

RESILIENT SHORES

**VIETNAM'S COASTAL DEVELOPMENT
BETWEEN OPPORTUNITY AND DISASTER RISK**

Jun Rentschler
Sophie de Vries Robbé
Johannes Braese
Dzung Huy Nguyen
Mathijs van Ledden
Beatriz Pozueta Mayo



An aerial photograph of a coastal town in Vietnam. The top half of the image shows a dense residential area with many small houses and buildings, mostly with blue and red roofs. A wide, paved road runs horizontally across the middle of the town. Below the road is a sandy beach with several people walking and some small boats pulled up. The bottom half of the image shows the ocean, with many small boats scattered across the water. The text "RESILIENT SHORES" is overlaid in large, white, sans-serif capital letters in the lower right quadrant. Below it, in smaller, white, sans-serif capital letters, is the subtitle "VIETNAM'S COASTAL DEVELOPMENT BETWEEN OPPORTUNITY AND DISASTER RISK".

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Executive Summary

In a country that is among the most exposed to natural hazards, Vietnam's coastline often bears the brunt. Typhoons, storm surges, riverine flooding, coastal erosion, drought, or saline intrusion are all-too-familiar threats to most people living along the coast. Yet despite these risks, coastal regions host thriving economic sectors, providing livelihoods for a growing and rapidly urbanizing population. The coastal regions could be a powerful engine for Vietnam's continued socioeconomic development, but rapid urbanization, economic growth, and climate change mean that disaster risks are bound to increase in the future.

Although the government of Vietnam has made impressive progress in reducing and managing natural risks, current trends show that the work is far from complete. To guide effective action, this report provides an in-depth and multi-sectoral analysis of natural risks in coastal Vietnam and reviews current efforts in risk management, proposing a concrete action plan to balance the risks and opportunities of coastal development. These actions, if taken decisively, are an opportunity



HOI AN >> The flooded streets of historic old town.

iStock

to strengthen the resilience of coastal communities and hence the prosperity of coming generations.

Natural risks to coastal communities are substantial and increasing.

This report offers detailed estimates of the natural risks faced by people, towns, key economic sectors, infrastructure systems, and public services in Vietnam's coastal zone. The overall picture is clear: the threats are significant and growing. Around 11.8 million people in coastal

provinces are exposed to the threat of intense flooding¹ and over 35 percent of settlements are located on eroding coastlines. And on a coastline that is already crowded — more than one-third of it is built-up — development continues to concentrate along the coast, especially in high-risk areas. Flood risks in high-growth areas are twice as high as in low-growth areas. Key economic sectors that create the foundation for future development and prosperity are facing significant disaster risks. Each year, an average of \$852 million — or 0.5 percent of national GDP —

and 316,000 jobs are at risk from riverine² and coastal flooding in the agriculture, aquaculture, tourism, and industry sectors.

Essential public services are also at risk: 26 percent of public hospitals and health care centers and 11 percent of schools are exposed to intense coastal flooding, compromising their ability to provide critical services when they are most needed. Flooding of facilities is not the only concern: every year, typhoons and floods cause about \$144 million in direct damages to public transport infrastructure.³ Average annual damages to energy infrastructure amount to \$330 million, not least because more than one-third of Vietnam's transmission grid is located in forested areas, at risk of falling trees and branches during storms.³ When infrastructure is affected by disasters, it obstructs people's access to jobs, education and health care, and damages the competitiveness of firms. The lack of reliable and resilient infrastructure disrupts firms' operations, causing some \$280 million in utilization rate losses each year.⁴

While the risks from flooding, drought, erosion, and saline intrusion are already substantial, climate change is expected

to intensify these natural hazards. In a pessimistic scenario, mean sea levels are estimated to rise 30 centimeters by 2050 and 70 centimeters by 2100.⁵ This increases exposure of urban areas to intense flooding by 7 percent, exposing an additional 4.5 million people in coastal areas. Without action, human pressures on ecosystems — for instance, due to ground water extraction and sand mining — will exacerbate these risks.

Despite much progress, current risk management measures are falling short of needs.

The government has made impressive progress in managing disaster risks in recent decades, investing in structural and non-structural risk reduction measures and adopting extensive legal, regulatory and policy frameworks to guide coastal development in safe and sustainable ways. However, these measures fall short of the country's needs.

Hazard and socioeconomic risk information is fragmented and incomplete, often drawing from global databases and relying on a single scenario in plans and project designs. A lack of guidance, enforcement,

capacity and funding have led to shortcomings in implementing risk-informed spatial planning, building codes and safety standards, and systematic maintenance of infrastructure systems. Two-thirds of Vietnam's dike system, which stretches over 2,659 km, does not meet the prescribed safety standards; in many high-growth provinces, even the set standards leave substantial protection gaps.⁶ Nature-based systems have an often underappreciated role in boosting coastal resilience, and are under increasing pressure from development and over-exploitation. And although Vietnam has made tremendous progress in reducing losses from natural disasters, evolving and intensifying risks mean that the government must further improve its systems for disaster financing, relief, and response.

An action plan to balance the risks and opportunities of coastal development.

To ensure that Vietnam's coastal regions can continue fulfilling their potential as engines of resilient socioeconomic growth and prosperity, the government must take urgent action. If the current trends of rapid economic development in high-risk areas continue, disaster losses are bound to

increase unless such growth is resilient and risk-informed. Delaying action by 10 years could expose an additional \$4.3 billion of economic growth to natural shocks.

This report presents a concrete action plan to strengthen resilience in coastal areas, outlining five areas of strategic interventions:

- 1. Strengthening data and decision-making tools.** To manage risk effectively, decision makers need up-to-date information. Establishing systematic, detailed hazard, risk and assets management information at national and subnational scales is essential for making evidence-based decisions on coastal area development and planning.
- 2. Enforcing risk-informed planning.** To ensure economic growth in coastal zones does not irreversibly lock in unsafe development, risk-informed zoning and spatial planning is vital and this should be based on the best available risk information.
- 3. Strengthening the resilience of infrastructure systems and public**

services. To ensure that lifeline infrastructure systems can deliver their essential services, critical assets should be strengthened by integrating risk information into the planning, design, and maintenance stages of all infrastructure investments. Upgrades should start in the most exposed and under-protected areas and existing safety standards should be reviewed and updated.

- 4. Taking advantage of nature-based solutions.** To harness the protective function and economic contribution of ecosystems (including mangroves and sand dunes), a systematic approach to their rehabilitation, conservation, monitoring, and management is essential. Relevant policy, regulatory and legal frameworks must be strengthened and lessons from past initiatives consolidated to inform technical guidelines and future programs.
- 5. Improve preparedness and response capacity.** Disaster risk can never be fully eliminated. To manage residual risk and prepare Vietnam for more intense natural risks, the government

must further strengthen its emergency response capacity. This includes upgrading the effectiveness of its early warning system, strengthening local response capacity, adapting social safety nets, and implementing a comprehensive risk financing strategy.

The government's experience with disaster risks, and its proven long-term planning approaches, are important elements for implementing a resilient development strategy. Through decisive action, Vietnam has an opportunity to safeguard future prosperity and development in the face of climate change and disaster risks.

Endnotes

1. Intense flooding refers to flooding with a 100-year return period or a 10 percent probability of occurrence in a decade.
2. In this report, riverine refers to as the combination of fluvial and pluvial flooding.
3. World Bank DRFI Program. 2019. Vietnam Country Risk Assessment. Washington, DC
4. Losses are associated with infrastructure disruptions caused by natural and non-natural shocks (Rentschler, J, Kornejew, M, Hallegatte, S, Braese, J and Obolensky, M. 2019. *Underutilized Potential: The Business Costs of Unreliable Infrastructure in Developing Countries*. World Bank Policy Research Working Paper no. 8899.)
5. MONRE. 2016. *Climate Change and Sea Level Rise Scenarios for Vietnam*. Hanoi, Vietnam.
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CHAPTER 01 >>

RESILIENT SHORES

RISK AND OPPORTUNITY IN COASTAL VIETNAM



On November 4, 2017, Typhoon Damrey hit Vietnam with its full force. The strongest typhoon in over 15 years, Damrey made landfall in Khanh Hoa Province. Its high wind speeds and floods also caused extensive damage in 14 other provinces. There were 107 deaths, almost 300,000 houses were damaged and another 3,550 collapsed. Overall, the storm caused around \$1 billion in economic losses. The agricultural sector alone — including fisheries, forestry, and crop agriculture — suffered losses of around \$241 million, with indirect effects on people's incomes and livelihoods (GFDRR 2018). In a country with long experience of natural disasters, the storm served as a devastating reminder of the destructive force of nature. It also highlighted the need to further boost communities' resilience to safeguard the development potential of one of Vietnam's most dynamic areas: its coastal regions.

TYPHOON DAMREY >> NASA satellite image

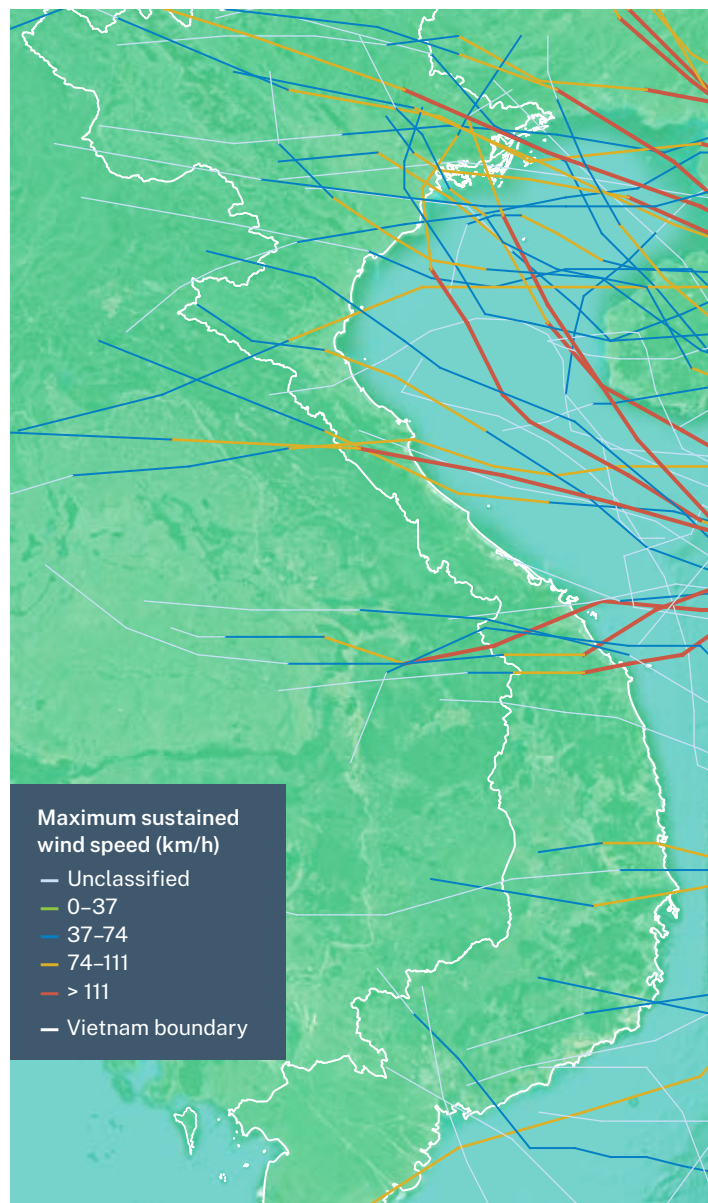
FIGURE 1.1 >>

Typhoon tracks from 2006 to 2016

Vietnam's extended coastline exposes its communities to typhoons

Sources: NOAA 2019; satellite image by Google Maps.

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Vietnam's diverse coastline spans over 3,000 kilometers. In the north and south, the Red River and Mekong Deltas are vast, low-lying areas with a complex network of river branches reaching into the sea. In between, the central coast encompasses a narrow coastal strip with small estuaries, bordered by high mountains. The coastline's wealth of resources and natural beauty offer economic opportunities to the 47 million people who live in the coastal provinces. These opportunities, however, come with risks, as they are exposed to natural hazards caused by the sea and a changing climate.

Amid the natural beauty of coastal Vietnam, natural risks loom large.

Unfortunately, Typhoon Damrey was not an isolated event. Vietnam's exposure to typhoons—caused by its long coastline and geographic location—makes them a recurring phenomenon. They are often accompanied by storm surges, in which coastal sea levels increase and masses of water are drawn onto the land, causing severe flooding. Their impact is further exacerbated by high rainfall and strong winds. Most typhoons make landfall on the northern coast (figure 1.1), and the four northernmost provinces are most at risk of high wind speeds. Exposure to storm surges is also concentrated in the north, where an effective dike system provides partial protection. In the central provinces, high rainfall runoff from the mountains increases the risk of coastal flooding.

Floods in Vietnam originate not only from typhoon storm surge, but the coastal region is also prone to urban

flooding during pluvial events and river floods. From May to September 2019, seven severe flood events were reported, each with many dead and displaced people.¹ Hydrological flood models confirm that flood risks are high, especially in Vietnam's delta regions. Urban areas without adequate drainage are particularly threatened, as much of their open space is covered by impermeable concrete. Heavy rainfall can also cause fluvial or river flooding, where the amount of water carried by a river increases to such an extent that it overflows its banks. This is prevalent in the provinces of the North Central and South Central Coast Regions, due to accumulated run-off from nearby mountains, and the two main river deltas with their massive catchment areas (Deltares et al. 2017; GFDRR 2017; World Bank and Asian Development Bank 2018).

In coastal and river delta regions, saline intrusion — which occurs when saltwater penetrates low water levels in freshwater aquifers — contaminates drinking and irrigation water, amplifying the effects of drought. During the 2015–16 drought, which was exacerbated by a strong El Niño, over 80 percent of the country was exposed to drought or saline intrusion, with 18 provinces severely affected. On average, saltwater intruded 20–30 km further inland than usual, with some areas experiencing intrusion up to 90km inland (MARD 2016; UNDP 2016).

Coastal erosion—the loss of landmass into the sea—is another threat. This has both natural and human causes. River or sea currents, waves, and storms cause irregular sediment transport, while artificial river structures block sediment input towards the coast, coastal structures



Mathijs van Ledden

PHAN THIET >> Houses have been overtaken by a receding shoreline.

prevent longshore sediment transport, dredging navigation channels reduces sediment supply, and deforestation destabilizes coastal soil. In the Mekong Delta, more than half the coastline showed signs of erosion between 2003 and 2012 (Anthony et al. 2015); north of the delta, about 40 percent showed signs of erosion between 1990 and 2015 (Deltares et al. 2017).

Coastal regions are home to dynamic economies that offer livelihoods to millions.

Economic and political reforms implemented in 1986 under the Doi Moi initiative have spurred rapid growth, transforming Vietnam from one of the world's poorest

nations into a middle-income country, and lifting more than 45 million people out of poverty between 2002 and 2018 (World Bank 2019). Following the strong development of the two metropolitan hubs of Hanoi and Ho Chi Minh City, rapid economic transformation and growth has also extended to coastal areas. Several key economic sectors have led this growth of the coastal economy:

- **Aquaculture and fisheries:** The Mekong and Red River Deltas contributed 87 percent of national aquaculture production in 2017. The aquaculture sector alone is estimated to provide about 2.6 million jobs in the Mekong and Red River Deltas, which also grow about

69 percent of the country's rice and around 26 percent of its other crops.²

- **Industrial production:** Accounting for one-third of gross domestic product (GDP) in 2016, industry is growing rapidly around Hanoi, Ho Chi Minh City and the North Central Coast. In 2017, about one-third of all industrial zones were in coastal provinces,^{2,3} and in 2016, 16 coastal economic zones generated over \$5 billion in exports, creating 130,000 jobs (ASEAN Secretariat and UNCTAD 2017).
- **Tourism:** Benefiting from the country's beautiful coastline, natural assets, and cultural heritage, the 28 coastal cities and provinces contributed 70 percent of national tourism GDP in 2017.²
- **Agriculture:** 40 percent of Vietnam's employed population works in agriculture, forestry, or fishing.⁴ Most of this production is in the low-lying deltas or near the coast—for example, 69 percent of rice is grown in the Red River and Mekong Deltas. The government also has plans to use the country's vast primary production to strengthen its food processing industry (World Bank 2016).

Disasters cause well-being losses of \$11 billion every year.

These economic sectors are crucial in supporting livelihoods and prosperity in coastal communities. However, their significant exposure to natural hazards



Thomas Gerlach / Pixabay

MUI NE >> The bustling fishing port in Binh Thuan Province.

What determines disaster losses in Vietnam?

Hazards: *What is the type and size of the shock?*

Vietnam faces many natural hazards, including floods, typhoons, saline intrusion, and coastal erosion. A natural hazard is a geophysical or climatological event that poses a threat to communities. Hazards are often described in terms of their probability of occurrence — also called *return periods* (box P.1) — and an associated severity, in terms of wind speed, flood depth and so on. Such modeled hazards are not meant to predict a specific event occurring. Instead, they are tools for obtaining insights into potential impacts should a similar event occur. By considering a range of severities for a given disaster type, such tools allow users to estimate impacts in greater detail.

Exposure: *Who and what will be hit by the shock?*

When analyzing natural disaster risk, exposure typically refers to populations and assets in an affected area. Considering exposure means recognizing the difference between a half-meter flood in an empty plain and a busy village. In Vietnam, a large and growing number of people live and work in risky areas, where they are directly exposed to natural hazards. Critical public assets — such as hospitals or power lines — are also in hazardous areas and therefore at risk of disruption. When considering the impact of a natural disaster, it is crucial to analyze natural hazards together with socioeconomic



Source: Based on Hallegatte et al. 2016.

data. Part 1 examines how the combination of risk and exposure is creating risk hotspots.

Vulnerability: *How much damage will the shock cause?*

Vulnerability describes the extent to which a shock will damage a household or asset. For example, if one house is built with sophisticated drainage capacity and an elevated concrete foundation, and another is a simple mud hut, the same flood could cause very little damage to the first house while destroying the second. The vulnerability of houses and their owners is typically strongly correlated with socioeconomic status, as poorer households tend to own more vulnerable assets. In Vietnam, such differences in vulnerability are crucial to understanding natural disaster risk. Poorer households that have migrated to the coast in search of opportunities tend to settle on cheaper and riskier land. Living in more informal settlements, their houses are less storm-resilient houses and have less

protection from dikes and drainage. If hit by a natural disaster, they are more likely to incur significant damages. Part 2 explains how current risk management measures are determining vulnerability in coastal communities.

Resilience: *How large is the capacity to recover from disaster damages?*

Resilience describes affected people's and systems' abilities to recover after a shock. For instance, it can describe how quickly a farmer can restore his damaged equipment and continue production, or how quickly a village can regain access to electricity after its local power substation is flooded. A strong post-disaster recovery and assistance framework is crucial for strengthening people's resilience, and can use a range of support mechanisms, including access to credit and support from friends, family or government programs. Part 3 makes concrete recommendations on actions in five areas that can boost the resilience of Vietnam's coastal communities.

results in substantial economic losses and damages. Average annual asset losses from all hazards in Vietnam are estimated at about \$8.1 billion in PPP terms, which corresponds to \$2.7 billion in real terms (UNISDR 2015).⁵ While this figure is staggering, the human hardship behind these estimates is even more significant.

As assets are damaged, people lose their ability to earn an income, with devastating effects on their well-being. When storms destroy crops or machinery, people may lose their single income source while also having to rebuild their homes in the face of future disasters. Low-income households suffer disproportionately from natural hazards. They tend to be overexposed, more vulnerable, and less able to cope and recover, faced with difficult choices — such as taking on debt or selling assets that are important sources of income — that can have detrimental long-term effects. Urban households are particularly exposed to flooding, as land scarcity and housing prices push the poor towards high-risk areas (Narloch and Bangalore 2018). And because poor households own lower-value goods, asset damage estimates tend to underestimate the risk to them.

All this means that asset losses do not tell the full story. Natural disasters can also be measured in terms of well-being losses, which take households' capacity to cope and recover into account. By this metric, annual expected losses in Vietnam increase from 1.5 percent of GDP to 2.07 percent of GDP (Hallegatte et al. 2016). In other words, the social cost of disasters in Vietnam (PPP\$11 billion) is 35 percent higher than direct asset losses. This

resilience premium accumulates over prolonged or failed microeconomic recoveries, and affects overall growth and inequality in Vietnam.

Today's risks will be aggravated by climate change.

Vietnam ranks in the top five countries most affected by climate change.⁴ Under a worst-case climate change scenario (RCP 8.5, see box 3.1), mean sea levels are estimated to rise 30 centimeters by mid-century, and more than 70 centimeters by 2100. In Vietnam, this will increase the number of people and assets exposed to floods, especially in the two deltas (IPCC 2013; World Bank and Asian Development Bank 2018). By some estimates, sea level rise could flood the land where more than 20 million people live today, affecting almost one-quarter of the population and 7 percent of agricultural land (GFDRR 2015; Kulp and Strauss 2019). Climate change is also expected to significantly increase the intensity of relatively frequent shocks (Bangalore et al. 2017).

