe provided support and direction to the local populace in their efforts to cultivate new varieties that were appropriate for the local environment. Attempts have been fruitful. Promote the continued habitation of the area. Fundamentally, farmers are inclined to remain in their country of origin and persist in their agricultural pursuits due to the substantial financial gains.

Young people and adolescents, however, rarely revisit this area. Based on statistical data from the 2022 annual economic report, the Mekong Delta, which is home to a population of 17.3 million individuals, exhibits the nation's lowest immigration rate but the highest emigration rate. Presently, over 10 million individuals of working age are employed in the region, constituting approximately 20% of the nation's working-age populace. Furthermore, the actual workforce present in localities

is considerably diminished from this figure (Nhân Dân, 2023). A lack of youthful human resources can result in a regressive society, which hinders the implementation of innovative technologies for sea level rise adaptation.

### *Infrastructure*

The Mekong Delta has garnered significant interest from the government, organizations, and NGOs, who have offered substantial financial aid and assistance in infrastructure development to the provinces in this area. The government has approved the technical infrastructure system, which includes significant expenditures in water management, wastewater treatment, and port facilities. Nevertheless, the infrastructure in this location remains rather weak, providing only limited assistance for preventative efforts. The majority of projects are not coordinated. To effectively mitigate issues associated with sea level rise, it is necessary to invest in comprehensive infrastructure. The building of infrastructure and port infrastructure lacks consistency, resulting in old structures in the region that are not promptly repaired or maintained.

Meanwhile, there is an acute need for seaports to accommodate the region's export volume of products. The investment budget for the waterway transportation system, on the other hand, has decreased significantly from 2% to 3% of the total transportation investment budget from 2011 to 2015 to a mere 1.2% from 2016 to 2020. As of now, the Mekong Delta lacks a genuinely global seaport; consequently, the regional seaports' contribution to the overall volume of container imports and exports is negligible in comparison to that of the entire nation (Thanh Niên, 2022).



**Figure 6. Weak infrastructure in the Mekong Delta**

Source: Thanh Nien Magazine

### *Economic effect*

The Mekong Delta is the principal economic region of Vietnam, accounting for the largest share of the country's agricultural exports. The economic magnitude is progressively broadening, with an estimated 970 trillion VND in 2020, constituting 11.95% of the nation's gross domestic product (GDP). Reports indicate that over the past five years, the volume of cargo transiting through the seaports of the Mekong Delta has increased annually, except in 2021, when the COVID-19 pandemic caused a decline. The volume of products transiting through the seaports of the Mekong Delta decreased from 19.30 million tons in 2017 to 20.84 million tons in 2021, from 22.28 million tons in 2019 to 22.91 million tons in 2020. The volume of goods exported via the seaports of the Mekong Delta in 2021 amounts to a relatively modest 0.43 million tons, representing over 2% of the overall import-export and domestic products passing through the port. As a consequence of the diminished severity of the pandemic, there is a worldwide inventory of goods, which subsequently reduces the volume of goods that are being delivered to ports. According to projections, the volume of commodities transiting through the seaports of the Mekong Delta is expected to rise from 64 million tons in 2030 to 208 million tons in 2050 (Báo Xây Dựng, 2022).

### *Policy and administration*

The Mekong Delta is situated downstream of the Mekong River, one of the largest rivers globally. Therefore, the region's location is profoundly impacted by any factors that occur upstream. In addition, water management initiatives close to this river must adhere to the overarching guidelines put forth by the Mekong River Commission. The initiation of extensive planning endeavors is additionally constrained and impacted to some degree by policy regulations imposed by pertinent entities.

Due to the absence of close collaboration among pertinent stakeholders, including shipping lines, logistics companies, private port enterprises, and logistics organizations, the present state of affairs in the Mekong Delta region necessitates the joint effort of local and regional governments to lobby the state for business support and to entice companies to relocate to the area in pursuit of sustained development. Recognizing the circumstances of the Mekong Delta, the Vietnamese government has enacted policies to bolster water transport companies and generate an abundance of investment opportunities.