Climate change could further aggravate the frequency and duration of droughts. Together with rising sea levels, this increase in drought frequency is expected to cause severe saline intrusion, which will threaten agricultural production. Large coastal and intertidal zones in the Mekong Delta are already subject to pervasive saline intrusion. By 2050, these areas are projected to increase by more than 20 percent in three of the delta's 13 provinces (MARD 2016; UNDP 2016). Intensifying economic activity and groundwater extraction is bound to add to these pressures.



FLOODING IN HOI AN >> Sea levels could rise 30 centimeters by mid-century in worst-case climate change scenarios.

Toomas Tartes / Unsplash

BOX 1.2 >> HOTSPOT FOCUS

In-depth risk assessments and priority actions in six selected locations

This study carried out in-depth risk assessments for six coastal districts — known as the study hotspots — and used these to develop an investment framework and identify priorities for reducing disaster risks in the country's coastal regions.

Selecting the study areas: Working with the national government, the team used semi-quantitative prioritization to select the six study areas, based on: urgency for improving resilience, distinguishing characteristics, geographical spread, and other factors. From north to south, these areas are: Tien Lang, Quynh Luu, Phu Loc, Quang Ngai, Tuy An and Phan Thiet (map B1.2.1).

The six hotspots reflect and provide examples of the wide range of physical and socioeconomic characteristics observed along the Vietnamese coast: beaches, dunes, lagoons, estuaries; rural and urban; agriculture, industry, tourism, trade, forestry, fishery, aquaculture, and services. One or more natural hazards — riverine, pluvial and coastal flooding and erosion — are at play in all locations.

Developing the framework: Using a stepwise approach (figure B1.2.1) and supported by local and national stakeholders, the study team developed an investment framework with prioritized investments. First, each area was characterized through an assessment of existing

MAP B1.2.1 >>

The six hotspot locations selected to develop tailored resilience strategies

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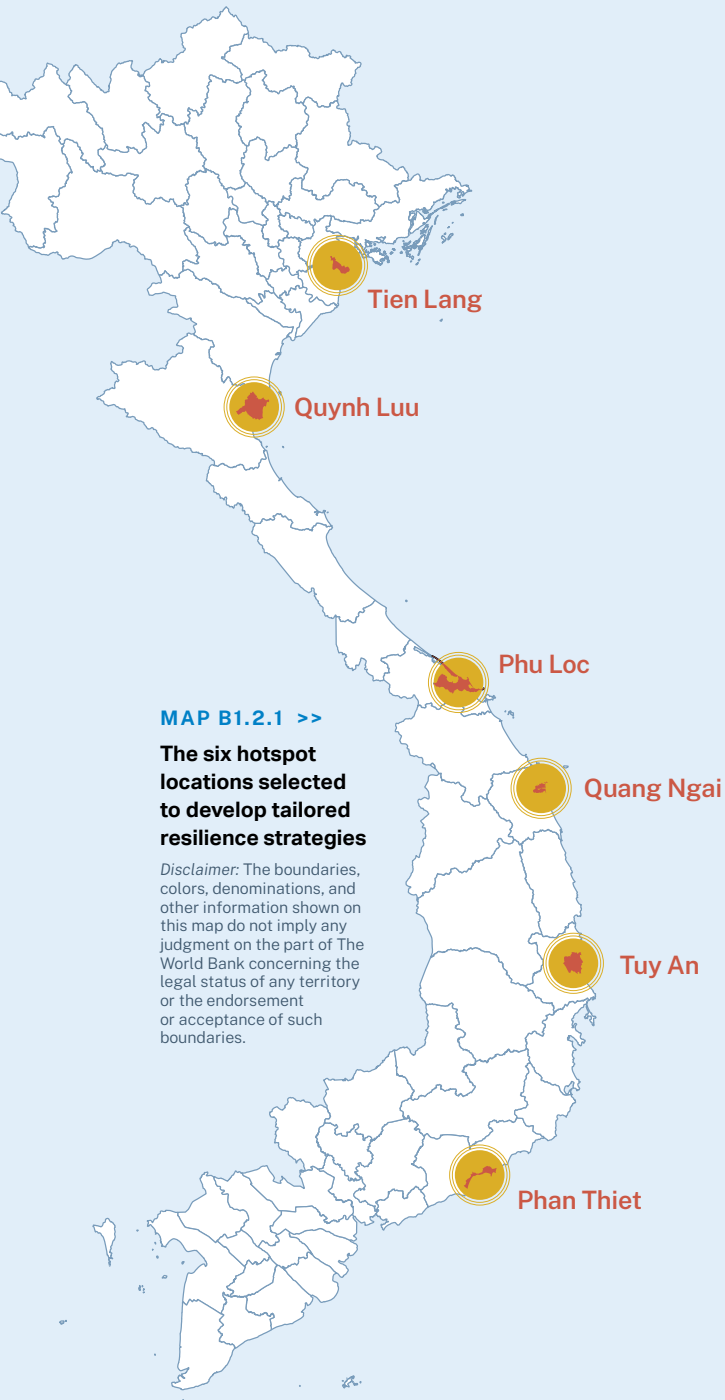
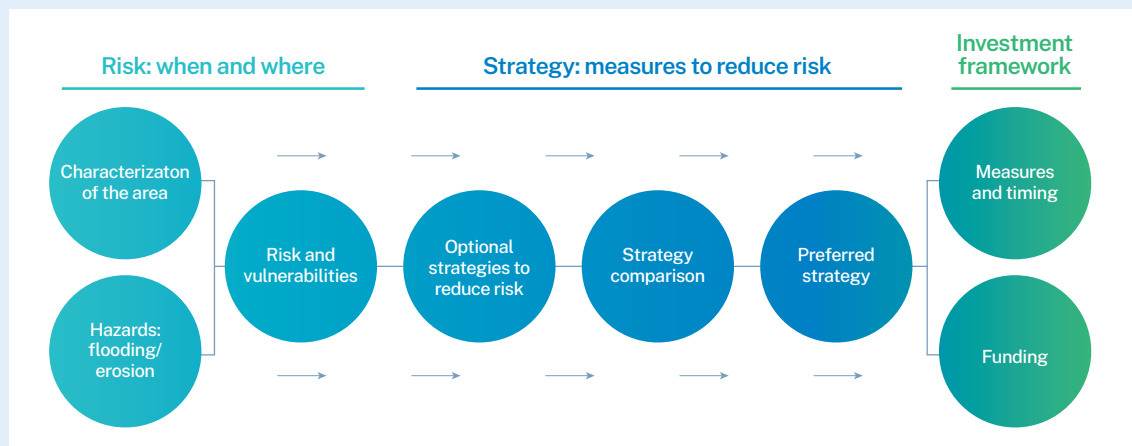


FIGURE B1.2.1 >>

Developing a hotspot specific investment framework



ecosystems, current and future socioeconomic situation and land use, and existing infrastructure. The districts' socioeconomic development plans (SEDPs) provided input for future or projected land use. The next step was a detailed assessment of the hazards (flooding and erosion) in each hotspot that analyzed their consequences and identified critical infrastructure that is vulnerable to coastal hazards and coastal risks in terms of economic damage and affected people.

The results of these risk and vulnerability assessments provided insight into the areas that will be at risk in the medium or long term, identified areas where unacceptable risks rendered new measures necessary and reviewed existing and planned measures to reduce and manage the risks — for example, in the provincial or national SEDPs. Using these inputs, the team developed several strategic options for managing flooding and erosion, and compared them on stakeholder support, flexibility and effectiveness to arrive at a preferred coastal resilience strategy. The next step involved using multi-criteria assessments and cost-benefit analysis to define prioritized investments within the preferred strategy and no-regret measures. From this, the study makes recommendations for long-term directions and proposes opportunities for financing and funding for each coastal area.

Throughout the process, the research team worked continuously with local and national stakeholders, organizing workshops to streamline the exchange of information, generate ideas about potential interventions, and validate assessment results and conclusions.

Coastal development continues in the face of growing risks.

Building on its past successes, the government of Vietnam has set ambitious goals for its future development pathway. Its SEDPs foresee a continued central role for the coastal region, seizing the opportunities offered by the coast and sea. The government's five-year plan (2016–2020) emphasizes the development of “economic zones, industrial parks and export processing zones associated with the development of coastal urban areas along the coast” (Government of Vietnam 2016). Its socioeconomic development strategy for 2021–2030 states that the 28 coastal provinces will contribute 65–70 percent of national GDP, with a strong focus on marine economic development. Priority sectors are tourism, marine services, transport, oil and gas, mining, aquaculture farming, offshore fishing, coastal industrial production, regenerative energy, and new marine sectors. Acknowledging that the coastal zone is most prone to natural hazards, however, it also includes plans to strengthen natural hazard forecast systems and climate change and sea level rise observation and environmental monitoring capacity (Government of Vietnam 2020).

Objectives of this report: a strategy for resilient and dynamic coastal development

Natural shocks already have a serious impact on Vietnam's coastal development and these risks will only increase as coastal populations and economic activities grow. At the same time, pressures from climate change are also bound to intensify. Without decisive action, further coastal

economic development will exacerbate these hazards and threaten the livelihoods of millions of people. This report shows that the government must continue to develop ambitious policies to reduce natural risks and protect its people and economy. Understanding the interplay between hazards and socioeconomic assets is key for the success of development plans.

To address this challenge, this report develops a coastal resilience strategy to ensure that Vietnam's ambitious coastal development objectives are not jeopardized by natural hazards. In line with this object, the report is divided into three parts:

- **Part 1—Diagnosis:** Offers the first systematic, multi-sectoral assessment of natural risks to Vietnam's coastal communities, infrastructure systems, public services, and economic sectors.⁶
- **Part 2—Stock take:** Takes stock of Vietnam's current measures to reduce and manage disaster risks in coastal regions, assessing their scope, effectiveness, and shortcomings.
- **Part 3—A way forward:** Introduces an integrated resilience framework with concrete risk reduction actions to help the government and coastal authorities formulate resilient SEDPs to minimize or manage threats while boosting economic growth.

The report is an innovative combination of a nationwide cross-sectoral risk assessment and detailed hotspot

analyses for six coastal locations (map B1.2.1). At the national level, it analyzes sectoral risks and offers a comprehensive assessment of risk reduction measures to identify priorities for interventions. The hotspot analyses provide methodological approaches and solutions to address specific problems and consider different hazard types, socioeconomic scales and natural coastal conditions (box 1.2). Together, the breadth and depth of this analysis provide a detailed understanding of the concrete actions actors at all levels need to take to reduce and manage disaster risks to safeguard a resilient and prosperous future for Vietnam's coastal communities.

Endnotes

1. Information retrieved from Floodlist, <http://floodlist.com/?s=vietnam> on November 25, 2019.
2. Information retrieved from General Statistics Office of Vietnam, <https://tinyurl.com/tq3s66s> on April 5, 2019.
3. Information retrieved from World Bank Climate Change Knowledge Portal: Vietnam, <https://tinyurl.com/u25ndz3> on April 2, 2020.
4. Information from World Bank Open Data, <https://data.worldbank.org/>
5. Real and PPP asset and wellbeing losses are denominated in \$2015.
6. All \$ figures estimated in Part 1 are in 2010 real terms, unless otherwise stated.

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PART 1 >>

DIAGNOSIS

AN ANALYSIS OF THE
EVOLVING NATURAL RISKS
IN COASTAL VIETNAM

A satellite image of the Mekong River Delta, showing a complex network of rivers and a dense grid of agricultural fields. The image is overlaid with a semi-transparent teal rectangle containing text.

Vietnam's coastal provinces have played a major role in the country's socioeconomic development, and their importance is bound to increase in the future. Home to half of the country's population, the coastal zone holds tremendous economic potential for a dynamic and diverse economy. At the same, this area is the most exposed to natural hazards, putting its inhabitants at risk, and jeopardizing the country's future prosperity. Part 1 of this report explores how large these risks are, where they are concentrated, and which economic sectors and public services are most exposed.

MEKONG RIVER DELTA >> ESA satellite image

FIGURE P.1 >>

Findings from Part 1: a risk assessment of Vietnam's coastal provinces



People

11.8 million people are directly exposed to the threat of intense flooding

Chapter 2 >>



Towns

Over **35%** of coastal settlements are located on eroding coastlines

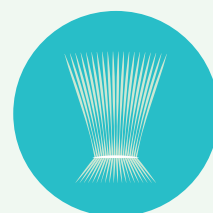
Chapter 2 >>



Economy

Flood risks in high-growth areas are nearly **twice as high** as in low-growth areas

Chapter 2 >>



Agriculture

\$1 billion of agricultural GDP and **1.5 million** workers are directly exposed to the threat of intense flooding

Chapter 3 >>



Aquaculture

1.1 million tons of aquaculture production is at risk of flooding each year, corresponding to **\$935 million** in exports

Chapter 3 >>



Tourism

42% of coastal hotels are located near eroding beaches

Chapter 3 >>



Industry

Half of all industrial zones are directly exposed to the threat of intense flooding

Chapter 3 >>



Schools

22% of schools could be directly exposed to the threat of intense flooding

Chapter 4 >>



Health care

26% of health care facilities are directly exposed to the threat of intense flooding

Chapter 4 >>



Transport

A typhoon with wind speeds of up to 200 km/h can close roads, resulting in daily losses of **\$114–324 million**

Chapter 5 >>



Energy

36% of transmission lines are in forested areas, exposed to falling trees in severe storms

Chapter 5 >>



Water

52 out of 63 provinces could depend on water-stressed river basins by 2030

Chapter 5 >>

Note: Intense flooding here refers to flooding with a 100-year return period.

Coastal regions have the potential to be a powerful engine for Vietnam's continued socioeconomic development. Key economic sectors are thriving and provide viable livelihoods to a growing and rapidly urbanizing population. The coast promises diversified economic development, with growth sectors including modern large-scale agriculture, aquaculture, a booming tourism sector, manufacturing, service industries in growing coastal towns, and hubs for international maritime trade.

However, in a country that is among the most exposed to natural hazards, the coastline often bears the brunt. Typhoons, storm surges, riverine flooding, coastal erosion, or saline intrusion are all too familiar threats to most people living along Vietnam's coast. The losses and damages associated with natural shocks are substantial: by one estimate, Vietnam incurs about \$2.7 billion in asset losses and damages every year, which corresponds to around \$8.1 billion in PPP terms (UNISDR 2015).

And yet, asset losses are not the whole picture. As

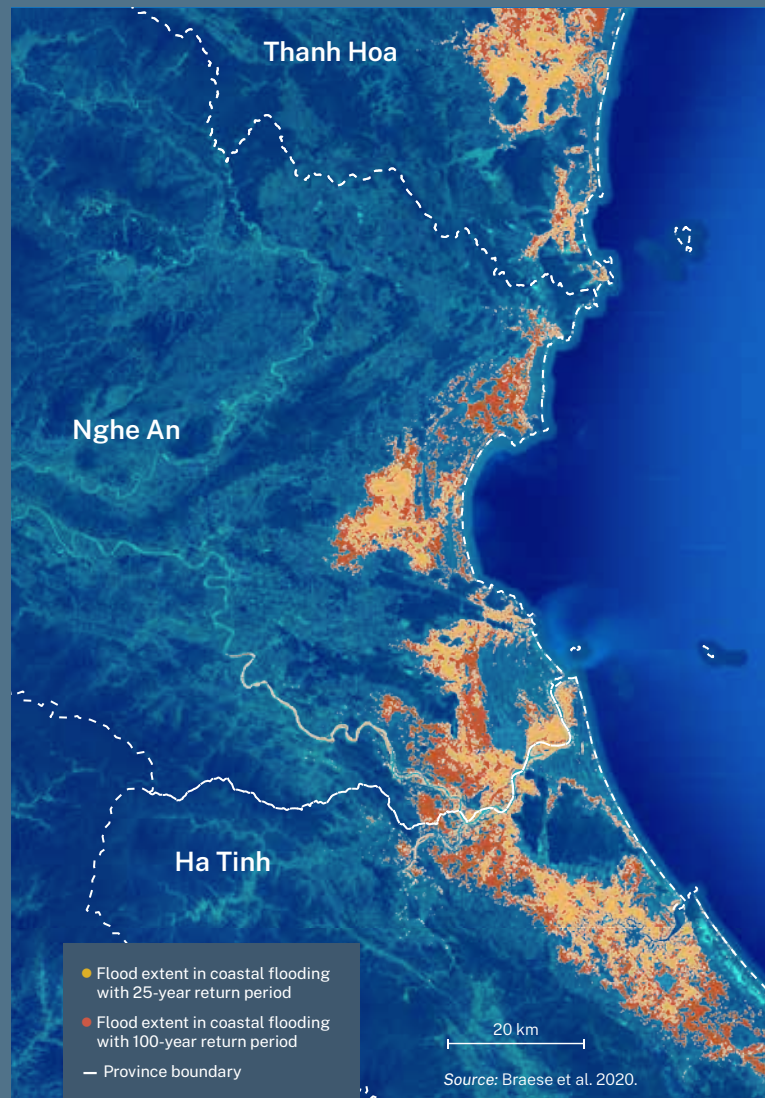
assets are damaged, people lose their ability to earn an income, with devastating effects on their well-being. These consequences are particularly harsh for low-income households, who are more likely to live in risky areas and less resilient dwellings, and to lack access to support systems that would enable a quick recovery. The World Bank's *Unbreakable* model takes these factors of socioeconomic resilience into account, and estimates Vietnam's true annual well-being losses to be around \$11 billion (Hallegatte et al. 2016).

Part 1 of this report uses a wide range of new analyses to offer detailed estimates of the natural risks faced by the people on Vietnam's coast. It looks at potential exposure and losses for people, settlements, economic sectors and infrastructure systems. Figure P.1 offers a selection of the headline findings from this national multi-sectoral risk assessment. The overall picture is clear: the threats are significant and growing. As such, a well-planned and coordinated coastal resilience strategy will be vital to safeguard future development.

\$2.7 billion >> Vietnam's estimated annual asset losses due to natural shocks.

FIGURE BP1.1>>

The extent of 1-in-25 and 1-in-100-year floods in Vietnam's North Central Coast Region



BOX P.1 >>

Return periods: classifying the probability and intensity of natural shocks

Much of the risk analysis presented in this report relies on natural hazard data that distinguish return periods to describe the spatial distribution and intensity of natural shocks. A return period describes how much time is expected to pass before a natural shock of the same intensity occurs again. Using historic data and based on the statistical frequency of a shock of a certain intensity, it describes the probability of such an event.

Figure BP1.1 illustrates the extent of floods with two return periods: one with a 25-year return period (or a 1-in-25-year flood) and one with a 100-year return period (or a 1-in-100-year flood). The 1-in-25-year flood has a $1/25$ or 0.04 annual probability of occurring. In other words, each year there is a 4 percent chance of such an event occurring, regardless of when the last such event took place. The probabilistic nature of return periods means that there is a 64 percent probability that a flood of at least this intensity will occur once within a 25-year period. But this also leaves the possibility for this event to not occur at all, or to occur several times. In comparison, a 1-in-100-year flood is a more extreme event with a lower probability but higher intensity — that is, it affects a wider area and has a greater depth.

As time passes, more climatic data become available, which will update the empirical probabilities associated with certain natural shocks. As the impacts of climate change increase, intense shocks will probably become more frequent. This means that there is significant uncertainty around the probability of natural shocks, and historic data only offer limited guidance on the future. So, when taking long-term investment and planning decisions, selecting options that offer robust performance under a variety of scenarios is crucial (Hallegatte et al. 2019).

Vietnam's coastal regions offer many economic opportunities and attract a growing number of people who settle there. But this proximity to the coast increases people's exposure to a range of natural hazards. As the overall population grows, so does the number of people living in areas threatened by floods, erosion, and typhoons. With many safe spaces already occupied, a disproportionate share of new developments is taking place in risk zones. This section explores the risks people face in Vietnam's coastal areas. On average, around 508,000 people are directly exposed to coastal flooding every year (figure 2.1). These disproportionately affect the poorest and most vulnerable people, threatening Vietnam's success in lifting its population out of poverty and promoting shared prosperity.

2.1 >>

Rapid coastal urbanization exposes people to natural hazards

Coastal urbanization grants economic opportunity, but increases exposure to natural hazards.

Sustainable and resilient cities can offer people access to essential services and jobs, thus improving livelihoods and reducing poverty. Around the world, the share of people living in cities is increasing rapidly, and Vietnam is no exception. The country has been experiencing strong rural-urban migration as people seek to improve their livelihoods in urban labor markets.

The share of population living in urban areas steadily rose from 22 to 36 percent between 1995 and 2019.¹ In its

socioeconomic development strategy for 2021–2030, the government predicts that this trend will reach 50 percent by 2030 (Government of Vietnam 2020). Hanoi and Ho Chi Minh City are already home to 17 percent of the population.²

Secondary cities in the North and South Central Coast Regions are experiencing some of Vietnam's highest urban growth rates (World Bank 2020). Poverty rates in coastal towns are among the lowest in the country, as strong economic growth in and around them has helped to sustain prosperous livelihoods in tourism, aquaculture, industry, and other sectors. Several major ports also offer jobs in fisheries and access to overseas markets. Analysis conducted for this report shows that at least 28 percent of Vietnam's 3,000-plus-kilometer coastline is now covered by cities and settlement. The way in which settlements concentrate in a narrow coastal corridor is evidence of the opportunities that the coastline can offer, such as in

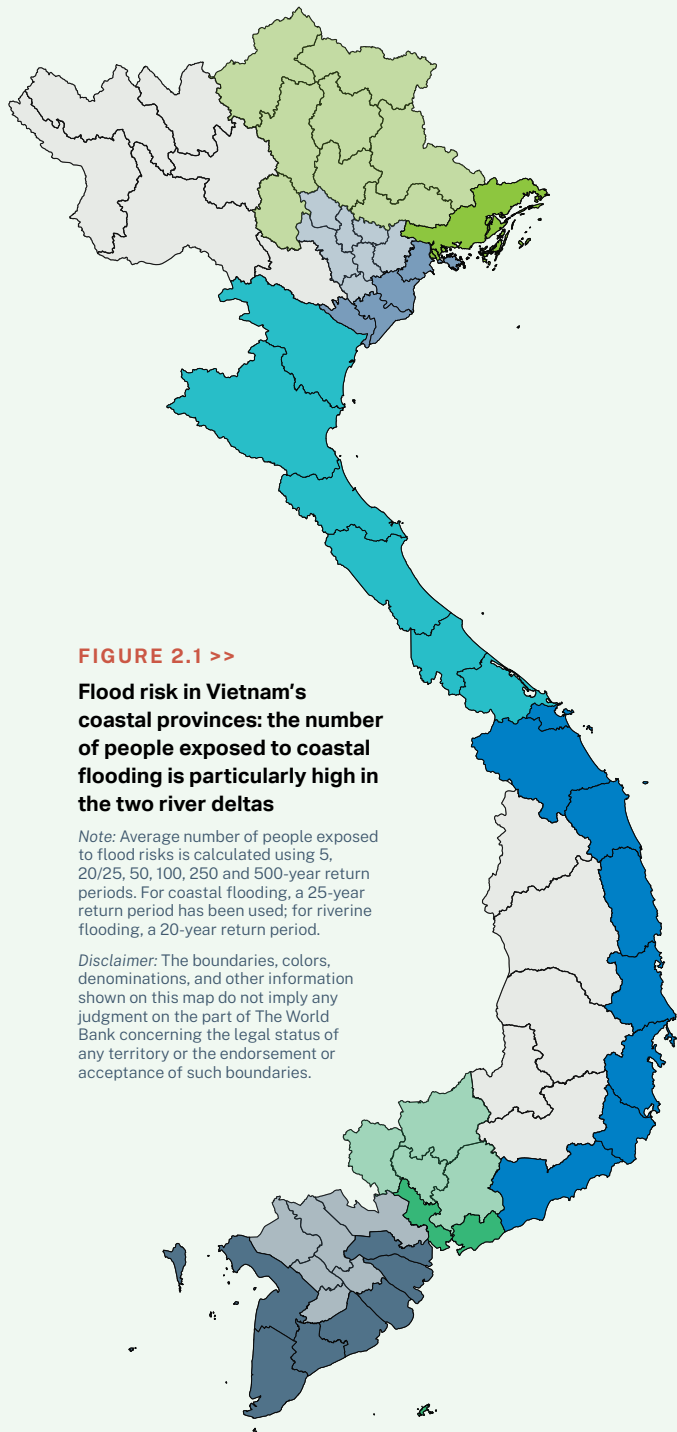


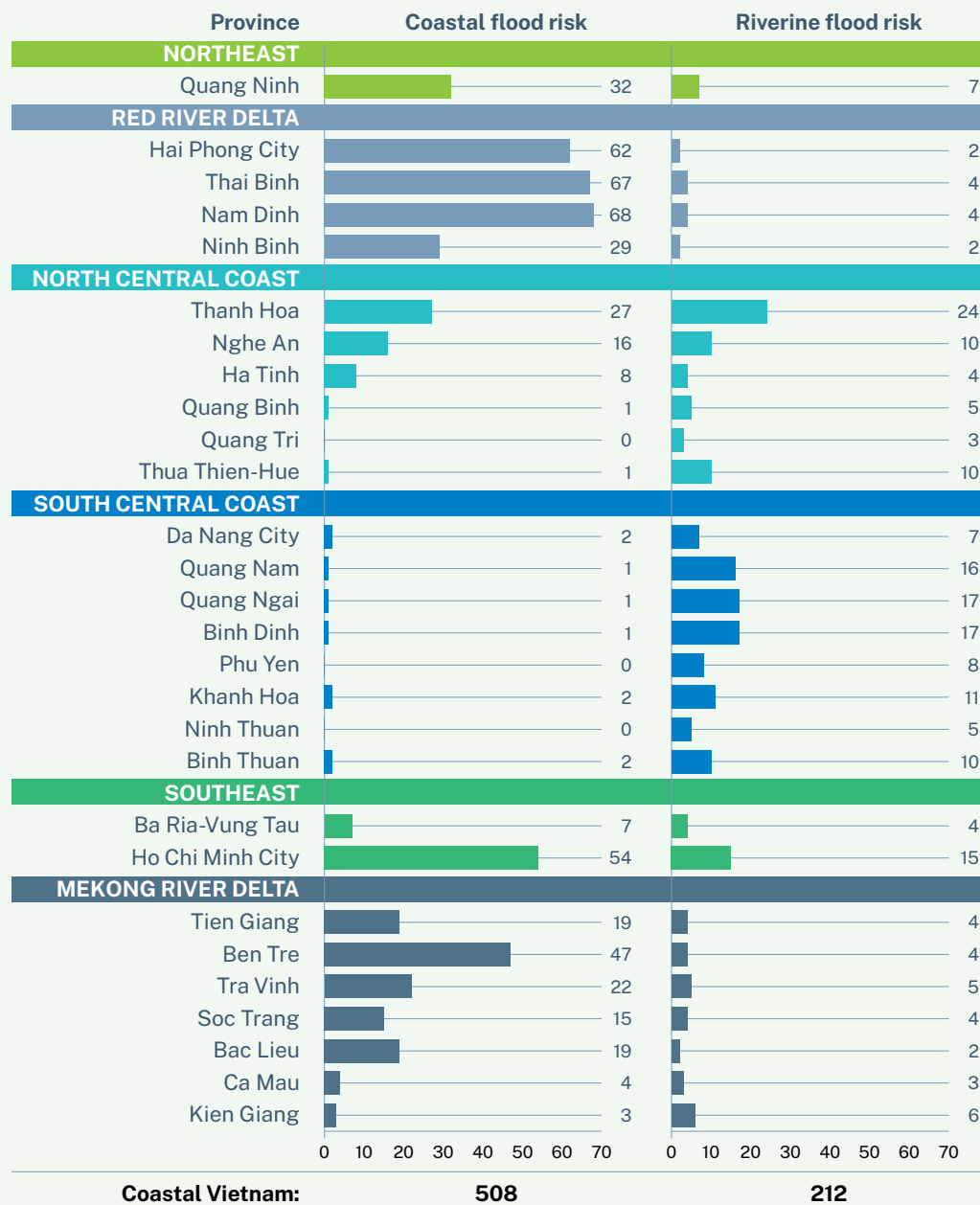
FIGURE 2.1 >>

Flood risk in Vietnam's coastal provinces: the number of people exposed to coastal flooding is particularly high in the two river deltas

Note: Average number of people exposed to flood risks is calculated using 5, 20/25, 50, 100, 250 and 500-year return periods. For coastal flooding, a 25-year return period has been used; for riverine flooding, a 20-year return period.

Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Average number of people exposed to flooding each year (thousands)



Ha Tinh and Quang Binh provinces (figure 2.2). However, in coastal zones, access to opportunities also means exposure to a range of natural hazards that can threaten people's lives and livelihoods (box 2.1).

Flooding poses significant threats to coastal settlements.

The cases of Quynh Luu and Phan Thiet illustrate the risks faced by many towns and settlements along the coast, where economic development continues despite the threat of natural hazards (box 2.1). But how widespread are such risks along the country's coast? This section evaluates the magnitude of flood risk to people living along the Vietnamese coast using spatially disaggregated estimates of this risk. This systematic analysis of flood risk in coastal settlements uses information from three types of map:⁴

- 1. Flood maps:** Incorporating data from digital elevation and climate models (Braese et al. 2020; Fathom³), these detailed 90x90-meter spatial resolution flood maps show estimates of the extent and depth of coastal, fluvial, and pluvial flooding for event intensities associated with different probabilities—for example, 5, 20, 25, 50, 100, 250, or 500-year return periods. For simplicity, fluvial and pluvial flooding are combined and referred to as riverine flooding in this report.
- 2. Urbanization maps:** Detailed urbanization maps from satellite imagery by the Japanese Aerospace Exploration Agency (JAXA EORC 2018), which captured all built-up areas, from small rural settlements to large

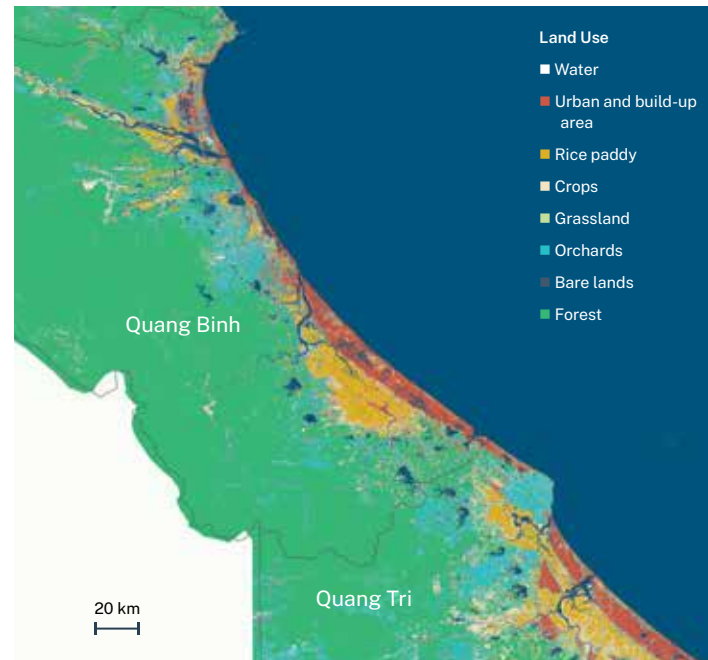


FIGURE 2.2 >>
Settlements and agriculture tend to concentrate on Vietnam's coastline

Land use along the coastline in Ha Tinh, Quang Binh and Quang Tri provinces in central Vietnam

Source: JAXA EORC 2018.

cities. These are combined with population data from the Vietnam Government Statistics Office.

- 3. Protection maps:** These show details of the country's existing coastal protection infrastructure, including its extensive sea and river dike system (based on van Ledden et al. 2020).

Based on the flood exposure of urban areas, it is possible to estimate the number of people exposed to flood risk. Figure 2.3 shows that the threat to settlements varies significantly across provinces and a large number of people are exposed.

BOX 2.1 >> HOTSPOT FOCUS

Natural risks are threatening vibrant economies in Quynh Luu and Phan Thiet

Hotspot:	Quynh Luu District
Location:	Nghe An Province, North Central Region
Population:	250,000

The opportunities offered by coastal settlements are accompanied by

substantial risks. Quynh Luu, a rural area in the northern part of the central coast, is home to about 250,000 people, whose livelihoods rely predominantly on agriculture and aquaculture. Fishery is also an important economic activity: the district, which exports about 40 percent of its aquatic products, had a fishing fleet of more than 1,200 boats in 2018. In

2017, its economy was growing rapidly at 14 percent.

Strong storms and high river levels pose a significant flooding risk in the district (figure B2.1.1). In the northeast, dunes and coastal forest provide some protection, while the coastal dike system protects other parts of the district, but only for floods with up to a 30-year return period. River dikes are also in place, but they have no safety standard and are generally low. A 1-in-10-year flood would inundate 30–40 percent of the district, with some northern areas on the banks of the Hau River experiencing flood depths of over one meter.

Estimates show that by 2030, about 65,000 people — 24 percent of the district population — will be at risk of flooding each year.⁸ Large rural and agricultural areas are also estimated to incur economic damages of over \$12 million. Although most damage is expected to be concentrated in the low-lying northern rural areas of Quynh Thanh and Quynh Bang, adjacent to the Hau River, the urban area of Cau Giat could also face significant economic damage (figure B2.1.1). These risks are exacerbated by the risk of typhoons,

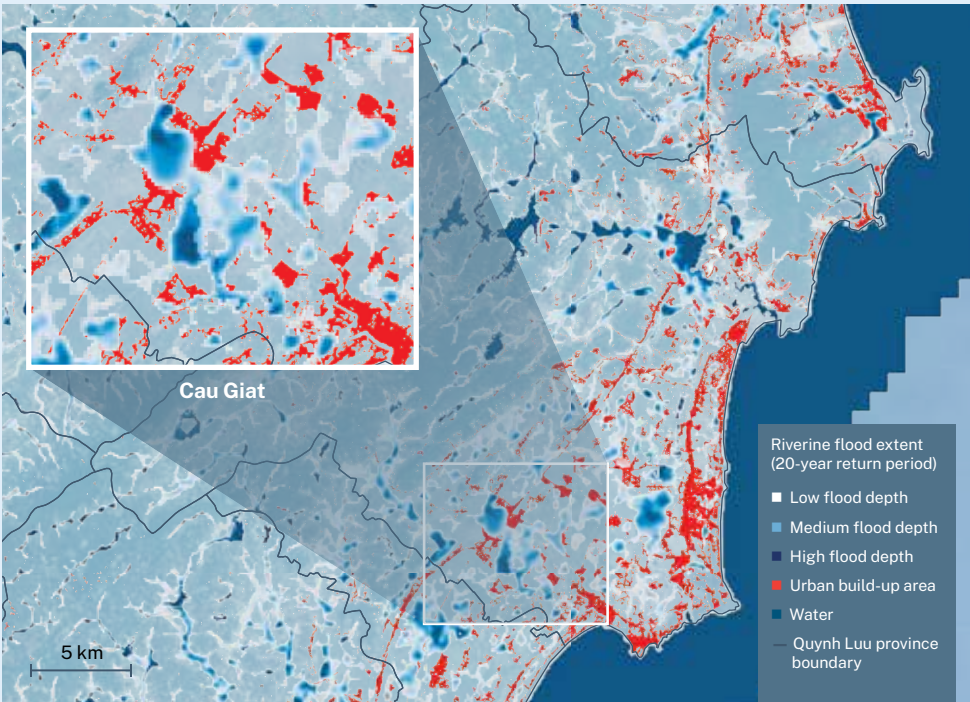


FIGURE B2.1.1 >>
Flooding poses a significant risk in Quynh Luu, for example, in the urban area of Cau Giat

Source: Based on data from Fathom.³

which are common in northern Vietnam. Each year, Quynh Luu is affected by three to five storms between June and November. In 2017, Typhoon Doksuri highlighted the area's vulnerability to floods, leaving multiple casualties in its wake. Overall, these figures show that reducing the risk of flooding is vital to safeguard economic opportunities for the people of Quynh Luu, especially considering the trends of climate change and economic development.

Hotspot: Phan Thiet

Location: Bin Thuan Province,
South Central Region

Population: More than 300,000

Phan Thiet has a diverse local economy, with offshore fisheries operating from its port, nearby beaches attracting increasing numbers of domestic and international tourists, and peripheral areas hosting agricultural and industrial firms. The urbanized area depends heavily on tourism and is mainly concentrated in the northern part of Phan Thiet, which has numerous water-side resorts. The rapidly developing local economy is growing at 7 percent, and poverty rates are declining. But although the economy is booming, its residents are all too familiar with the devastating impacts of natural hazards.

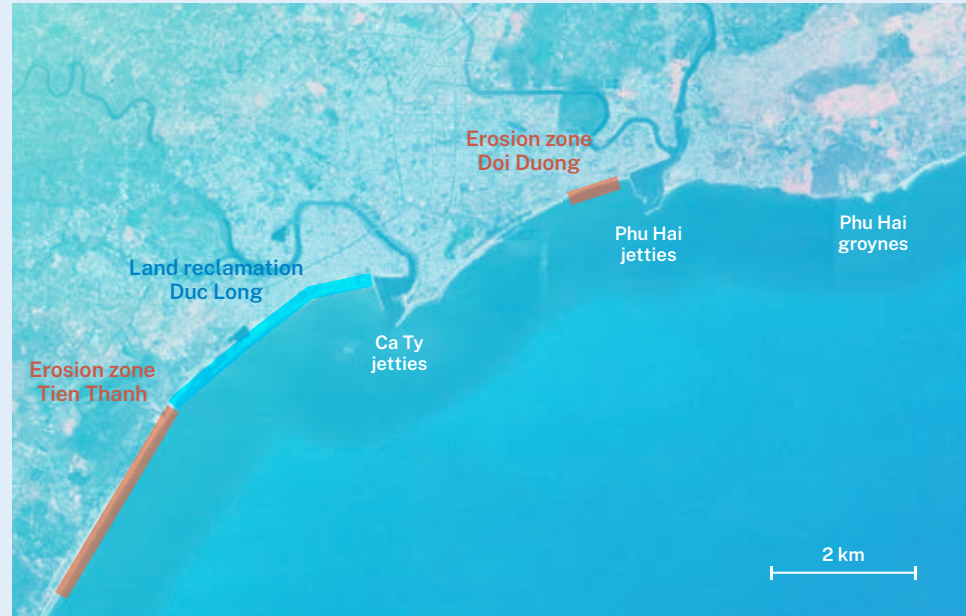


FIGURE B2.1.2 >>

Several locations in Phan Thiet City encounter severe erosion due to human-induced activities

Source: Authors; see Appendix A.

Coastal erosion is heavily affecting communities and properties in Phan Thiet, which are typical of many locations along the coast. Although long-term erosion and accretion over the last 10 years have been relatively small (10–30 meters), a severe storm can temporarily erode more than 40 meters of beach, inflicting significant damage to resorts, houses and restaurants in some coastal communes.

In Tien Thanh and Dol Duong communes, long jetties in the Phu Hai River and land reclamation activities in Duc Long are blocked natural southward sand

transport and caused structural erosion. The coastline has retreated by more than 100 meters in parts of Tien Thanh, with severe consequences for settlements in this area (figure B2.1.2). Climate change will lead to more structural coastal erosion. Without action, sea level rise will result in a gradual retreat of the sandy coastline. It is also expected that changes in frequency of typhoons will have significant impacts on erosion, and the state of the coastline more generally. Understanding and managing the risks faced by communities will be vital to safeguard Phan Thiet's position as a regional growth engine.

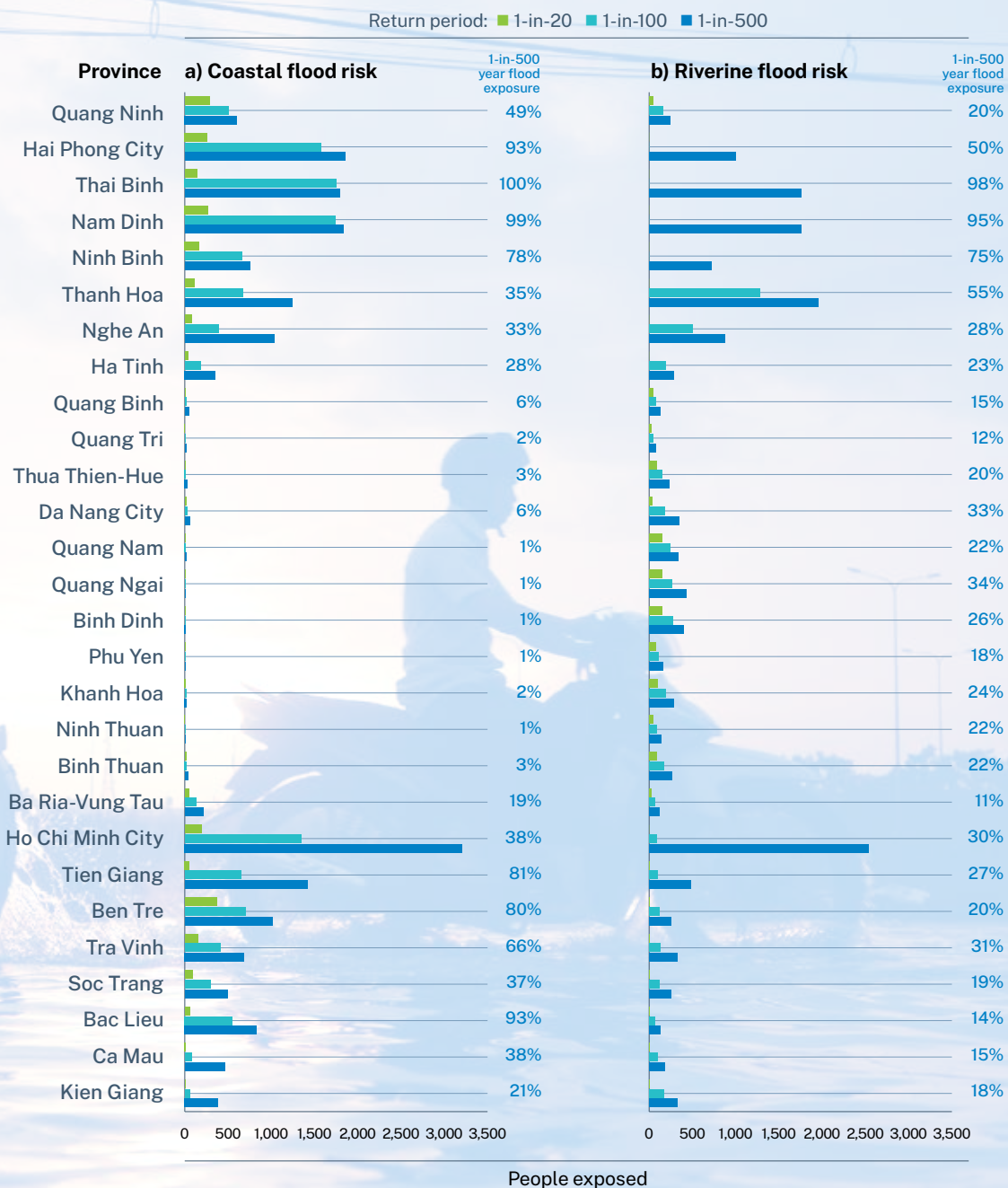
FIGURE 2.3 >>

Coastal and riverine flood risks to coastal settlements

Sources: Based on data from: Braese et al. 2020 (coastal flood maps); Fathom (riverine flood maps);³ and General Statistics Office of Vietnam (population).²

Note: Shown percentages represent the share of people exposed to more than 25-centimeter flood levels occurring, on average, once every 500 years.