### *Risk management*

The rate of urbanization in the Mekong Delta is very fast but the supporting components are not developed and are absent, delaying the growth rate of the region. The logistics system in the Mekong Delta region lacks synchronization and infrastructure does not meet actual needs. Most logistics services only stop at individual activities, which often causes delays and costs that are higher than global logistics costs. Moreover, the situation of seaport planning is still inadequate, there are no major ports or large regional and international logistics centers. The connection between modes of transport and low water transport capacity makes logistics costs high, reducing the competitiveness of Vietnamese goods.

The Mekong Delta region is encountering issues stemming from the consequences of increasing sea levels and natural calamities. These phenomena, including ground subsidence, floods, droughts, and salinity, pose more frequent and severe dangers. They have detrimental effects on technical infrastructure, compromising safety for both living and operating conditions, and disrupting people's lives. However, the ability to predict and evaluate sea level rise based on different scenarios

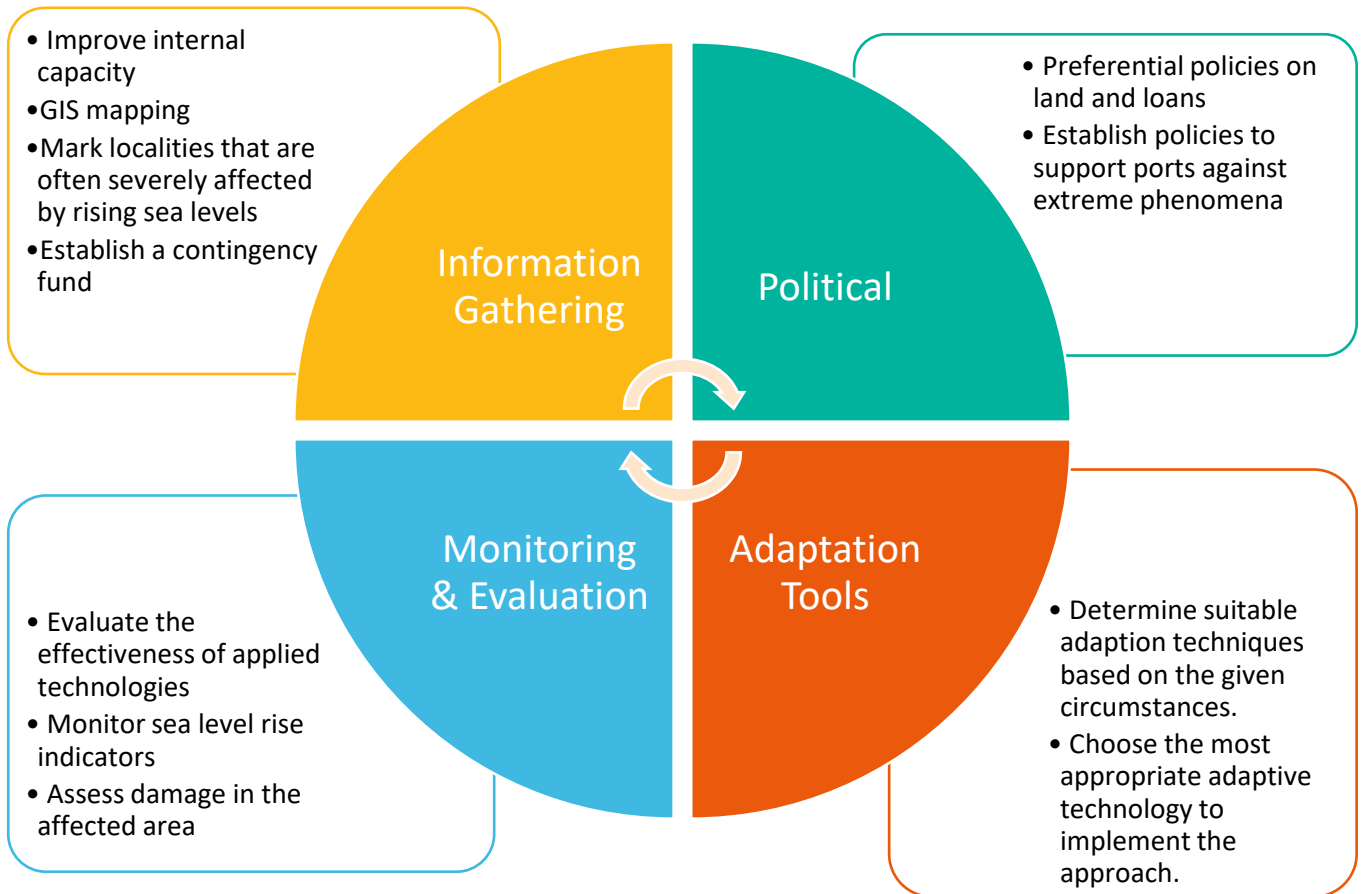
and natural calamities is still restricted. Constructing infrastructure systems in the Mekong Delta area is a major difficulty due to unfavorable geological and hydrogeological circumstances. This is especially true for the development of technological infrastructure, particularly port infrastructure.

The need for investment in infrastructure development to serve sustainable development in the Mekong Delta is huge while resources are limited, mainly relying on budget sources. Financial support is not enough to keep up with the rapid urbanization of the region. There are too many projects and works that need investment but insufficient finance leads to cumbersome connections.

Furthermore, the timely and adequate execution of infrastructure maintenance has been compromised, thereby constraining the overall efficacy of the undertaking. The current state and capabilities of management, operation, and maintenance remain inadequate in light of the system's complexity, failing to guarantee synchronization and technical prerequisites.

## **5 Adaptation Framework Development**

This chapter will establish the method of adapting to sea level rise. To establish a suitable adaptation framework at the regional and local levels, it is necessary to rely on a proposed model that encompasses the whole region. Before implementing any of the recommended adaptation methods outlined in this chapter, it is imperative for local authorities to carefully assess and openly communicate the current situation on the ground to regional agencies. To effectively address the implications of sea level rise in different regions and account for their sensitivity, the regional level needs to have the flexibility to delegate power to the local level for prompt adaptation measures. Simultaneously, local authorities can utilize the overarching framework designed for the entire region to adapt the implementation process to better align with the specific circumstances at hand.



**Figure 7. Sea Level Rise Adaptation Framework**



The aforementioned adaptation framework specifies in detail the phases by which the Mekong Delta region can initiate a process of reforming seaport operations in response to sea level rise scenarios that are becoming progressively more severe. The adaptive framework guarantees that local and regional implementation is carried out appropriately. The initial stage, known as the information accumulation process, facilitates the enhancement of the internal capabilities of the pertinent governmental apparatuses to enable them to promptly adjust to the prevailing circumstances. Simultaneously, this phase grants governments of all tiers the flexibility to identify financial constraints, resource limitations, and any other deficiencies that may exist in the region's efforts to adapt to sea level rise.

Once all the fundamental data of each place has been gathered, regional authorities may assess and pinpoint the challenges that each locality is encountering. To expedite the development of favorable policies and provide assistance to the affected parties in the region due to the rise in sea levels, submit a report to the state authorities. Analyzing the tangible obstacles that hinder the promotion of inclusivity and openness yields important insights that may be disregarded by both municipal and port authorities during the evaluation phase. While it may be challenging to measure the extent of the harm caused by these issues, there is a chance for collaboration between local governments and port authorities to develop vulnerability reports. These reports may then be authorized by the government to facilitate the necessary corrective actions.