Photo: iStock



We estimate that 11.8 million people — around 12.6 percent of Vietnam’s total population — are exposed to 1-in-100-year coastal floods. Similarly, 4.9 million people, or roughly 5.2 percent of the population, are exposed to riverine floods of similar intensity. Provinces in the Mekong and Red River Delta Regions—which have high protection standards for riverine, but not coastal, flooding — have the largest number of exposed people. For detailed results of coastal and riverine flood events with 5 to 500-year return periods, see Appendix B.

Vietnam’s coastline is urbanizing more rapidly than any other part of the country.

With its growing economic opportunities, the coast continuously attracts new people from rural and peripheral areas. With some of the country’s highest economic and urban growth rates, coastal districts are establishing themselves as growth engines for Vietnam’s continued development.

Tien Lang District in Hai Phong Province is one of many rural areas exhibiting rapid urban growth and economic development, with its agriculture and fisheries sectors transitioning from small-scale to more industrial-scale and intensive production. Developments like the new high-tech agro-processing Lavifood factory, which opened in May 2019, and improved connectivity to Hai Phong City contribute to urbanization in this area (Jhaveri et al. 2017). But as people — and therefore private and public assets — move into coastal areas, their exposure to natural hazards increases too.

FIGURE 2.4 >>

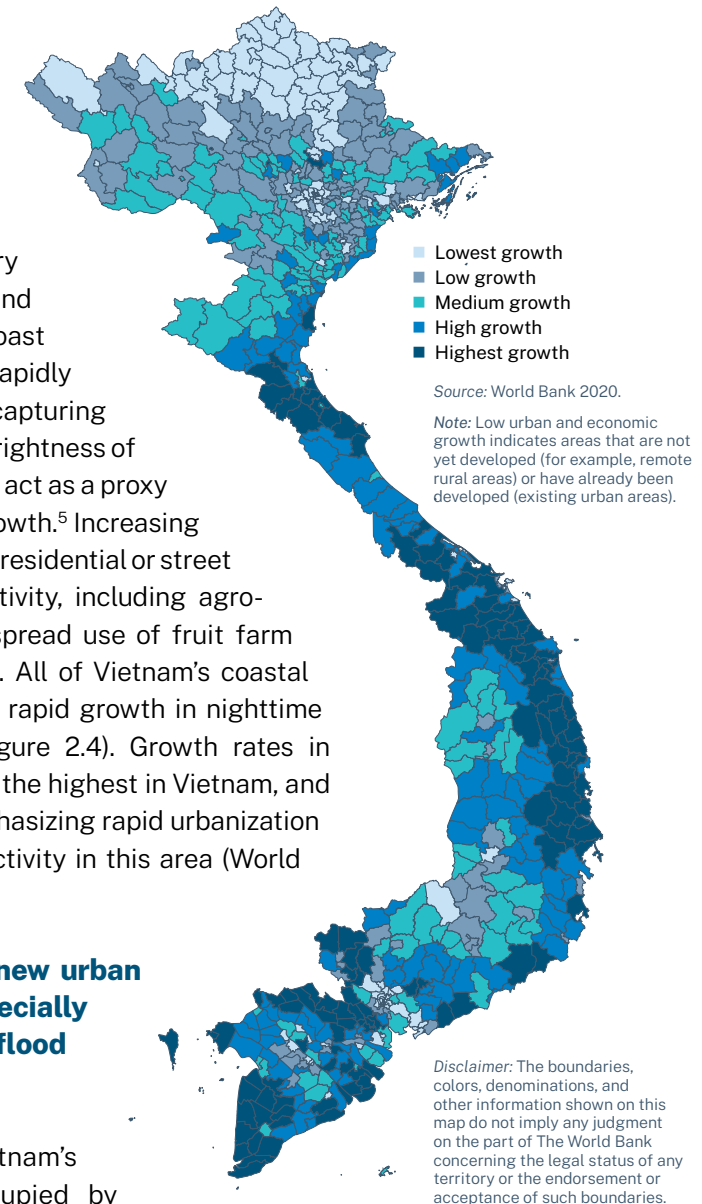
Urban and economic nightlight growth in coastal regions is among the fastest in Vietnam

*Nightlight growth 2012–2017
(district-level quintiles)*

Nighttime satellite imagery can illuminate this trend and highlight the fact that the coast is among Vietnam’s most rapidly developing regions. By capturing changes in the nighttime brightness of a particular area, such data act as a proxy for urban and economic growth.⁵ Increasing brightness reflects a rise in residential or street lighting, and industrial activity, including agro-industry, due to the widespread use of fruit farm lighting to increase yields. All of Vietnam’s coastal districts have experienced rapid growth in nighttime brightness since 1996 (figure 2.4). Growth rates in coastal regions are among the highest in Vietnam, and have been since 2012, emphasizing rapid urbanization and emerging industrial activity in this area (World Bank 2020).

Economic growth and new urban developments are especially rapid in areas with high flood risk.

Almost one-third of Vietnam’s coastline is already occupied by

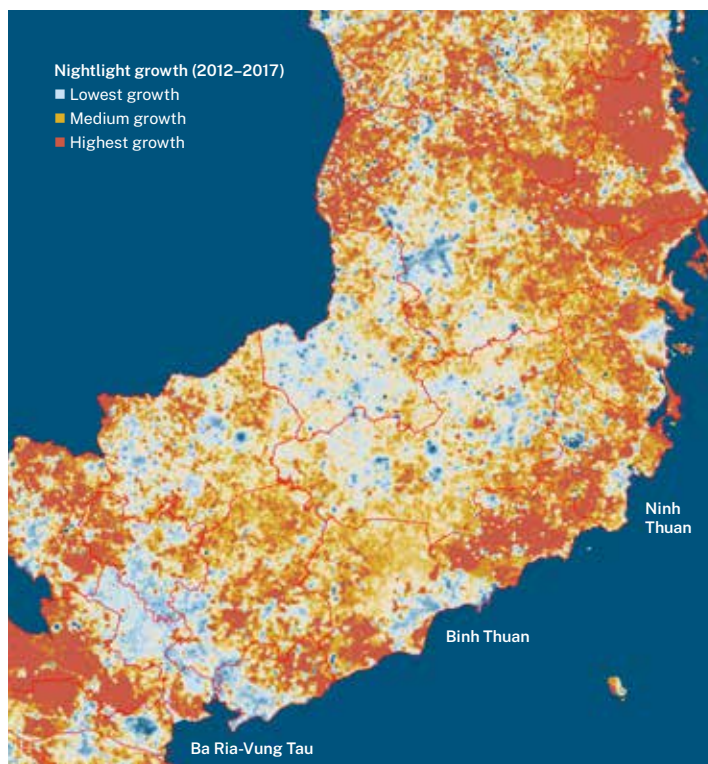


towns and built-up settlements, and the 28 coastal provinces are home to 46.6 million people.² With the safest and most productive locations already occupied, new developments are increasingly forced to use sub-optimal land. This trend means that people are turning to areas that they previously avoided, either because of their distance from regional hubs or because of the heightened threat of natural hazards. Hence, if natural risks are already high for existing factories or settlements, they will be even higher in new development areas.

FIGURE 2.5 >>

Urban and economic growth is concentrated in some of Vietnam's areas most exposed to natural hazards

Sources: Based on data from Fathom³ and World Bank 2020.

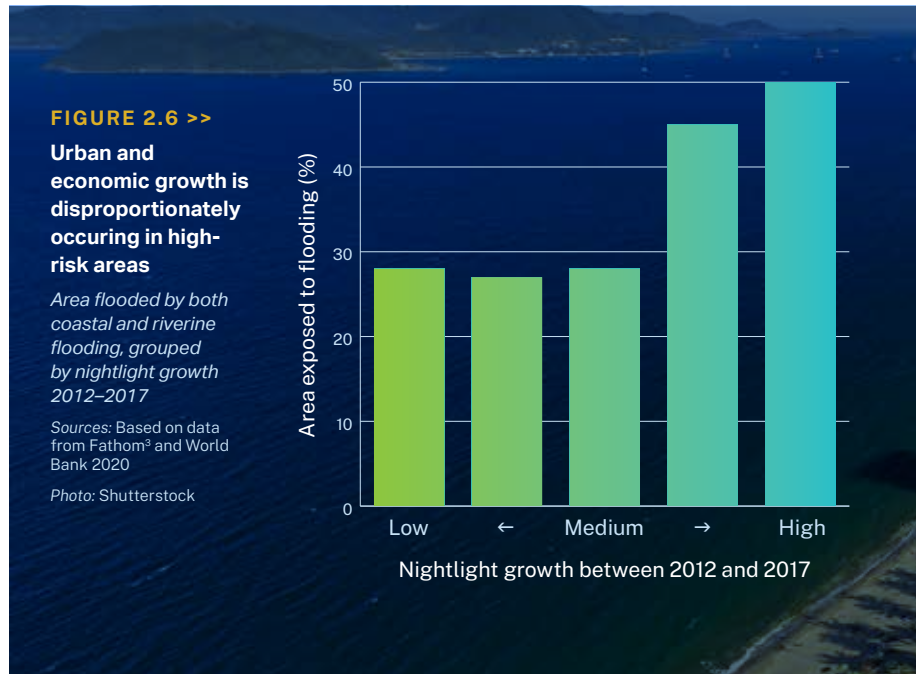


Such pressures can already be observed in Da Nang, where new housing developments have sprung up in low-lying or former drainage areas. People living in these new settlements — often recently-arrived immigrant laborers from inland districts — face hazardous living environments. The resulting reduction in the city's drainage capacity also diverts water to other areas in the city, leading to localized flooding (100 Resilient Cities 2017). From 1998 to 2015, Da Nang experienced 26 typhoons, 13 tropical depressions, and 46 flood incidents. Average private and public asset losses due to natural shocks are modeled to amount to \$43.2 million a year. About 60 percent of these are caused by typhoons and accompanying storm surges (World Bank DRFI Program 2019; 100 Resilient Cities 2017).

This challenge is not unique to Da Nang and can be observed throughout the coastal regions. Combining satellite-based nightlight imagery and flood hazard maps, an analysis conducted for this report systematically assessed risks in high-growth areas. This analysis confirms that areas with high urban and economic growth face significantly higher flood risk than low-growth areas (figure 2.5). About 27 percent of areas with low urban and economic growth are estimated to be exposed to flooding with a 100-year return period, compared to some 50 percent of high-growth areas (figure 2.6).

Erosion and drastic coastline changes are putting urban areas at risk.

Many cities and villages along the coast depend on their proximity to the beach for economic purposes. As coastal



areas experience urban and economic growth, erosion is increasingly affecting the homes and livelihoods of more and more people. Coastal zones are dynamic environments subject to continuous change and the drivers of coastal erosion are diverse. They include gradual natural factors, sudden impacts of typhoons and storm surges, ongoing interference from artificial structures such as groins and breakwaters, and large-scale sand mining. With few localities enforcing coastal zoning corridors and setback lines that could prevent settlement in dynamic coastal zones, areas that have allowed urban and industrial development up to the beach edge are feeling massive impacts, sometimes within months of development (Chapter 7).

There are many examples of the destructive force of erosion. In La Gi district, a fishery jetty has caused significant sediment build-up to the north and eroded built-up areas to the south (figure 2.7). This has moved the coastline inland in several places, by as much as 300 meters in parts, displacing hundreds of low-income households and threatening many more. For communities that depend on fishery incomes, being relocated inland can cause substantial disruption to livelihoods. Along the coast, some entire settlements are built on unstable dunes that are vulnerable to erosion—such as Tan An village in Thua Thien-Hue Province and Khe Tan village in Quang Ngai Province. As their beaches erode, their buildings are

swallowed by the sea and tourism hotspots lose some of the main assets that attract visitors (Chapter 3).

To assess how erosion and accretion (sediment build-up) have affected urban areas along the coastline, this study analyzed the exposure of built-up areas to coastline changes. Using satellite-based location data for built-up areas within 250 meters of the coast and estimates of coastal erosion over 25 years, it provides a systematic assessment of erosion risk for all settlements along more than 3,000 kilometers of coastline.⁶

This analysis confirmed that only 19 percent of settlements are near stable coastlines, more than one-third are near moderately or severely eroding shores, and almost half

experience moderate or severe accretion (figure 2.9). It also found that the Mekong Delta's coastline is among the most dynamic, with more than two-thirds of built-up areas experiencing severe coastline changes—more than 20 meters of accretion or erosion—between 1988 and 2015 (figure 2.10). In the northern and central regions, more than one-third of built-up areas experienced severe positive or negative coastline changes over the same timeframe.

These findings highlight that Vietnam's coastal zones are highly dynamic and require careful spatial planning. Most coastal settlements already experience the effects of significant coastline change, with detrimental consequences for economic activities and livelihoods. Addressing these risks requires coastal dune system protection, sand mining regulations, and systematic coastal zoning and spatial planning. These strategies are discussed in Part 3 of this report.

Climate change is expected to increase the risk from natural shocks and stresses in coastal urban areas.

Sea level rise brought on by climate change is likely to increase flood hazards in coastal cities, while irregular precipitation patterns increase the risk of river flooding, drought and saline intrusion. More frequent typhoons and storm surges will also increase the likelihood and rate of coastal erosion. All these effects will be highly location-specific and their scale will depend on actions for managing and mitigating risk, and guiding socioeconomic dynamics. Low-income communities in sub-standard dwellings and exposed locations are likely to be hit particularly hard.

FIGURE 2.7 >> Satellite images of La Gi show the changing coastline

Source: Google Earth



FIGURE 2.8 >> About 200 meters of beach have disappeared in 10 years in Cua Dai, near Hoi An Source: Google Earth



2011



2020

FIGURE 2.9 >>

One-third of built-up areas on Vietnam's northern and central shores are subject to erosion

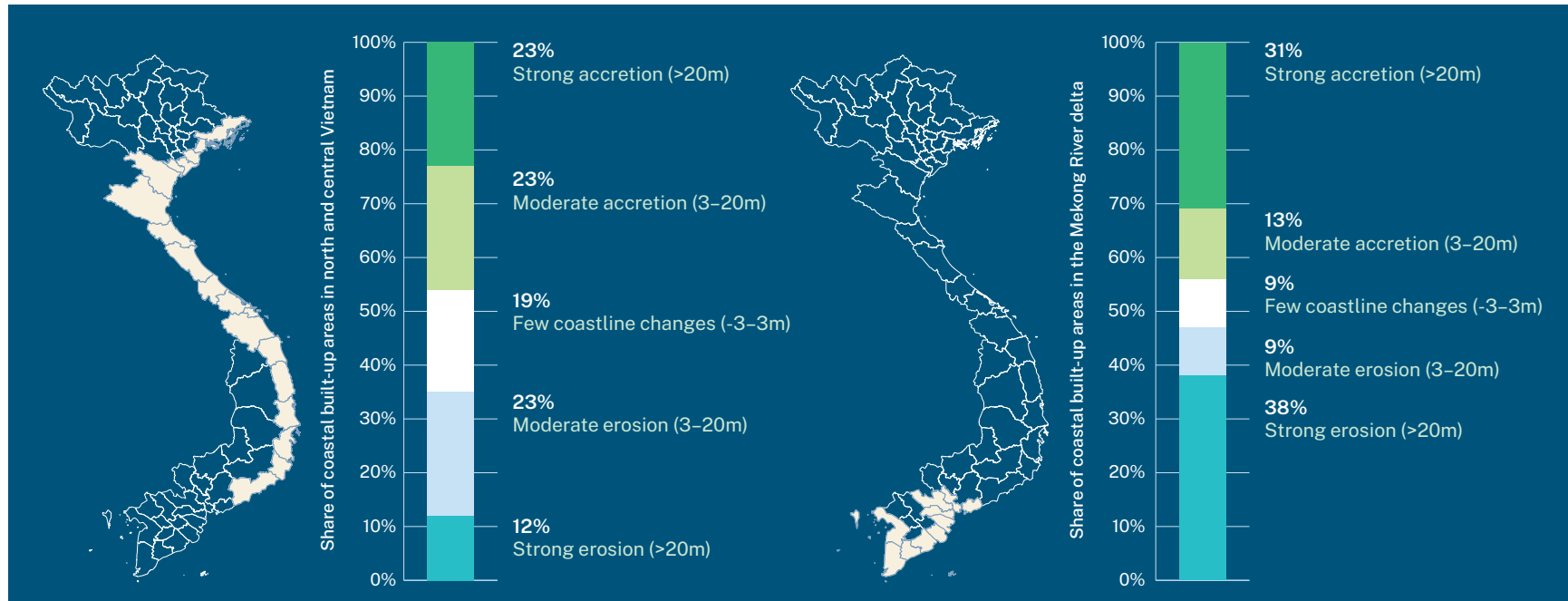


FIGURE 2.10 >>

Over two-thirds of built-up areas along the shores of the Mekong River Delta are subject to strong coastal changes

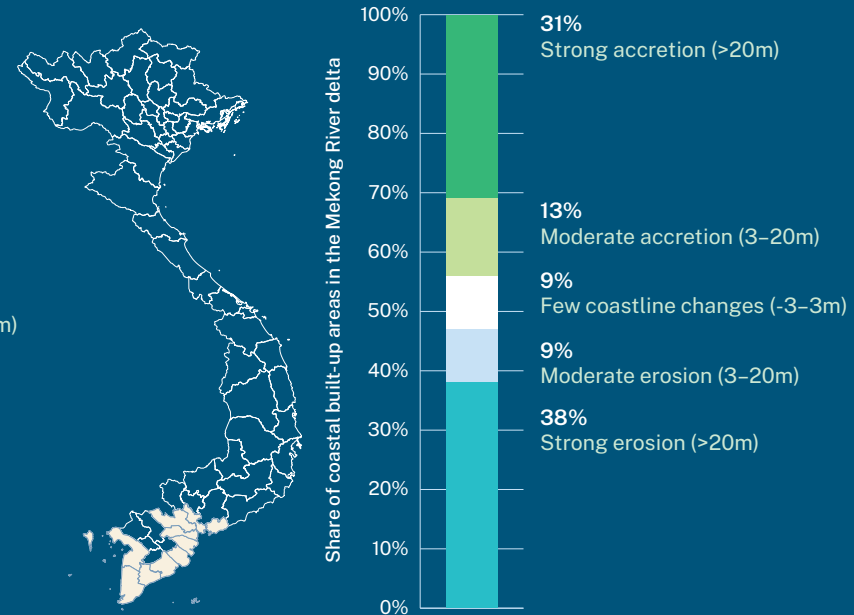


Figure 2.9 Source: Based on erosion estimates for 1990–2015 from Deltares et al. 2017. Figure 2.9 Note: Estimates are for Binh Thuan Province and all coastal provinces north of Binh Thuan. Figure 2.10 Source: Based on erosion data for 1988–2015 provided by the Viet Nam Disaster Management Authority (VNDMA). Figure 2.10 Note: Estimates are for coastal provinces in the Mekong River Delta, including Ho Chi Minh City and Ba Ria-Vung Tau Province. Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

In Ho Chi Minh City alone, estimates show that without protection systems, a 1-in-10-year flood could affect about 63 percent of urban areas (Bangalore et al. 2017). The same event endangers 69 percent of slum areas, highlighting the impacts of constrained space on the most vulnerable. A further 30-centimeter sea level rise increases the disproportionate exposure of the poor: while the whole city would face a 6 percent rise in exposure, in slum areas

it would rise by 15 percent. As well as increasing the impact of storm surges, sea level rise will slow floodwater drainage, thus increasing the impacts of pluvial flooding (100 Resilient Cities 2017).

Heat stress from rising average and extreme temperatures will also hit particularly hard in urban areas, including those on the coast. Land covers like concrete, which are

commonly used in urban areas, are more likely to absorb and retain heat, thus creating an urban heat island effect. The demand for air conditioning systems rises, which in turn increases peak demands on an already strained power system. In addition, heatwaves are bound to result in negative health consequences where populations cannot afford cooling and reduce productivity (World Bank and Asian Development Bank 2018).

2.2 >>

Increasing natural risk and human exposure threaten to reverse poverty reduction

Poverty rates have dropped significantly in the last 10 years, and are below the national average in coastal regions.