Subsequently, the government may facilitate the Mekong Delta region in the identification of suitable adaptation strategies by collaborating with pertinent agencies, including the Ministry of Natural Resources and Environment, to ascertain the present and prospective circumstances. Careful calculation is required for the implementation of both short-term and long-term strategies to enable the government to allocate funds from the national budget. Governments, organizations, and non-governmental organizations (NGOs) have provided financial support to the Mekong Delta region, as was discussed in prior chapters. To further its defense efforts, the Vietnamese government also obtained loans from the FDA, AFD, and JICA. Nevertheless, the provision of financial assistance for the development of defensive systems across the Mekong Delta region appears to be inadequate. As a consequence, it is imperative to establish and prepare a procedure for identifying the provinces that have sustained the greatest losses across all domains and are the most severely damaged to strategize for protection.

**Implementing adaptation actions**

Additionally, the implementation of adaptation measures must be contingent on the extremely particular circumstances of each region. However, many innovative adaptation actions have been identified as a result of the project, along with additional prospects for enhancing logistics flows, managing infrastructure lifecycles, and mitigating potential risks. The research initiative identified several opportunities, which encompassed technological advancements, infrastructure modifications, planning enhancements, and innovations in management systems. The subsequent table provides specifics regarding the actions, which are cited concerning the achievements of prominent developed nations (Australia, the United States, Singapore, Canada, and the Netherlands). In addition, the subsequent adaptation measures have been executed to a greater extent by prominent port authorities and researchers globally, with enhanced outcomes.

**Table 2. Opportunity for adaptive action**

Action Area	Adaptation Action
Infrastructure	<p>Gray Infrastructure:</p> <ul style="list-style-type: none"> <li>– To combat dual problems such as rising sea levels, flooding, and abnormal wave activity, invest more in upgrading and maintaining seawall systems, bulkheads and dike systems throughout the region. Mekong Delta.</li> <li>– Invest in complete construction of the water management infrastructure system. Pipelines, ditches, sewers and reservoirs require large investments to fully complete the defense system for the entire area.</li> <li>– Changing the height of port infrastructure, increasing the height above sea level as predicted by the Ministry of Natural Resources and Environment and IPCC.</li> <li>– Construction of a super offshore seaport.</li> </ul> <p>Green infrastructure:</p> <ul style="list-style-type: none"> <li>– Enhance aquaculture and plan coral farming locations. Increasing coral aquaculture because their structure can buffer coastlines against waves, storms and floods, helps prevent loss of life, property damage and erosion.</li> </ul>
Planning	<ul style="list-style-type: none"> <li>– Establish collaboration among municipal authorities, harbor authorities, and suppliers of supply chain logistics infrastructure to strategize cargo operations and effectively create interconnected logistics hubs. The approach necessitates maintaining the security of cargo and reducing the quantity of items moved during anticipated sea level rise.</li> <li>– Port authorities, local authorities and logistics service providers need to cooperate with each other to continuously issue damage reports and assess vulnerability due to sea level rise on a regular basis. more (annual natural disaster risk report).</li> <li>– Port authorities coordinate with local authorities to publish an annual assessment of the resilience of coastal infrastructure. So that regional authorities can understand the status and resilience of measures, making it convenient for improvement</li> <li>– Alliance formation and collaboration among nations that utilize shared maritime routes are endeavors aimed at safeguarding the worldwide commerce network. As an illustration, Vietnam may form alliances with other major port systems in Southeast Asia, including</li> </ul>

	Singapore or Thailand, to facilitate emergency route changes for ships.
Management system	<ul style="list-style-type: none"> <li>– Develop a quick response plan to support minimizing disruptions in implementing measures to respond to natural disasters at the port.</li> <li>– Develop annual inspection and maintenance plans for port infrastructure and coastal defense systems.</li> <li>– Develop a plan to support trade networks in routing when goods cannot access certain ports.</li> </ul>
Technological	Risk assessment techniques for individual ports along with analyzes of port and hinterland connectivity.

## 6 Conclusions

This chapter will provide an overview of the findings during the research process, answering the questions established in the first chapter. Besides, this chapter will also argue about the value, reliability and ethics of this research that has contributed to the world's research treasure.

### 6.1 Answering the research questions

The results obtained during this investigation indicate that port operations in Vietnam have been impacted by climate change-induced by-products in recent years, and this trend is expected to continue in the future. Concurrently, to assist Vietnam's port operations in enhancing their future resilience, adaptation strategies have been meticulously chosen, assessed, and tailored to the regional and national environment.

- In impact assessments of sea level rise, the Mekong Delta region is at a high warning level.
- Sea level rise in the area is increasing, leading to an increase in saltwater intrusion and seawater inundation, leading to consequences that affect port operations and damage to port infrastructure.
- Rising sea levels make it difficult for ships transporting goods to move and it is not easy to access ports in the area. Causing transportation routes to change, increasing logistics costs and increasing product prices, causing damage to the Vietnamese economy and people in the region.
- To build resilience for each locality in the Mekong Delta region, requires transparency in information and quick, organized action. That is, localities need to regularly report damage and impacts to regional authorities to establish appropriate adaptive actions for each context and time.
- Further water management initiatives in the region can be initiated by regional authorities promptly following the identification and quantification of the damages.
- To support the region's enhanced transportation roadmap, the Vietnamese government is also urged to increase financial support for infrastructure construction in the Mekong Delta

region and implement "open up" policies to attract more private investors in ports and logistics.

- Specific actions in the innovation and upgrading journey have also been suggested in detail in chapter 5

## **6.2 Scientific Contributions of the Research**

Furthermore, the study not only provides practical contributions but also offers further insights and stimulates conversations within the scientific community. Firstly, it can enhance comprehension of different facets of the matter of seawater effects, such as local communities, management policies, infrastructure, or risk management. The research briefly touched on these elements but did not go into them further. However, this focused approach improves comprehension of current weaknesses in the area and aids in the development of adaptation plans. Furthermore, the study on the integration of climate change modeling and forecasting with seaport operations reveals the significant influence of environmental change on port activities. Consequently, it enables readers to get a more accurate understanding of the concealed consequences that climate change is surreptitiously generating and provides them with the chance to gain further knowledge about adaptation strategies. Ultimately, providing more ideas to adjust to the problem and surmount it at certain levels, generates a wider array of options for readers to consult. This study has the potential to serve as a significant resource in the development of strategies to mitigate the impact of climate change on seaport operations in the Mekong Delta area in the future.

## **6.3 Research validity, reliability, and ethical reviews**

The author must substantiate the presence and precision of the data and findings through the application of reliable instruments or metrics that efficiently assess the material and establish a correlation. Precise correlations between pertinent theory and practical application. This research employed qualitative methodologies to ascertain the presence of validity in the study. The author conducted semi-structured interviews with preeminent authorities in the domains of water management and climate change, who possessed practical knowledge in both the Netherlands and Vietnam (Mekong Delta), which are both referenced in the study. Investigate pertinent documents to ascertain their applicability by soliciting input (answers and insights) from industry professionals, thereby identifying inaccuracies and voids that were not identified in alternative sources.

According to Messick (1989, p. 8), construct validity is essential not just for interpreting tests but also for their practical use. The test must be suitable and capable of being applied consistently. Reliability is assessed by evaluating the consistency and durability of a product or service over a while, which writers rely on when selecting it for their projects. To enhance the trustworthiness of this study, the author carefully chose prominent and esteemed academic texts, newspapers, and specialist media. Additionally, the author should be prompted to verify the sources and ascertain the date to prevent the content from becoming obsolete.

In addition, the author carefully checked, planned, and researched to ensure that the information in the research complied with ethical standards and that the author's proprietary results. Prior to recording, participants who are interviewed for the purpose of practicality are duly apprised of the intention, furthermore, their consent is required before any action is taken. Appropriate use was made of interview feedback data, and the integrity and repute of the participants were meticulously considered. In addition to clearly indicated citations and sources, the research has incorporated pertinent documents following ethical and legal considerations.