Vietnam has achieved extraordinary success in lifting people out of poverty and boosting shared prosperity. The number of people living under the national poverty line fell from 58 percent in the early 1990s to 9.8 percent in 2016 (figure 2.11).² This dramatic reduction has been accompanied by improvements in essential public services, including education, health care, and basic infrastructure. These achievements in reducing poverty are the result of a period of strong and steady economic growth. On average, per capita GDP grew by over 6 percentage points a year between 2000 and 2019. Crucially for poverty reduction, this strong boost in economic wealth has been well distributed. Income for the bottom 40 percent of the population has also grown

faster than for the average population. While this means that inequality has decreased, it has done so slowly, and ethnic minority groups continue to be left behind (Pimhidzai 2018; World Bank and Ministry of Planning and Investment of Vietnam 2016).¹

Despite this overall success, poverty remains a persistent problem, particularly in rural communities. While wage employment is common, most poor people in Vietnam work in the agricultural or low-end manufacturing sectors, on salaries that are significantly below national average. Poverty is especially prevalent in the northwest, whereas poverty rates in the two river deltas and most of

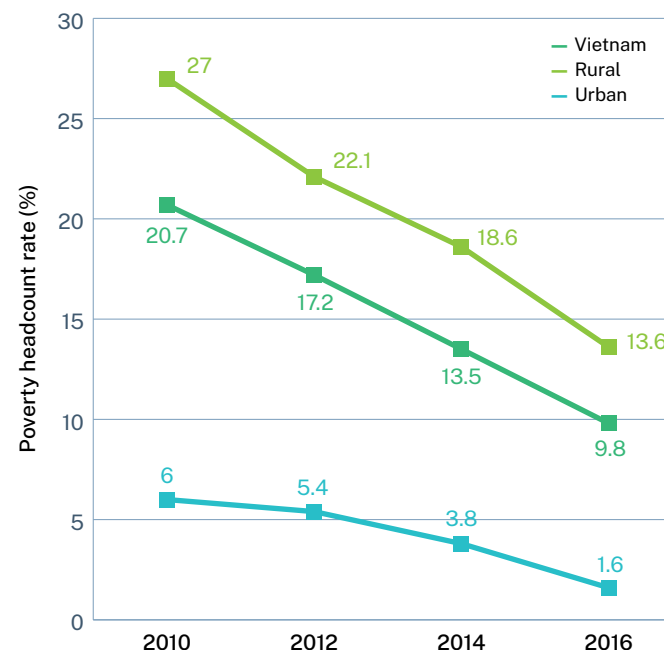


FIGURE 2.11 >>

Poverty lines in Vietnam, 2010–2016, based on international and national poverty rates

Sources: Based on data from Pimhidzai 2018; World Bank and Ministry of Planning and Investment of Vietnam 2016.

the coastal regions are particularly low (figure 2.12). The disproportionate prevalence of poverty among ethnic minorities is also reflected in the geographical distribution of poor people. In the poorer areas in the northern mountains, most of the population belongs to minority groups, whereas relatively few inhabitants of the coastal regions do (Pimhidzai 2018; World Bank and Ministry of Planning and Investment of Vietnam 2016).

Ambitious poverty reduction targets are in line with past successes.

The government has set ambitious targets to continue its successful track record of reducing poverty to address regional inequalities. In its five-year socioeconomic development plan for 2016–2020, the National Assembly defined its goal for reducing the poverty rate in the poorest districts and communes by 4 percent each year, compared to 1–1.5 percent at the national level. Vietnam’s socioeconomic development strategy for 2021–2030 seeks to achieve sustainable and inclusive poverty reduction, with a particular focus on areas with ethnic minority groups. But as the increasingly visible effects of climate change take hold, natural shocks could be a serious obstacle to achieving such poverty reduction goals.

Poor people are more exposed and vulnerable to natural hazards.

Natural shocks have a disproportionate impact on poor households, not only because they tend to live in riskier areas, but also because they tend to be more vulnerable to

natural shocks. Their dwellings are usually less resistant to floods or storms, and their lower wealth and asset quality means that they lose a far higher share of their assets in a disaster than non-poor people. They are also less able to cope and recover, as they have fewer savings and tend to receive less post-disaster assistance (Hallegatte et al. 2016). Natural shocks can also cause non-poor people to fall back into poverty, threatening progress in this area.

In-depth analyses have shown that poor people in Vietnam are disproportionately exposed to natural hazards. Poverty tends to be higher in districts that face high exposure to air pollution, tree cover loss, human-induced land degradation, land slide risk, surface water runoff and soil erosion, rainfall or temperature variability, and drought hazards (Narloch and Bangalore 2018). With flood hazards, however, the picture is more complex. Nationally, districts with higher flood hazards tend to have a lower poverty incidence on average (figure 2.12). For rural districts, this could be because most of the rural poor are in the northern mountains, while flooding primarily affects the less poor coastal zones and river deltas. But in urban districts, as for example in Ho Chi Minh City, the poor are disproportionately exposed to flooding (figure 2.13). This points to the challenges of increasing land scarcity and resulting price pressures that force the poor to settle in risky areas (Narloch and Bangalore 2018).

The regular El Niño-Southern Oscillation (ENSO) events show the high impact of weather variability on poverty in Vietnam,⁷ where poor people are more likely to experience ENSO-related welfare losses—and larger losses—than

the non-poor (Sutton et al. 2019). This is largely a result of lower agricultural yields, which lead to surging food prices. These affect the poor more severely, as they spend a larger share of their income on food, are more dependent on agricultural income, and have fewer sellable assets to smooth their consumption behavior. Women, who are disproportionately active in the agricultural sector, are estimated to be most impacted by ENSO events. The overall effects on poverty are drastic; a strong El Niño event is estimated to increase the national poverty rate by around 1.9 percentage points, or 1.7 million people.

Climate change impacts could drive up to 1.2 million people into poverty by 2030.

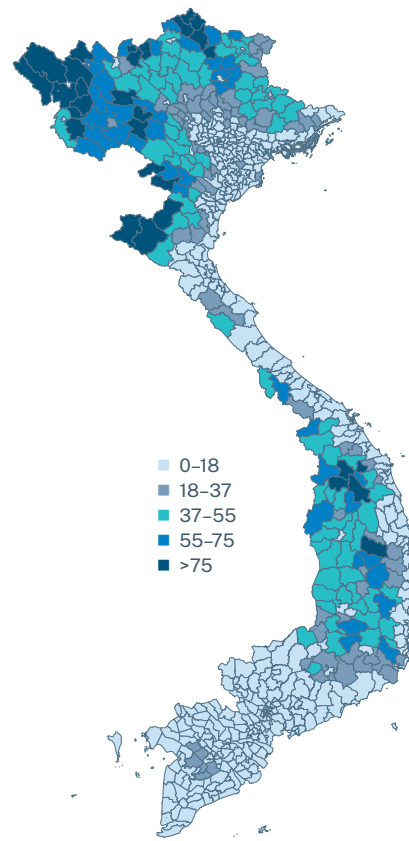
The Vietnamese population's overall exposure to flooding is substantial and will only increase. Without taking into account current protection systems, around one-third of the population is exposed to a riverine, flash or coastal flood event with a 25-year return period. Low levels of climate change could increase this exposure to 38 percent, and high levels could increase it to 46 percent. As natural shocks become more frequent, further reducing poverty rates in vulnerable and highly exposed communities is bound to become more challenging. In Ho Chi Minh City, for example, floods disproportionately affect slum areas (figure 2.13). Climate change will exacerbate this dynamic, as the fraction of affected inhabitants rises much faster in slum areas than for other population groups (Bangalore et al. 2017).

As climate change is bound to increase the frequency of disasters, it threatens the achievements of Vietnam's

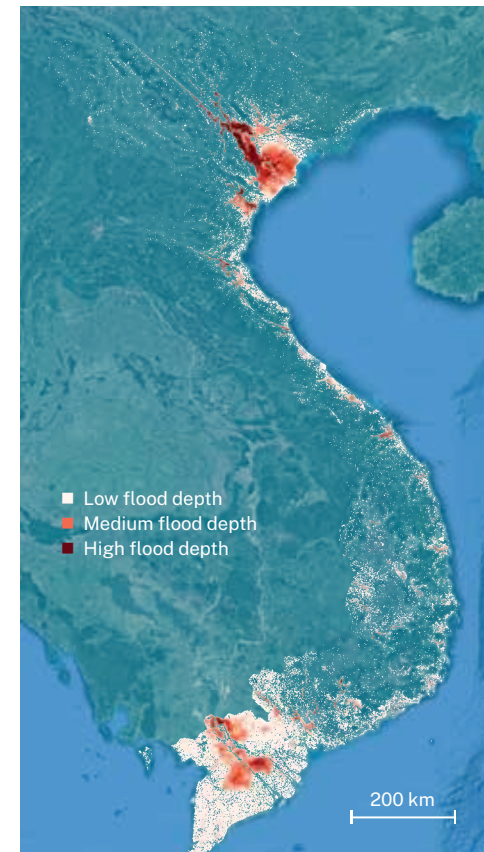
FIGURE 2.12 >>

Poverty incidence and exposure to flooding in Vietnam at district level

a) District-level poverty rates in 2014 (%)



b) Riverine flood risk with a 100-year return period



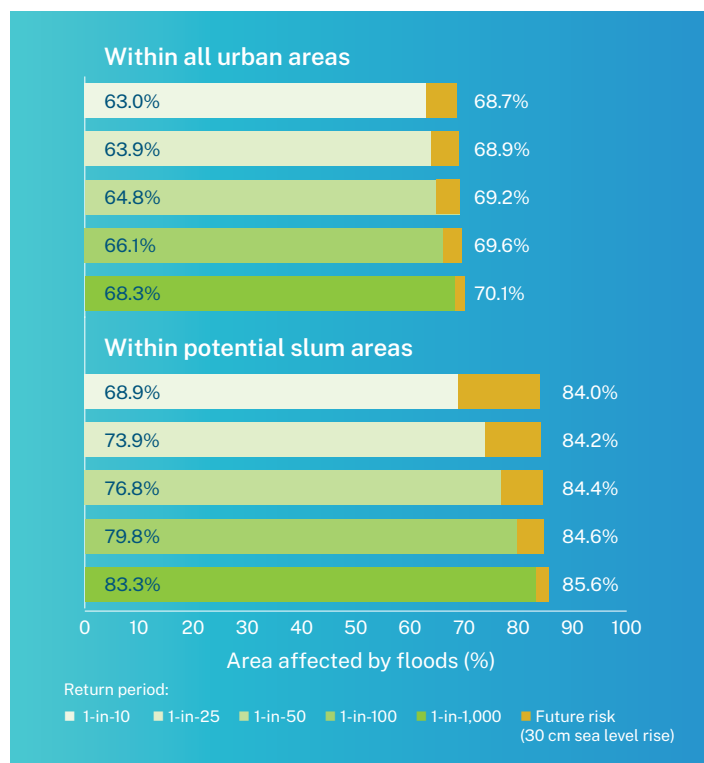
Sources: Based on data from: (a) General Statistics Office of Vietnam² and (b) Fathom.⁴

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development and poverty reduction goals. However, climate models leave significant uncertainty regarding the extent and timing of climatic changes in specific locations.

FIGURE 2.13 >>
Slum areas in Ho Chi Minh City are disproportionately exposed to flooding

Source: Based on Bangalore et al. 2017.



To address this uncertainty, one study simulated a range of climate and socioeconomic futures, and their impact on poverty outcomes in Vietnam. In a pessimistic scenario, it found that climate change could push an extra 1.2 million people into poverty by 2030 (Rozenberg and Hallegatte 2016). These severe consequences are driven by changing agricultural incomes and food prices, natural hazards, and health impacts.

Two conclusions can be drawn from such studies. First, it is possible to mitigate the impact of climate change by developing skilled manufacturing and service sectors and ensuring high growth in agricultural productivity. In this way, people can move away from income generating activities that make them heavily exposed to climate change, in particular small-scale agriculture. Second, if Vietnam does not consider the impacts of natural hazards and climate change in its investment and planning decisions, the number of people falling into poverty will pose a serious threat to its ambitious goals for poverty reduction. To design robust strategies in the face of uncertainty, it will be particularly important to design investments and strategies in a way that make them flexible and robust to a wide range of potential future scenarios.

Endnotes

1. Information from World Bank Open Data, <https://data.worldbank.org/>
2. Information retrieved from General Statistics Office of Vietnam, <https://tinyurl.com/tq3s66s> on April 15, 2019.
3. Information from Fathom Global, <https://tinyurl.com/sfzgo7z>
4. For a more detailed explanation of the data sources and analytical methodology used in this report, see Braese et al. (2020).
5. For further details, refer to Braese et al. (2020) and World Bank (2020).
6. Erosion data for northern and central provinces cover 1990–2015 (Deltares et al. 2017), while coastline changes in the Mekong Delta, including Ho Chi Minh City and Ba Ria-Vung Tau, were evaluated based on data for 1988–2015 provided by the VNDMA.
7. ENSO refers to oceanic and atmospheric fluctuations in temperature that affect global weather patterns and manifest in two multi-year phases, El Niño and La Niña. El Niño usually decreases rainfall while La Niña increases it, but there are regional fluctuations, as seen in Chapter 3 (figure 3.2).
8. For more information please refer to Appendix A.

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Natural hazards threaten key sectors of Vietnam's coastal economy

Outside the metropolitan hubs of Hanoi and Ho Chi Minh City, Vietnam's coastal regions have been the most important engine of economic growth and prosperity. In the coming decades, the development of these areas, with their dynamic and diversified economy, is expected to accelerate. However, the opportunities offered by the coast also bring significant risks that can threaten key economic sectors. For example, coastal tourism contributes 70 percent of national tourism GDP, but its location means it is particularly exposed to floods, storm surges and erosion. Similarly, agriculture employs 40 percent of the population. Rice and aquaculture production is concentrated in the two low-lying river deltas, where there is a constant risk of coastal and riverine flooding. This chapter shows that coastal Vietnam's key economic sectors have significant exposure to natural hazards. Figure 3.1 summarizes the annual average losses in four of these — agriculture, aquaculture, tourism and industry — as a result of both riverine and coastal flooding.

3.1 >>

Impacts on agriculture threaten vulnerable population groups

Agriculture, a crucial part of Vietnam's economy, is expected to become increasingly industrialized.

As a key sector of the economy, agriculture provides livelihoods for many of the country's poorest people. Vietnam is one of the world's leading exporters of agro-food commodities, and among the top five for rice, coffee, tea, cashews, black pepper, rubber, cassava, and aquatic products. The sector achieved enormous progress in

smallholder productivity and intensification in the 1990s, which played a crucial role in the country's economic development and poverty reduction (World Bank 2016).

In 2017, agriculture, forestry, and fishing accounted for 15 percent of Vietnamese GDP (\$25.9 billion) and provided jobs for 28.9 million people, or 40 percent of the employed population.¹ To boost value creation in the sector, the government aims to intensify secondary produce processing through increased industrialization. Overall, agro-food, which includes both primary agriculture and agro-industry, is expected to remain at around 25 percent of GDP and the major livelihood or source of employment for 25–30 percent of the population (World Bank 2016).

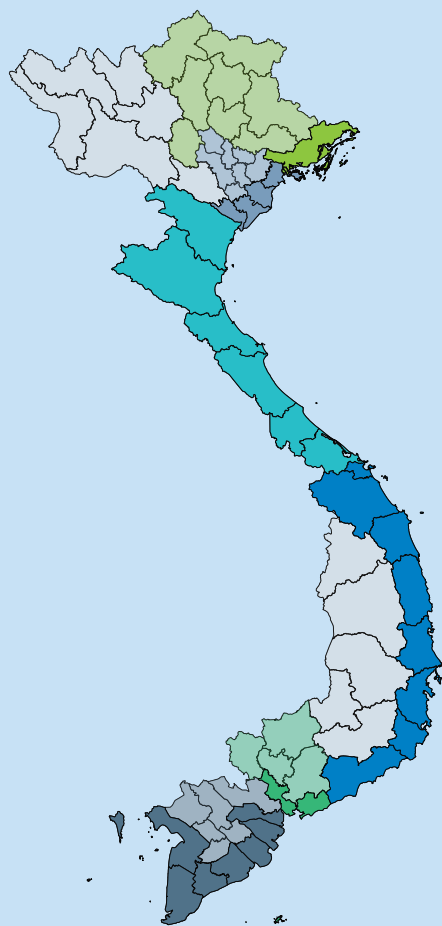
70%

The portion of national tourism GDP contributed by coastal tourism.

FIGURE 3.1 >>

Coastal and riverine flooding have a significant impact on key economic sectors in Vietnam

Average annual production value at risk in four key economic sectors, based on exposure to both riverine and coastal flooding



Sources: JAXA EORC, 2018 (land use maps), Open Street Map (tourism data), World Bank DRFI Program, 2019 (industry data), Braese et. al 2020 (coastal flood data); and Fathom (riverine flood data).² Note: For all sectors except industry, estimates are based on contribution to GDP. For industry, estimates are sourced from World Bank DRFI Program (2019). For aquaculture, geo-referenced pond data were only available for provinces in the Red River and Mekong Deltas, which account for about 86 percent of national aquaculture production. *Disclaimer:* The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.




		Average annual value at risk (\$, millions)							
Sector	Province	 Agriculture		 Aquaculture		 Tourism		 Industry	
		Coastal flood risk	Riverine flood risk	Coastal flood risk	Riverine flood risk	Coastal flood risk	Riverine flood risk	Coastal flood risk	Riverine flood risk
NORTHEAST	Quang Ninh	1.5	0.6	--	--	15.7	10.2	20.3	0.8
	RED RIVER DELTA								
	Hai Phong City	2.9	0.1	2.4	0.1	8.3	0.9	14.2	0.4
	Thai Binh	4.9	0.3	5.5	0.3	1.1	0.1	1.1	0.1
	Nam Dinh	5.6	0.3	4.1	0.2	0.8	0.0	1.4	1.4
	Ninh Binh	3.0	0.1	1.5	0.1	25.3	0.9	2.4	2.0
NORTH CENTRAL COAST									
	Thanh Hoa	2.7	2.2	--	--	4.0	3.3	5.9	7.7
	Nghe An	2.1	1.8	--	--	3.2	2.6	3.8	9.0
	Ha Tinh	1.9	0.9	--	--	1.1	1.5	6.5	11.6
	Quang Binh	0.7	2.1	--	--	9.6	27.9	1.1	1.4
	Quang Tri	0.2	1.8	--	--	0.7	7.3	0.2	0.1
	Thua Thien-Hue	0.5	1.7	--	--	15.6	41.9	1.0	1.0
SOUTH CENTRAL COAST									
	Da Nang City	0.0	0.3	--	--	7.2	22.5	4.6	2.4
	Quang Nam	0.0	3.2	--	--	14.4	40.1	1.5	2.9
	Quang Ngai	0.1	2.4	--	--	0.4	7.7	3.2	0.3
	Binh Dinh	0.1	1.8	--	--	0.5	14.4	2.7	0.7
	Phu Yen	0.0	0.9	--	--	1.1	7.8	0.3	0.0
	Khanh Hoa	0.1	1.3	--	--	6.5	25.2	0.8	0.9
	Ninh Thuan	0.0	0.8	--	--	0.8	5.6	0.2	0.1
	Binh Thuan	0.0	2.7	--	--	12.1	41.0	0.4	0.8
SOUTHEAST									
	Ba Ria-Vung Tau	0.1	0.3	--	--	14.7	25.7	2.4	0.1
	Ho Chi Minh City	0.8	0.1	--	--	16.0	10.8	3.3	13.7
MEKONG RIVER DELTA									
	Tien Giang	3.3	0.4	5.2	6.6	2.1	3.5	0.2	0.1
	Ben Tre	5.9	0.5	24.7	11.9	2.9	2.5	0.1	0.0
	Tra Vinh	5.2	0.7	7.9	4.7	1.1	0.7	0.0	0.0
	Soc Trang	1.9	0.6	6.3	8.8	0.0	0.3	0.0	0.0
	Bac Lieu	2.0	0.1	13.0	10.6	0.1	0.1	0.0	0.0
	Ca Mau	0.6	0.1	4.6	15.5	0.2	1.1	0.0	0.1
	Kien Giang	1.2	2.0	3.3	0.4	12.7	18.1	0.1	0.1
COASTAL VIETNAM		47.2	30.0	78.5	59.1	178.2	323.7	77.6	57.9

FIGURE 3.2 >>

The impact of natural disasters on farmland and livestock is substantial and volatile

Source: Based on data from VNDMA.³

Photo: iStock



HOI AN >>

A farmer rides a tractor through his fields.



Frequent weather shocks threaten agricultural production and cause significant losses.

Each year, natural shocks cause significant damages to Vietnam's agricultural sector. Storms destroy crops; floods inundate fields, damage yields, and kill livestock; droughts and storm surges cause saline intrusion, devastating the fertility of fields. These all affect agricultural production, with direct and dire consequences for jobs and incomes.

Historic government data documents the magnitude of these impacts. For example, records of annual farmland and livestock losses due to natural shocks (figure 3.2) suggest that they are volatile, yet substantial. In seven of the past 20 years, more than one million head of livestock were lost due to natural shocks, while only marginal losses were reported in other years. There are similar fluctuations in farmland lost due to flooding and saline intrusion. For example, the 2016 drought caused severe saline intrusion, especially in the Mekong Delta, with over 1.4 million hectares of farmland lost nationally.

Vietnam's exposure to natural stresses is not limited to rare and extreme events. Shocks are experienced frequently, most notably those associated with ENSO, which occurs roughly every four years. The two phases of ENSO—El Niño and La Niña—result in significant rainfall deviations (figure 3.3) that have varying effects on crops, depending on their resistance to drought. For example, maize is more drought-tolerant than rice, and production can increase under La Niña, cancelling out reductions from El Niño. Rice is more vulnerable, and potential volume gains during La

Niña average at half the losses from El Niño. Simulations show that El Niño causes around \$2.5 billion in national GDP losses, whereas gains under La Niña are only around \$1.1 billion (Sutton et al. 2019).

Such ENSO-related production losses lead to higher food prices, which in turn have disproportionate impacts on the poor and other marginalized groups. Women play a central role in agriculture in Vietnam, contributing more hours of labor than men in cultivation, livestock breeding, agricultural processing and agriculture produce marketing (ADB 2002). This increases their vulnerability, and they suffer disproportionately from ENSO-related

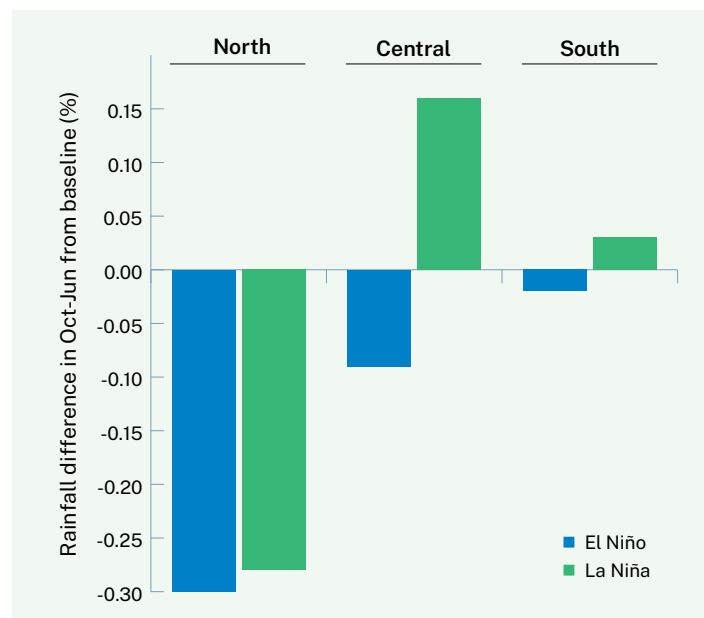


FIGURE 3.3 >>
Rainfall difference between ENSO and neutral phases in north, central and south Vietnam, 1980–2015

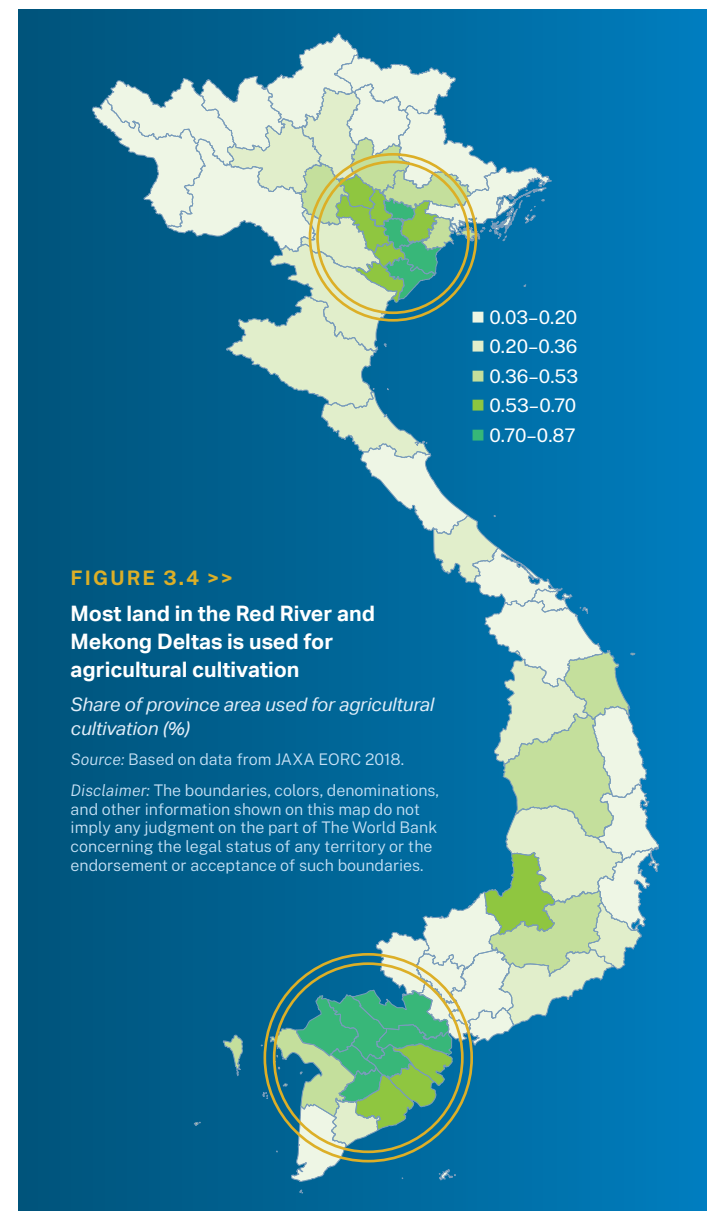
Source: Sutton et al. 2019.

shocks. Female-headed households are also more likely to be poor and rely on agriculture for their income, so such events hit them harder. Simulations show that strong El Niño events lead to a 2.7 percent poverty rate increase in female-headed households, which is higher than in male-headed households (Sutton et al. 2019).

Most of Vietnam's agricultural production is near the coast.

Geography is a key reason for the agriculture sector's high exposure to natural shocks. As the country's inland regions are mountainous, most cultivated land is concentrated in the two low-lying deltas or near the coast (figure 3.4). For example, 69 percent of rice is grown in the Red River and Mekong Deltas and 14 percent of rice paddies are within 10 kilometers of the coast.

Remote sensing techniques enable a detailed, spatially disaggregated view of agricultural production, and can shed light on the risks faced by the sector. Using high-resolution satellite imagery to assess the risks for Vietnam's three major agricultural land use types—rice paddies, crops and orchards⁴—a systematic pixel-by-pixel analysis for this report estimated how natural hazards may affect different sub-sectors.⁵ Figure 3.5 is a zoom view of the Red River Delta's agricultural landscape, which clearly faces substantial flood risks. Agricultural cultivation here includes rice paddy, crops, and orchards, though rice is the main crop.



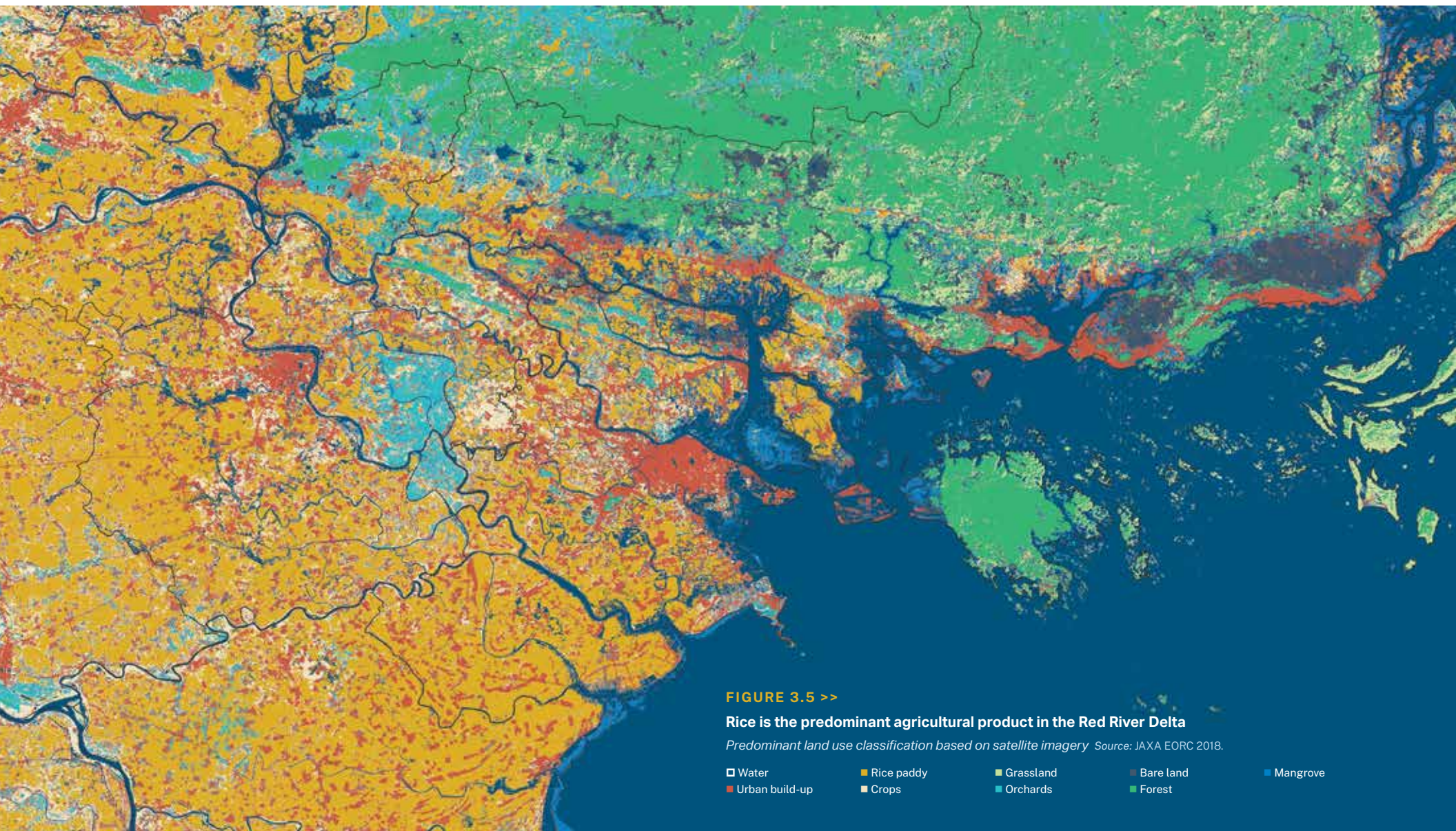


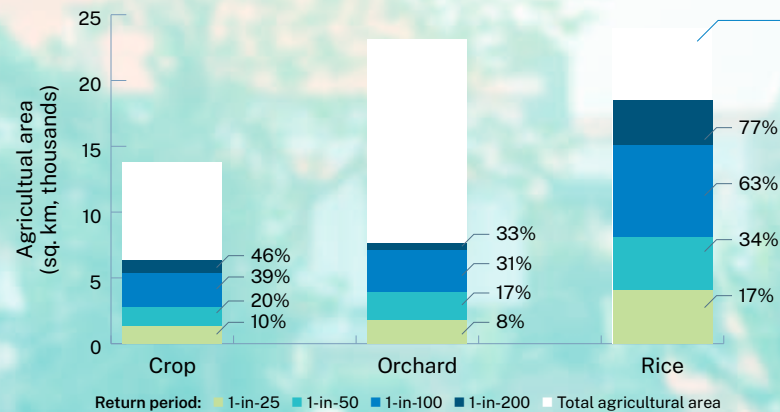
FIGURE 3.6 >>

Agricultural crops in coastal provinces are significantly exposed to flooding and rice is the most threatened crop

Source: Based on data from JAXA EORC 2018 (land use maps) and Fathom (flood data).²

Note: Flood risk refers to both coastal and riverine flooding. Crops are assumed to be destroyed by a flood depth of 25cm.

Photo: iStock



24K

There are 24,000 square kilometers of rice production area in coastal provinces

63%

of rice production area is exposed to a 1-in-100 year flood

17%

of rice production area is affected in a 1-in-100 year flood

HANOI >>

A farmer tends to the fields.



Flooding is a major and growing threat to agricultural production.

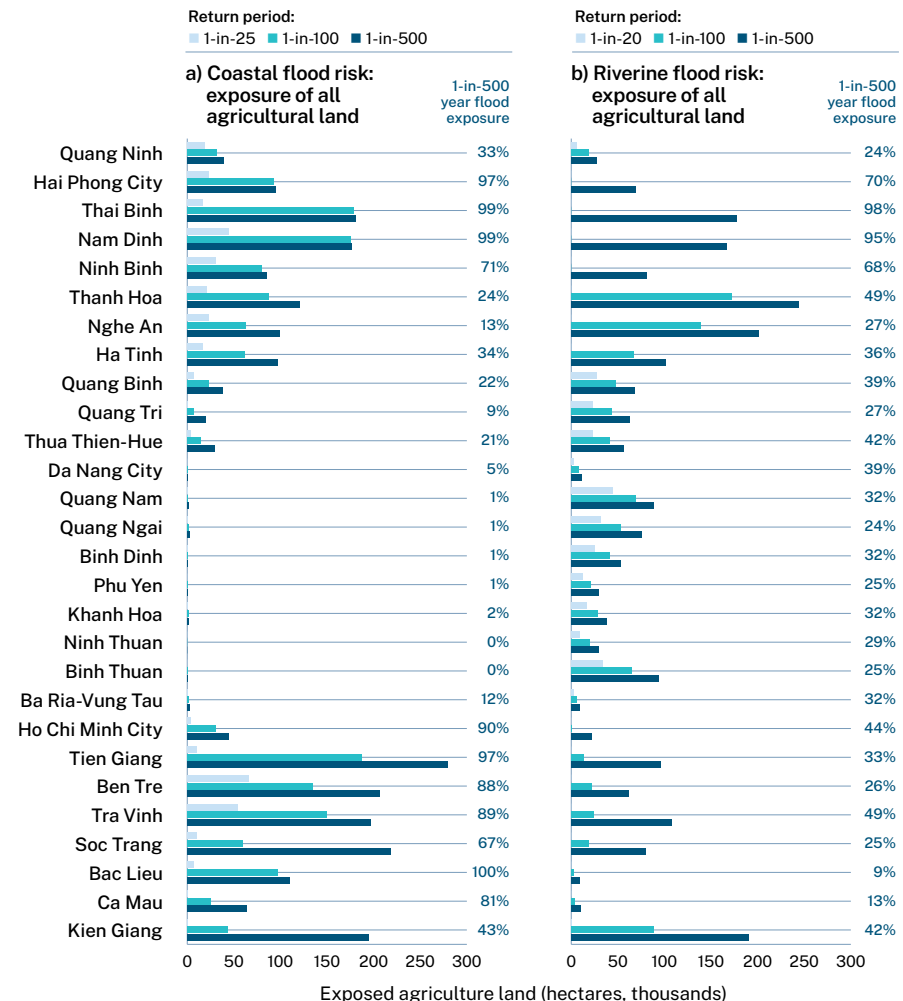
Flooding in coastal Vietnam has various causes, including excessive rainfall in catchment areas and coastal storm surges due to typhoons. Analysis conducted for this report systematically assessed flooding types to estimate the flood risk faced by the agricultural sector in coastal Vietnam. Although historic damage data suggest that natural shocks have caused substantial losses in the past, analysis of modeled extreme flooding scenarios demonstrates that potential maximum losses are likely to be significantly greater than those already experienced.⁵

The analysis clearly demonstrates the scale of flood risk to agricultural production. Of the three land use types analyzed, rice is at greatest risk: a combined riverine and coastal flood with a 25-year return period would inundate 17 percent of all rice paddies in coastal provinces (figure 3.6). This increases dramatically to 34 percent for a 1-in-50-year flood, and 63 percent for a 1-in-100-year flood. A 1-in-200-year flood would inundate more than three-quarters of the 24,000 square kilometers of rice production in coastal provinces. For other crops and orchards, exposure to flood risk is less pronounced, yet still substantial.

Losses in agricultural production, particularly as a result of coastal flooding, are concentrated in the two large river deltas (figure 3.7). All crop fields (rice, orchards and others) in Thai Binh and Nam Dinh Provinces and Hai Phong City in the north are vulnerable to coastal flooding: a 1-in-100-year flood exposes about 90 percent of the crop production in

FIGURE 3.7 >>

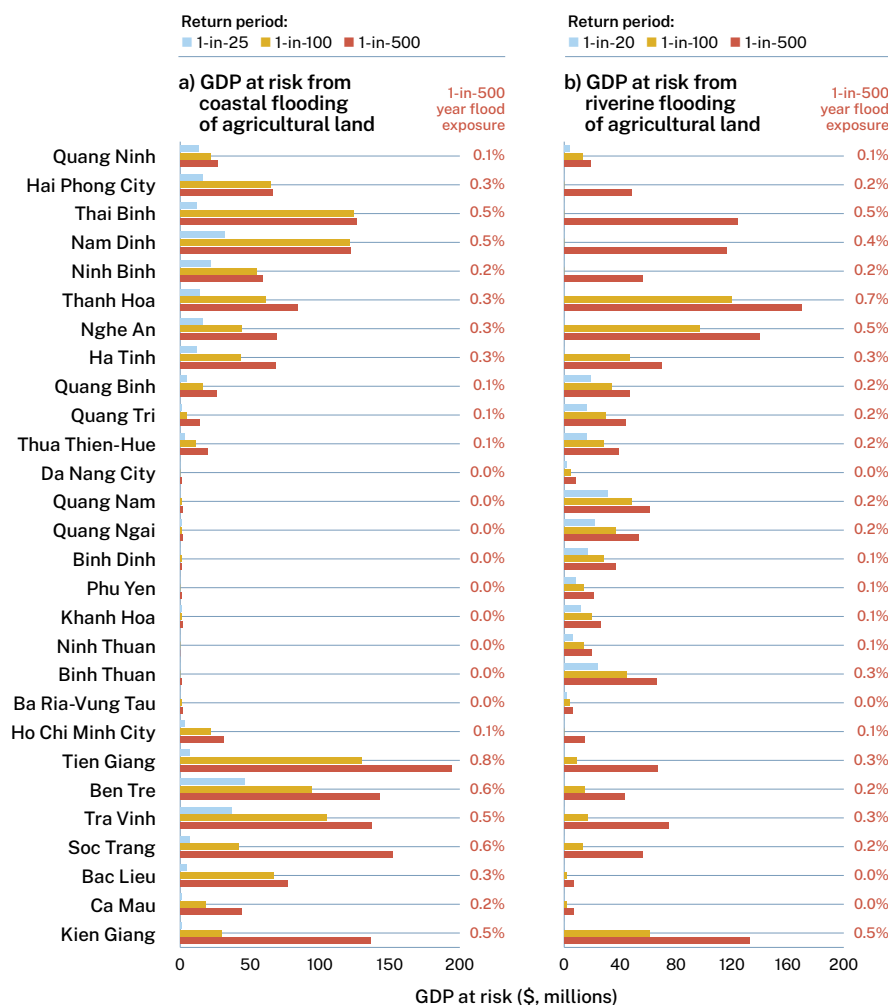
Agricultural crop production is particularly exposed in the Red River and Mekong Deltas, especially to coastal flooding



Sources: Based on data from JAXA EORC 2018 (land use maps), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).⁵ Note: Percentages refer to the share of total crop area exposed to a 1-in-500-year flood. Crops are assumed to be destroyed by a flood depth of 25 cm. Agricultural land refers to the land used for production of rice, crops and orchards.

FIGURE 3.8 >>

Exposure of agricultural land translates into significant risks at the macro-economic level



Sources: Based on data from JAXA EORC 2018 (land use maps), Braese et al. 2020 (coastal flood data), Fathom (riverine flood data)² and General Statistics Office of Vietnam (economic indicators).³ Note: Percentages refer to the share of total GDP exposed to a 1-in-500-year flood. Crops are assumed to be destroyed by a flood depth of 25cm. Calculations assume unchanged economy and do not consider losses from smaller, yearly recurring flood events. Agricultural land refers to the land used for production of rice, crops and orchards.

these Red River Delta provinces (and about 60–80 percent of crops in the Mekong Delta provinces). The Red River Delta’s dike systems protect crops against riverine floods up to 100-year return period in some provinces, but they cannot withstand more severe events (figure 3.7). Crop production in the central provinces is also exposed to riverine flooding, including the more frequent 1-in-20-year flood events. At the national level, 10 percent of the country’s crop area is exposed to coastal flooding with a 100-year return period, and 7 percent by a riverine flood of the same intensity.

In 2017, agriculture contributed up to 15 percent of Vietnam’s GDP. So these estimates translate into significant exposure at the macro-economic level. Coastal flooding with a 100-year return period is estimated to threaten \$1 billion worth of agricultural production — that is, 4 percent of agricultural GDP.⁷ It would also put 1.5 million workers’ jobs at risk. Riverine flooding with the same return period would mainly be contained by the current protection levels in the Red River Delta. As such, it would have a smaller, but still significant, impact of around \$700 million — or 2.7 percent of agricultural GDP — and on 1 million workers. Figure 3.8 shows a province-level breakdown of these losses, which are particularly great in the two major river deltas. The estimates confirm that these regions do not only have high agricultural production and economic potential, but also substantial risk.