## 7 Discussion

This chapter delineates certain constraints that arise from the study's scope. These stem from constraints on the research's scope, which are imposed by time and material limitations, as well as certain limitations on the research outputs themselves. On the basis of the limitations outlined in this chapter, it is also possible to speculate on potential avenues for future research.

### 7.1 Limitations in Research Scope

- Limited data on damage due to the impact of sea level rise affecting port infrastructure, port operations and cargo transport routes in the region. Therefore, it directly impacts the national economy.
- Facilities to prevent sea level rise and issues related to water management are not synchronized throughout the Mekong Delta region, leading to the effectiveness of overcoming them not being clearly demonstrated. Therefore, the adaptation model cannot be analyzed from a detailed perspective for each province according to each appropriate scenario.
- In this study, seaport operations were delved into to understand the causes of disruption but there was no real insight into inland port operations. This leads to the proposed adaptation framework and adaptation action being only suitable for sea transport, not feasible for river transport.
- In addition, the research topic was limited, only in-depth research on the issue of sea level rise affecting port operations. In reality, the impact can be accompanied by storms, floods or droughts, so natural disaster scenarios have not been analyzed in depth and the adaptation framework is not appropriate when double natural disasters occur.



## 7.2 Future Research

- As stated previously, the study conducted an in-depth analysis of a singular aspect of climate change—sea level rise. As a result, the conclusions drawn can only be applied to adaptation to this phenomenon. Consequently, future large-scale studies that involve the participation of a considerable number of individuals and have sufficient funding or time to conduct them will be able to investigate a more extensive spectrum of the effects of climate change agents.
- In fact, the lack of specific damage data due to sea level rise affecting goods makes analytical data inconsistent. In the future, this shortcoming can be improved through the data provided by the provinces and by unifying appropriate adaptation methods for the region.
- Based on each stage and circumstance, the sea level rise scenario for the entire region will vary. In light of the ongoing transformations taking place in each province of the Mekong Delta region, it is imperative that new research incorporates updated international data and information from the Vietnam Ministry of Natural Resources and Environment.
- The policies of the Vietnamese government are ambiguous, as are its adaptation efforts to climate-induced natural disasters. The government may consider implementing distinct policies for each controllable aspect in the near future to facilitate more adaptable coordination between private and public terminals. Additionally, logistics companies have access to more information to better adjust operations.

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## Appendices

### Appendix 1. Summary of Interview

Koos Neefjes, the director of Climate Sense (Viet Nam), and expert on climate change and water management, was approached and interviewed for the purpose of understanding the actual activities and policies that have been and are being applied in the Mekong Delta region. The interview will contribute to building an adaptation framework and adaptive actions appropriate to the actual context. In this section, the interview process is presented, and his answers are summarized.

Interview procedure.

Author: Phuc Nguyen

Respondent: Koos Neefjes – Director and Climate Change Expert

Date of Interview: March 18<sup>th</sup>, 2024

Project title: Climate Change Adaptation Strategy for Sea Port Operations in Vietnam. Case study of sea level rise in the Mekong Delta

#### Instructions

Good evening, Mr. Koos. Thank you for your time and availability for this interview. Let me introduce myself and the topic I am researching. Currently, I am completing my bachelor's thesis on the topic of climate change adaptation strategies in port operations in Vietnam, Case study of sea level rise in the Mekong Delta. As of today, I have made comparisons between the implementation of adaptation to sea level rise changes between the Netherlands and the Mekong Delta. However, these comparisons are currently only based on documents and articles available online. I am about to enter the phase of building an adaptation framework for the Mekong Delta after consulting the success of the Netherlands in its water management. Therefore, the purpose of this interview is to acknowledge the current situation of the Mekong Delta region, especially adaptation activities to sea level rise to support the information in the research paper should be realistic.