Rice, the most important agricultural crop, faces particular risks from flooding.

Rice is not only the most important staple food in Vietnam; in

rural regions, it is also one of the main sources of income. In 2017, rice exports were worth \$2.6 billion and accounted for about 15 percent of the country's total agricultural exports.⁶

Rice production is particularly exposed to flooding in the Red River and Mekong Deltas. These provinces tend to have high standards for riverine, but not coastal, flood protection (figure 3.9). The Mekong Delta — the country's largest rice-producing region, also known as Vietnam's "rice bowl" — is subject to a range of substantial and growing natural risks. As the delta of one of the world's largest river systems, its low-lying topography and location makes coastal and river flooding well-known risks in this region. Saline intrusion also affects rice production.

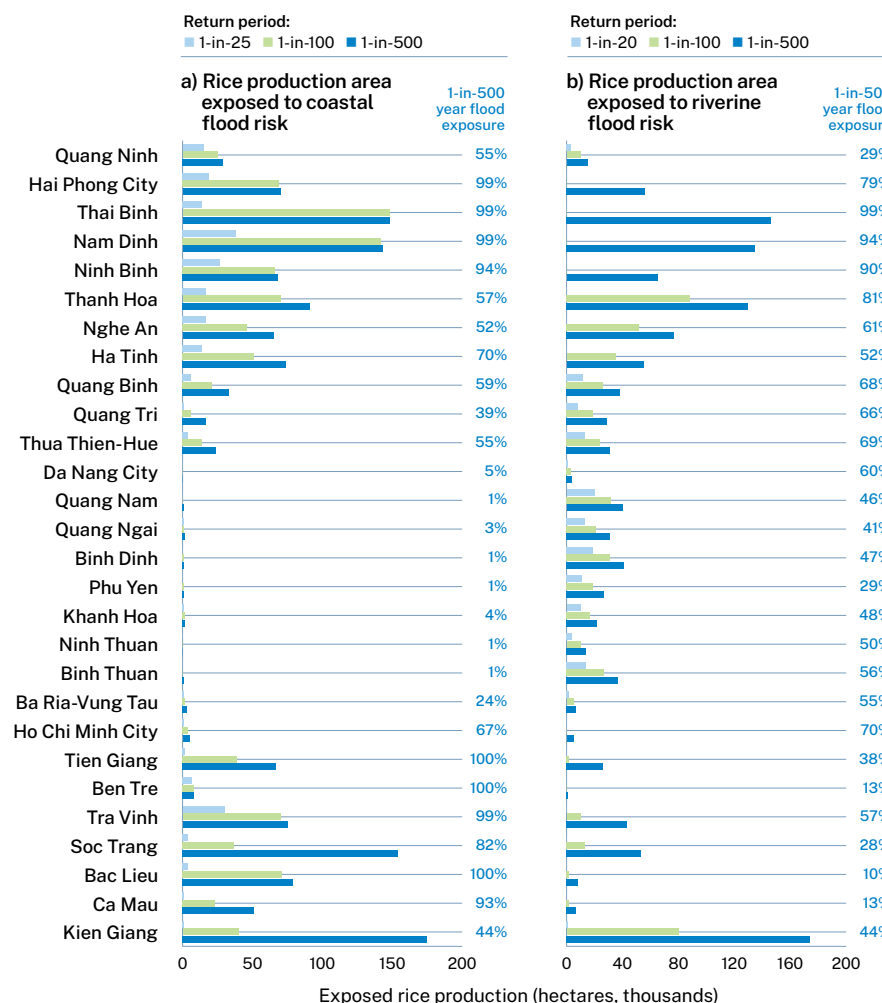
Coastal and riverine floods would hit both deltas hard in terms of rice export loss. Estimates produced for this report demonstrate the scale of the risk to rice production in coastal Vietnam (figure 3.10). For example, in the coastal provinces of the Mekong Delta, a 1-in-100-year coastal flood could threaten around \$242 million of rice exports and some 440,000 jobs (\$158 million and 269,000 workers in the Red River Delta). Nationally, about \$500 million of exports and 897,000 jobs are exposed to intense coastal flooding (\$255 million and 454,000 jobs to riverine flooding).⁸

Sea level rise due to climate change will increase the risks of coastal flooding.

Flood risks are already high, and while the effects of climate change can be felt in these highly exposed regions, the

FIGURE 3.9 >>

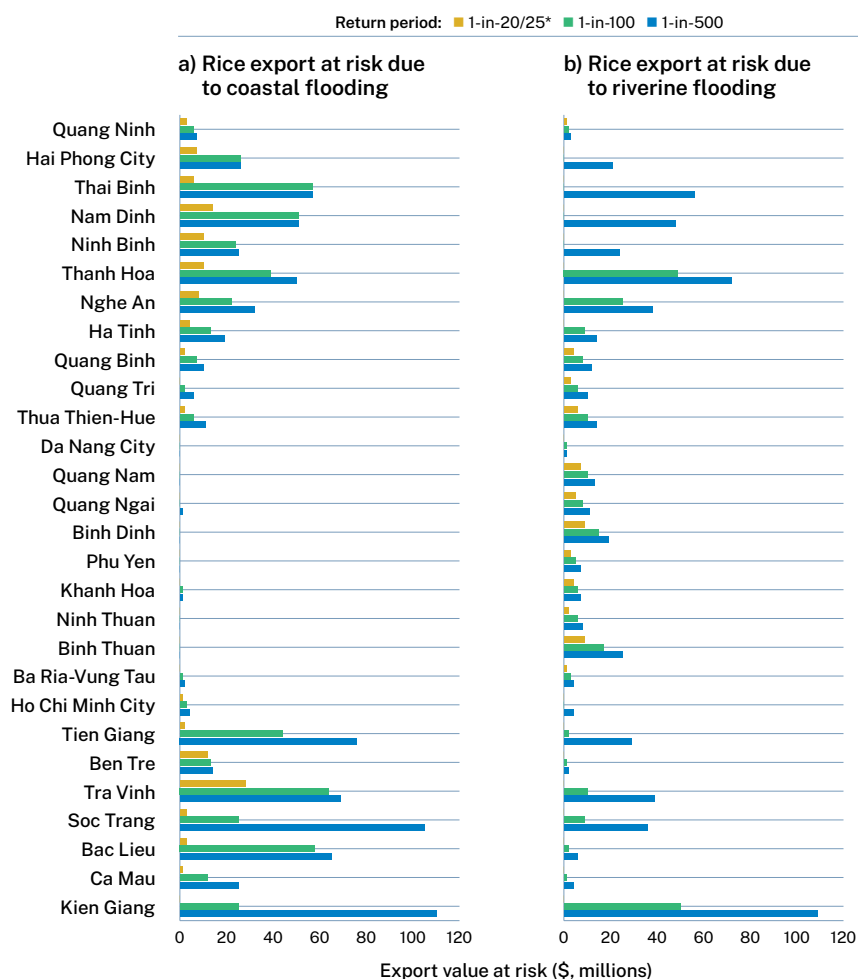
Rice production is particularly exposed to flooding in the Red River and Mekong Deltas, where standards tend to be high for river, but not coastal, flood protection



Sources: Based on data from JAXA EORC 2018 (land use maps), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).⁹ Note: Percentages refer to the share of total crop area exposed to a 1-in-500-year flood. Crops are assumed to be destroyed by a flood depth of 25cm.

FIGURE 3.10 >>

The two deltas are hit particularly hard in terms of rice export at risk due to coastal and riverine flooding



Sources: Based on data from JAXA EORC 2018 (land use maps), Braese et al. 2020 (coastal flood data), Fathom (riverine flood data)² and General Statistics Office of Vietnam (economic indicators).⁶ Note: Calculations assume unchanged economy and do not consider losses from smaller, yearly recurring flood events. For coastal flooding, a 25-year return period has been used; for riverine flooding, a 20-year return period. *For coastal flooding, a 25-year return period has been used; for riverine flooding, a 20-year return period.

risks are expected to intensify in the future. The scenarios determined by Vietnam's Ministry of Natural Resources and Environment (MONRE) estimate that sea levels could rise about 13cm by 2030 and 22cm–25cm by 2050 for RCP 4.5 and RCP 8.5 scenarios respectively (box 3.1) (Thuc et al. 2016).

Rising sea levels mean that the coastal flooding and storm surges associated with typhoons could become significantly more destructive. For example, coastal flooding with a 1-in-50-year intensity is estimated to threaten 34 percent of rice paddies in coastal provinces. Sea level rise in a strong climate change scenario⁹ would increase this exposure to about 42 percent (figure 3.11), assuming the current extent and distribution of rice production. In addition, sea level rise leads to increased saline water heads at the ocean boundary, likely increasing saline intrusion.

Over such long horizons, it is difficult to predict how the concentration of assets and economic activity will develop in coastal regions. But current trends strongly suggest that Vietnam's coast will continue to develop and urbanize. So, as climate change increases the threat of natural hazards, the exposure of people, assets, and livelihoods will also increase.

Drought and saline intrusion: the effect on rice production in the Mekong Delta.

Saline intrusion is a growing challenge to the productivity and viability of agricultural production in coastal areas.

BOX 3.1 >>

Climate models offer estimates of the magnitude of future sea level rise

Its long coastline means that Vietnam is strongly and directly affected by sea level rise resulting from climate change. To guide public policy on this matter, MONRE has released official sea level rise estimates for the country up to 2100. These were obtained by feeding results from global climate models into high-resolution regional models that synthesized these results with local observational data (MONRE 2016).

Greenhouse gas emissions responsible for climate change depend on socioeconomic factors around the world. To avoid modeling these factors explicitly, climate change scenarios such as those published by MONRE rely on representative concentration pathways (RCPs) — four scenarios of the trajectory of greenhouse gas concentration in the atmosphere until 2100. RCP2.6 and 4.5 describe scenarios where greenhouse gas

concentration stays relatively low; RCP6.0 and 8.5 describe quickly rising concentrations.

The potential impact of sea level rise is analyzed for several sectors in this report. For simplicity, these analyses do not explicitly model RCPs, but instead consider scenarios with sea level rising about 0.3 and 0.6 meters (based on Narloch and Bangalore 2018). These are referred to as scenarios of moderate and strong climate change, respectively.

TABLE B3.1.1 >> Sea level rise scenarios for Vietnam's coastline

Scenarios	Sea level rise projections in centimeters with confidence intervals in parenthesis							
	2030	2040	2050	2060	2070	2080	2090	2100
RCP2.6	13 (8–19)	17 (10–25)	21 (13–32)	26 (16–39)	30 (18–45)	35 (21–52)	40 (24–59)	44 (27–66)
RCP4.5	13 (8–18)	17 (10–25)	22 (14–32)	28 (17–40)	34 (20–48)	40 (24–57)	46 (28–66)	53 (32–76)
RCP6.0	13 (8–17)	17 (11–24)	22 (14–32)	27 (18–39)	34 (22–48)	41 (27–58)	48 (32–69)	56 (37–81)
RCP8.5	13 (9–18)	18 (12–26)	25 (17–35)	32 (22–46)	41 (28–58)	51 (34–72)	61 (42–87)	73 (49–103)

Source: MONRE 2016.

With sea level rise of 0.3 meters, the moderate scenario provides a reasonable approximation Vietnam in 2060, no matter the RCP scenario. This is because there is little difference between greenhouse gas scenarios until the end of the century, when they become more pronounced. The strong (0.6 meter) climate change scenario, however, describes a sea level rise which is only reached by the end of the century under the high-concentration RCP6.0 and 8.5 scenarios.

FIGURE 3.11 >>

Sea level rises pose an increasing risk to rice production

Rice production in coastal provinces threatened by a 1-in-50-year flood in the current climate and in moderate and strong climate change scenarios

Sources: Based on data from Fathom (flood data)² and JAXA EORC 2018 (land use maps).

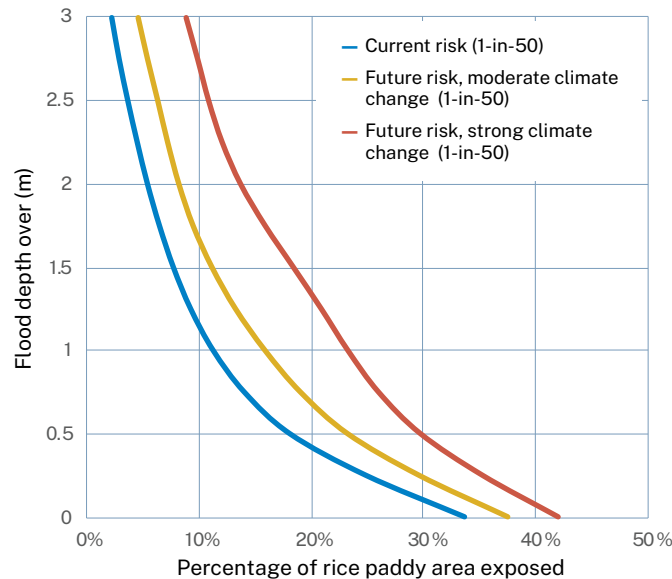
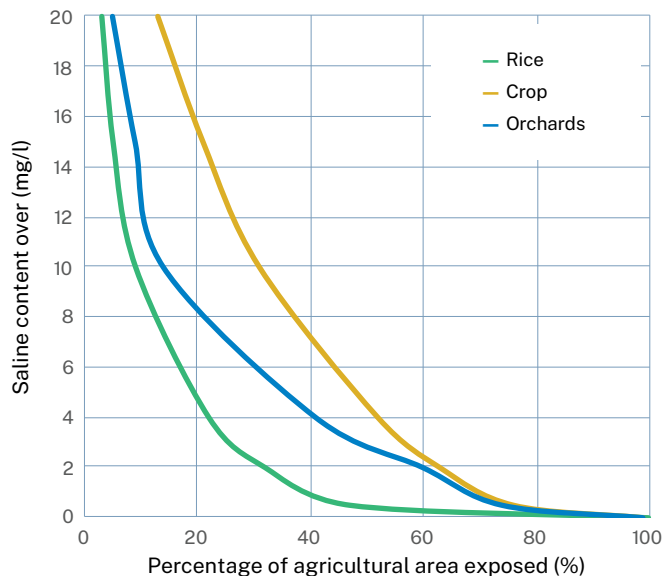


FIGURE 3.12A >>

Saline intrusion poses a significant risk to rice production in the Mekong Delta

Saline exposure per agricultural area for rice, crops and orchards

Sources: Based on data from SIWRR¹⁰ (saline intrusion) and JAXA EORC 2018 (land use).

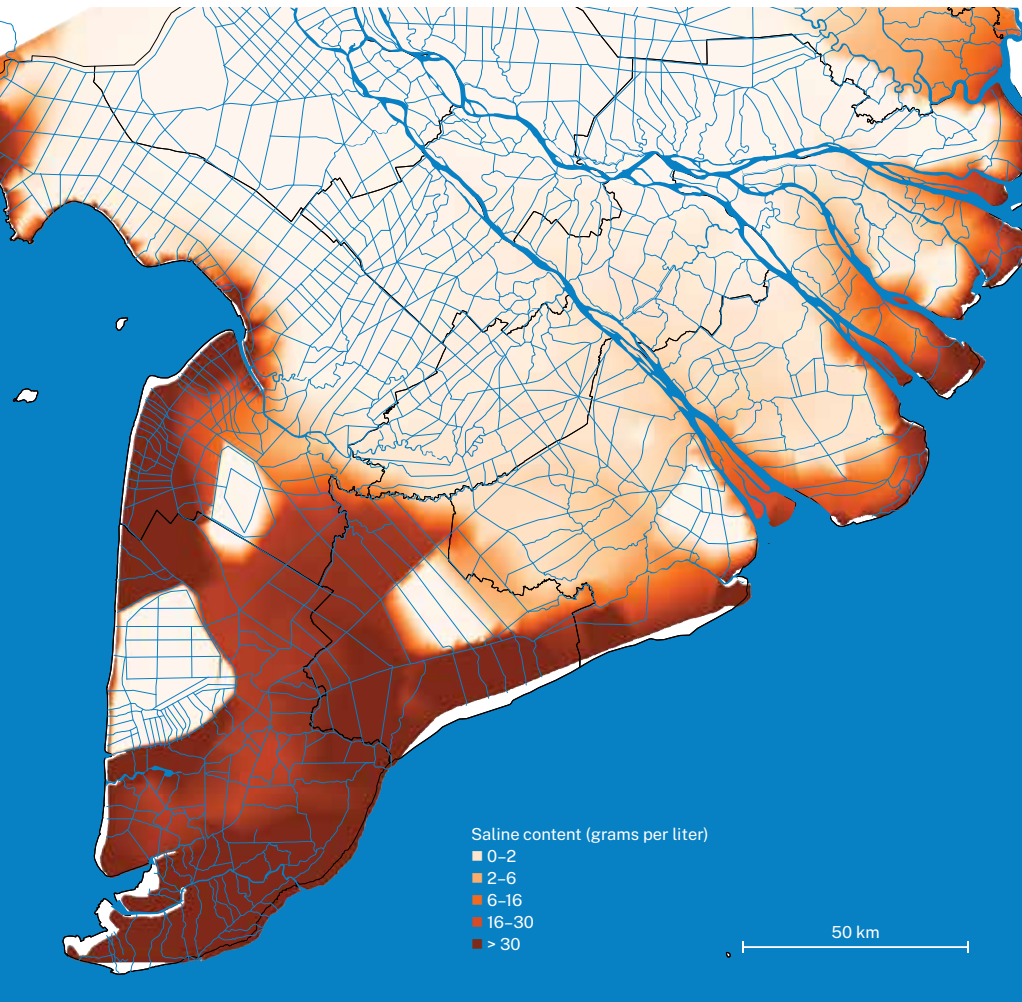


In the Mekong Delta, a region seriously affected by this problem, freshwater aquifers have been depleting as a result of groundwater extraction and droughts caused by erratic precipitation patterns in upstream areas. This imbalance causes sea water with high saline concentrations to flow into freshwater aquifers. The heightened salinity levels are detrimental to water-intensive rice production, irrigation more generally, and high-quality water supply to households and firms (Hyland et al. 2019). As saline intrusion is recognized as a major threat, Vietnam's Southern Institute of Water Resources Research (SIWRR) plays an essential role in monitoring and modeling salinity levels. This section compares SIWRR's salinity maps with agricultural land use maps (based on satellite imagery) to systematically quantify the impacts on agricultural production.⁵

One of the most intense incidents of saline intrusion in recent years was experienced in 2016 in the Mekong Delta. Estimates produced for this report show that a significant share of agricultural production was affected by critical salinity levels (figure 3.12). Although saline intrusion seriously affects orchards and non-rice crops (as a share of total cultivated area), rice is the delta's — and the country's — most important crop. Empirical evidence shows that saline concentrations of over 4 milligrams per liter make monocultural rice production unviable (Nhan et al. 2012). In 2016, 22 percent of rice paddies in the Mekong Delta were exposed to salinity levels above this threshold. Equivalent to 12 percent of national rice production and 8 percent of national agricultural GDP, it directly affected the livelihoods of some 3 million rice farmers.

FIGURE 3.12B >>

Saline intrusion in the Mekong delta in 2016



Sources: Based on data from SIWRR¹⁰ (saline intrusion) and JAXA EORC 2018 (land use).