#### Recording Permission

Before commencing the interview, I would like to request your consent to record the conversation. The objective of this conversation recording is to guarantee that I obtain every aspect of your response while maintaining a reflective dialogue with you. I assure you that the recording will be utilized solely for my research objectives and will remain strictly confidential.

#### The questions:

1. The Mekong Delta region has received a lot of attention and large investments from governments, organizations, and non-profit organizations for climate change in general and sea level in particular. So, in your opinion, what value could this investment bring to the region?

- 2 As you know, every year the losses caused by sea level rise in the Mekong Delta region are huge. So how can this value be estimated?
- 3 What policies or recommendations does Vietnam need to improve on the problem of sea level rise in the Mekong Delta in supporting the development of national and private sea-ports?
- 4 I watched the podcast session between you and Hao Tran, CEO of Vietcetera on water management issues. And I also learned that building a protective wall like Delta Works in the Netherlands is a challenge for the Mekong Delta. Also, you mentioned an issue about green solutions, can you elaborate a little more on how these solutions can impact infrastructure protection or more specifically, whether they can protect port infrastructure?

At the end of the interview:

Thank you very much for your time and responses. In addition, I especially want to thank you for loving Vietnam and Vietnamese people. Your helping Vietnam over the past 20 years has been truly meaningful to our people. The value and time you spend staying in Vietnam and helping people is truly a great value.

And I find what you share very interesting and of course useful for my study. I also assure you that your personal information will not be published without your permission. I hope we can stay in touch via email, and I will get back to you at the end of the study and with the results I develop. Also, I would be honored if you could introduce me to people who share your interest in climate change and especially aquatic change.

Summary of Answers:

- Large investment funds from the government, organizations and NGOs have been and continue to sponsor the Mekong Delta region. At the same time, loans from the Vietnamese government were also made to re-plan the area to design infrastructure to help this area overcome water management problems. Even so, investments appear to be problematic. First, investments to support local people in experimenting with crop and livestock models suitable to the context of natural disasters in the Mekong Delta have achieved fixed successes. It is effective in helping people adapt to the water environment in this area with fixed products such as rice or shrimp that they can grow. This means they do not need to migrate to other areas. In addition, another problem lies in the fact that the infrastructure has not really achieved its effectiveness, requiring additional investment and loans from the government to fully complete the unfinished infrastructure. The construction of unfinished

infrastructure will not achieve effective defense methods, and the reason comes from not fully completing the entire project.

- It is difficult to estimate the damage that the Mekong Delta region suffers every year. It is impossible to accurately predict natural changes, so natural disasters that suddenly strike the palace are not part of a pre-existing plan, so determining losses is still out of control. In fact, experts in this field in Vietnam have conducted interviews with local authorities but the damage data is still not accurate. Therefore, confirmation of other economic data is not possible.
- Green solutions are extremely difficult to implement in infrastructure. Considering ocean surges and cyclones complicates the implementation of environmentally friendly infrastructure construction in delta regions worldwide, including Vietnam, where challenges extend beyond sea level. Once upon a time, green solutions emerged, such as an experimental program in the province of Bac Lieu, however, it failed within a year and required an inordinate amount of time to reconstruct. Consequently, the use of natural materials to construct protective barriers is utterly impracticable. However, the use of combined materials may be considered, this requires additional study. An additional factor that warrants consideration is the course of motion exhibited by vessels that are approaching the port. By constructing with eco-friendly materials, it may be impossible for ships to enter.
- Indeed, Vietnam has implemented commendable policies to assist the local populace in sustaining their livelihoods in regions prone to frequent natural disasters. Expert-explained and proposed adaptation policies have also received government approval and are currently undergoing implementation. Vietnam has actively embraced international assistance regarding climate change, demonstrating a cognizance of the perils it confronts and engaging in numerous international climate change organizations. The fact that people continue to reside in the region and that its economy continues to expand rapidly is the most unmistakable indication that Vietnam's policies to support adaptation to climate change and sea level rise are exceptionally sound.