FIGURE 3.12C >>

Agricultural production in the Mekong Delta

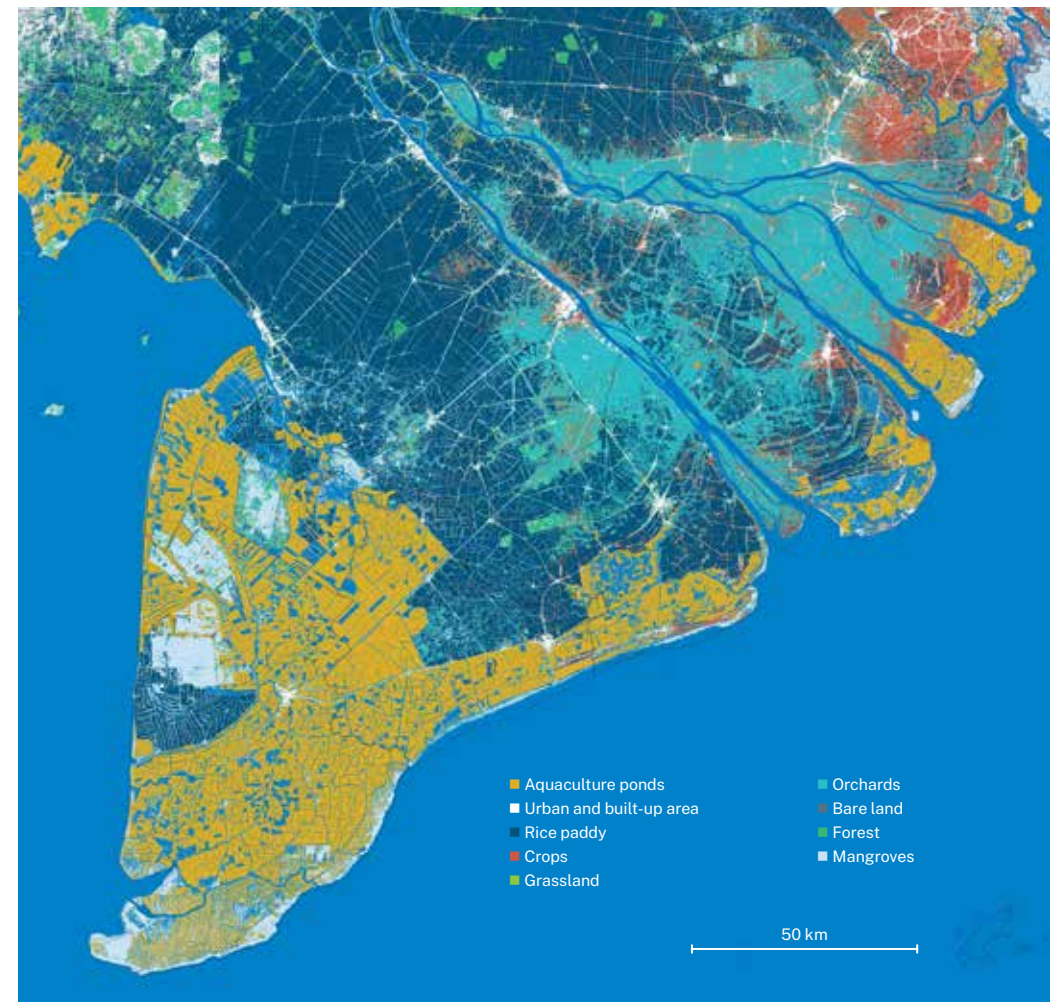


FIGURE 3.13 >>

Satellite imagery allows the systematic mapping of aquaculture ponds to enable risk assessments

Left: Location of aquaculture ponds in the Red River Delta. Right: Location of aquaculture ponds in the Mekong Delta



Sources: Based on data from Ottinger et al. 2018 (Red River Delta aquaculture ponds data) and SIWRR[®] (Mekong River Delta aquaculture ponds data).

3.2 >>

Aquaculture production is a key growth sector that is concentrated in high-risk coastal regions

Fisheries: the basis for many livelihoods and an important export sector.

The aquaculture and capture fisheries sectors have been vital for Vietnam's economic growth and development, accounting for 54 percent of production in coastal regions. In 2017, aquacultural production stood at 3.9 million tons derived from a total of 1.1 million hectares of production area and the output by capture fisheries more than doubled to reach 3.4 million tons.⁶

In 2017, the Mekong Delta Region's coastal and inland provinces produced 70 percent of all national aquaculture output and the Red River Delta produced 16 percent.⁶ A substantial share of the sector's activity is exposed to serious natural hazards, especially coastal flooding.

In the coming decades, the fisheries sector is expected to continue growing. With a target of generating \$8–9 billion a year — or about 5 percent of agricultural GDP — by 2020, production was set to reach 6.5–7 million tons in 2020, with aquaculture contributing 65 percent and creating jobs for five million people (MARD 2015). Considering this growth and the role it plays in coastal job creation, safeguarding aquaculture against natural shocks will be crucial for its continued development.

Rapid expansion of aquaculture and fisheries has threatened mangrove systems and resulted in sustainability challenges.

As a result of the rapid expansion of the aquaculture sector, mangrove forests have been cleared to create space for new production areas, increasing coastal risks and undermining the reputation of the country's seafood products. Overfishing in coastal waters, poor enforcement of zoning regulations, and a lack of consistent monitoring of natural fish stocks and mangrove systems aggravates such challenges (Chapter 9).

Recognizing these challenges, Vietnam has set clear sustainability goals in its National Fisheries Development Strategy to 2020 and Socioeconomic Development Strategy 2021–2030. Both aim to develop the fishery sector as the country's leading commodity sector by focusing on high value-added growth and sustainable development. However, the issues identified above increase the gap between stated goals and the current environmental situation (Thi et al. 2017).

The aquaculture sector is highly exposed to weather variability and natural shocks.

Because aquaculture production is highly dependent on the availability of clean water sources, climate shocks — like reduced rainfall and drought associated with ENSO — can have a substantial impact on aquaculture production. Upstream droughts affect salinity levels of freshwater sources. Simulations estimate that, in 2016, El Niño led to

a 2.6 percent decrease in aquaculture production (Sutton et al. 2019).

More severe weather events also regularly destroy essential productive assets in Vietnam's fisheries and aquaculture industries. Flooding can damage boats and fishing gear, wash away ponds and cages, destroy hatcheries and feed stores, and impair infrastructure such as harbors, jetties, processing plants, as well as storage and transport equipment (FAO 2018). The magnitude of these impacts becomes evident in historical government damage data related to natural disasters (figure 3.14).

Flooding is a serious and growing risk to the aquaculture sector, especially in the delta regions.

Flooding in the Red River and Mekong Deltas is a major threat to aquaculture farming. Using satellite data covering 86 percent of Vietnam's aquaculture sector, the analysis conducted for this reports finds that a significant part of the aquaculture ponds in both these areas are exposed to flooding. For example, figure 3.15 presents a zoom in to the Red River and Mekong Deltas' aquaculture ponds during hypothetical 1-in-500-year riverine flood events.

Figure 3.16 summarizes the flood exposure of aquaculture production in the two large river deltas' coastal provinces. Although both areas would be severely affected by coastal flooding, the Red River Delta's protection system would defend ponds from less severe riverine floods (up to 100-year return periods). However, these defenses

FIGURE 3.14 >>

Natural hazards cause frequent and substantial losses to the fisheries and aquaculture sector

Government-reported damages to fish farming area, aquatic products, and boats, due to natural shocks

Source: Based on data from VNDMA.³

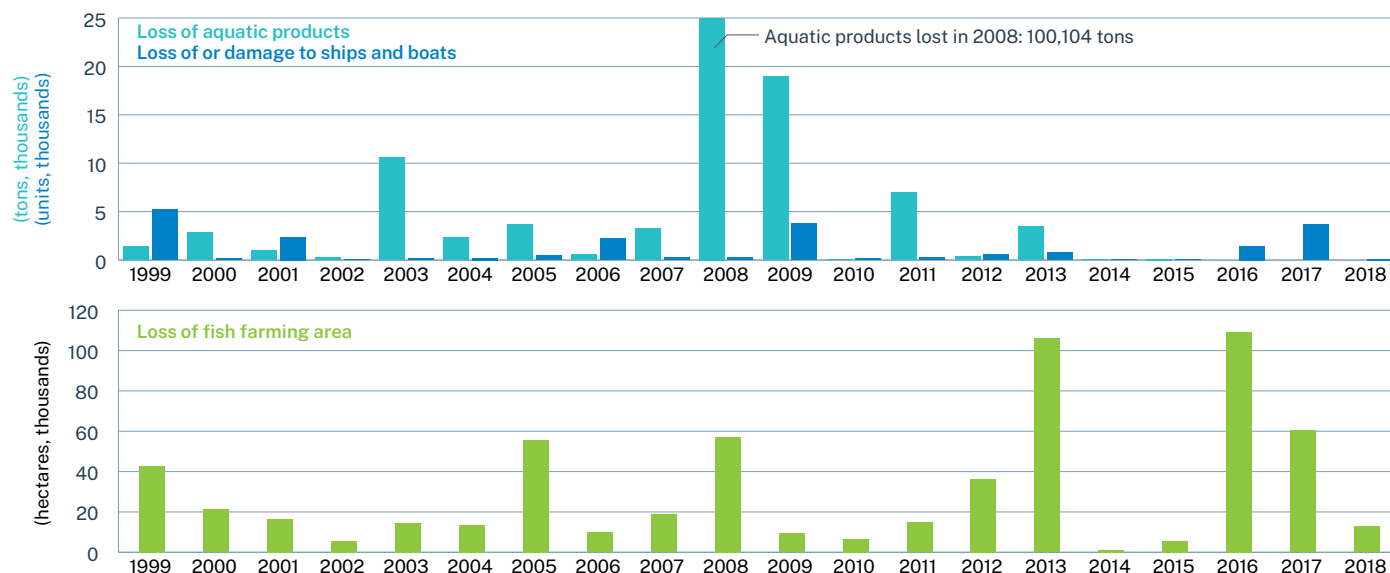
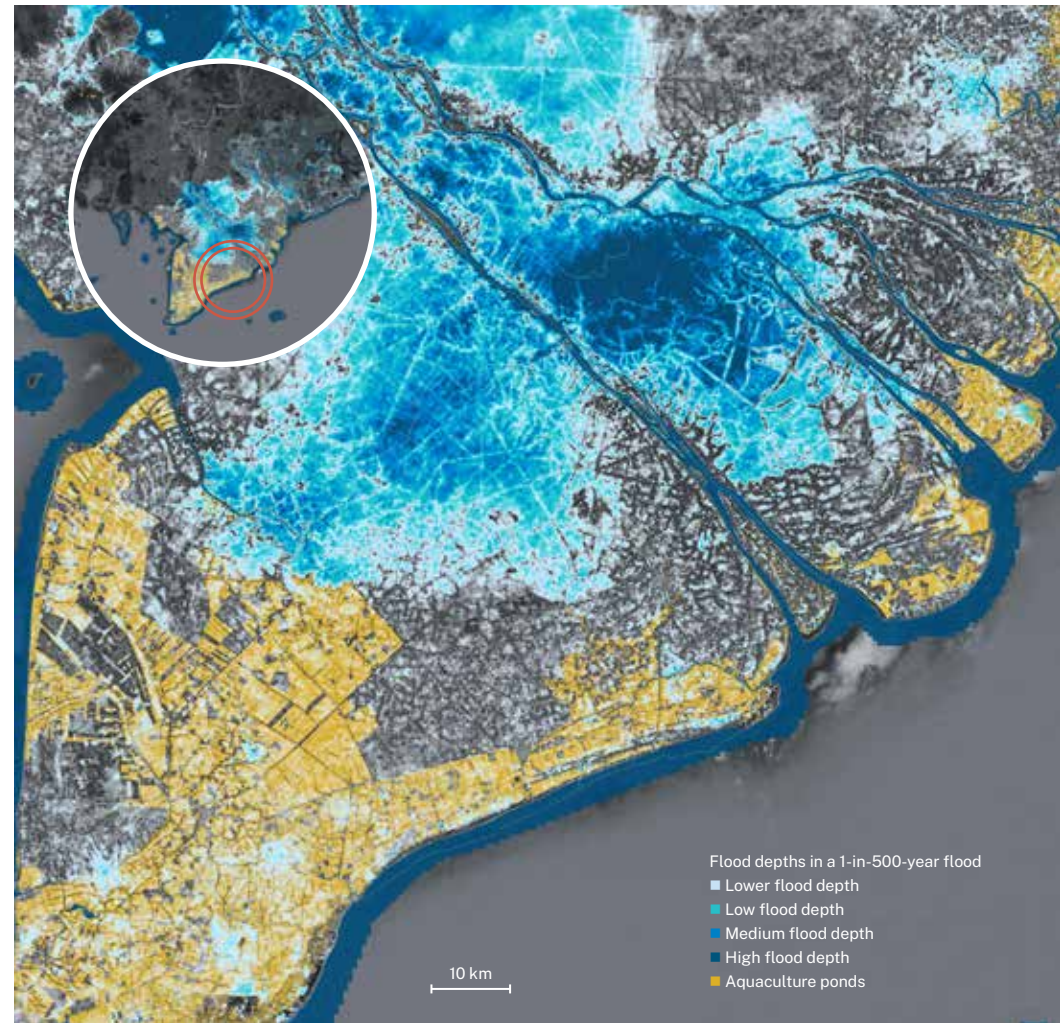
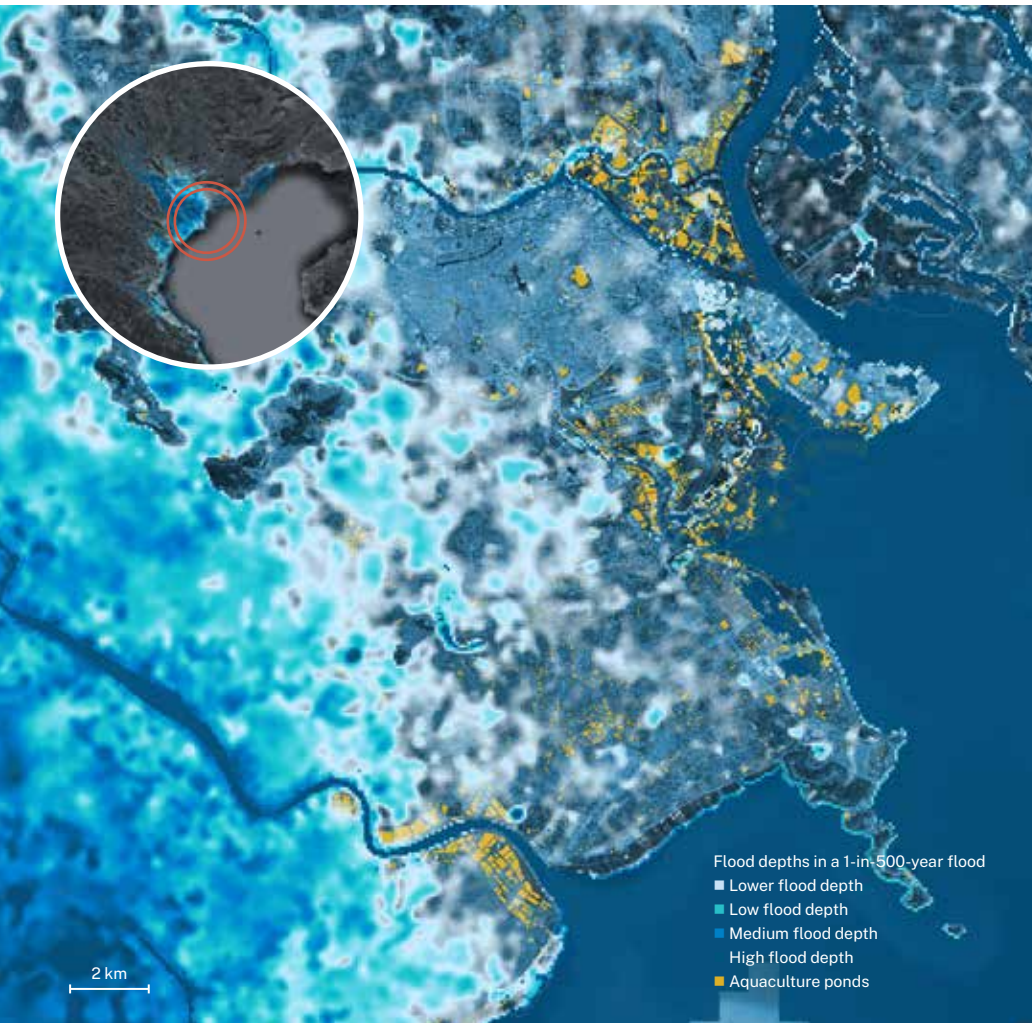


FIGURE 3.15 >>

Almost all aquaculture ponds in the Red River and Mekong Deltas are exposed to 1-in-500-year riverine floods

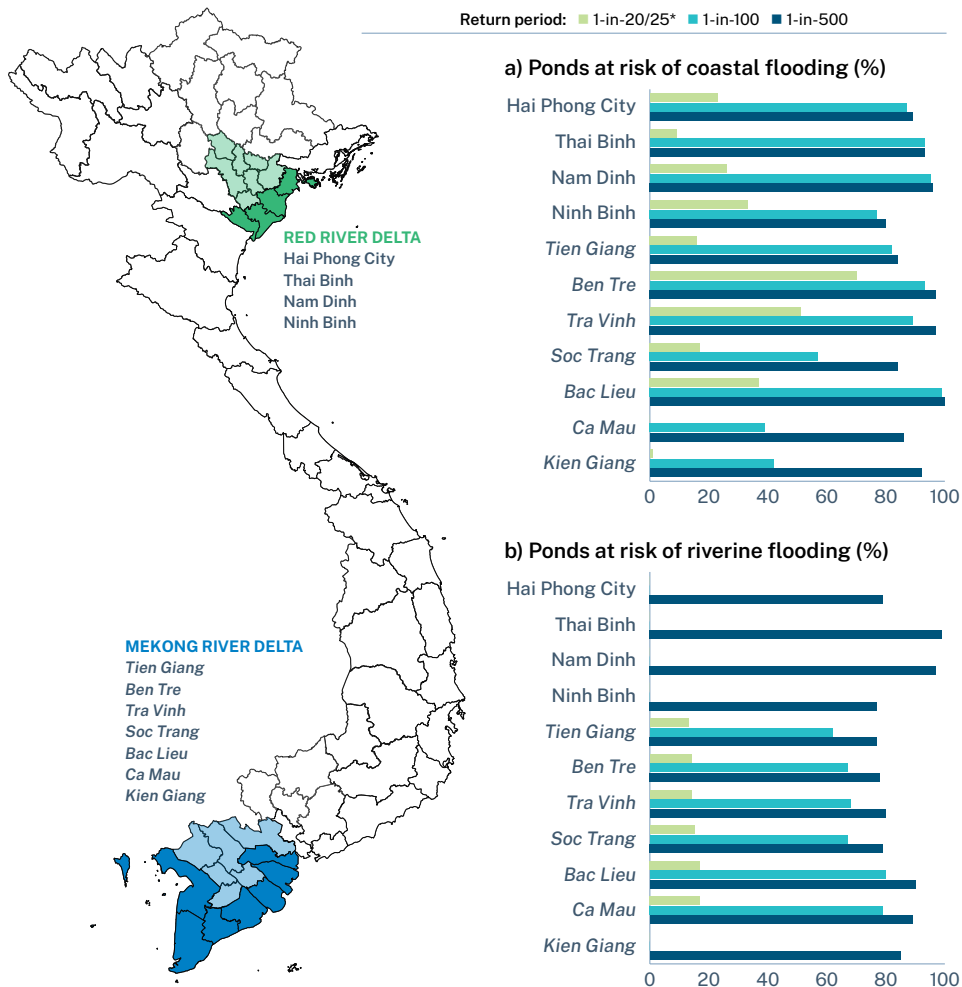
Left: Aquaculture and riverine flooding in the Red River Delta. Right: Aquaculture and riverine flooding in the Mekong Delta



Sources: Based on data from SWIRR¹⁰ (Mekong River Delta aquaculture ponds data), Ottinger et al. 2018 (Red River Delta aquaculture ponds data) and Fathom (flood data).²

FIGURE 3.16 >>

Aquaculture is severely threatened by coastal flooding but the protection system means the risk of river flooding is lower



Sources: Based on data from JAXA EORC 2018 (land use maps), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).² Note: *For coastal flooding, a 25-year return period has been used; for riverine flooding, a 20-year return period. Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

would not withstand larger (1-in-500-year) floods. Coastal flooding with a 100-year return period is estimated to threaten around 62 percent of aquaculture pond area in both deltas. Riverine flooding would put about 65 percent of aquaculture production in the Mekong River Delta at risk, but only 10 percent in the Red River Delta.

Flooding in the deltas could have significant economic implications. Vietnam's aquaculture sector is at risk of large losses from flooding, driven by coastal flooding and losses in the Mekong River Delta. A 1-in-100-year flood in the coastal provinces of both deltas would put 1.1 million tons of aquaculture production at risk. That corresponds to \$935 million in exports, 4 percent of agricultural GDP, and 1.5 million workers (figures 3.17 and 3.18).¹¹ Almost 80 percent of this at-risk production is in the Mekong River Delta's coastal provinces. Riverine flooding losses are estimated at 940,000 tons and \$706 million in exports and would affect 716,000 workers. Loss estimates for riverine flooding are comparably smaller than coastal floods, as Red River Delta's protection system can withstand less severe floods. For more extreme flood events, estimated losses are higher (figures 3.17 and 3.18).⁸

Rising sea levels are likely to hit aquaculture production.

Several models suggest that Vietnam's fish stocks could be significantly reduced by climate change, though there is considerable uncertainty about these estimates. Global

catch potential variability predictions range between 10 percent variation by 2050 (Barange et al. 2014) and 30–70 percent increase in high-latitude regions and 40 percent decrease in the tropics (Cheung et al. 2010). Such divergence can be attributed to the complex task of modeling the impacts of greenhouse gas emissions on ocean properties, and consequently living marine resources. Still, the possibility of significant declines in catch potential should inform future economic planning.

Aquaculture production is also likely to be affected by climate change. In a model of aquaculture vulnerability based on a series of indicators, Vietnam emerged as one of the five most vulnerable countries for aquaculture production in freshwater, brackish water, and marine environments (FAO 2018). In a one-meter sea level rise scenario, the country is estimated to lose over 8,500 square kilometers or about 65 percent of its freshwater wetlands (Blankespoor et al. 2014).

According to the sea level rise scenarios adopted by MONRE (box 3.1), a worst-case climate change scenario (RCP 8.5) could increase the share of aquaculture ponds at risk of flooding in the Red River and Mekong Deltas by 6–10 percentage points (figure 3.19). Gradually increasing salinity will also pose a major obstacle to shrimp producers, with high costs for adaptation options such as pumping water to maintain pond volumes and salinity (World Bank and Ministry of Planning and Investment of Vietnam 2016).

FIGURE 3.17 >>

Estimated aquaculture losses from flooding are driven by coastal flood exposure in the Mekong Delta

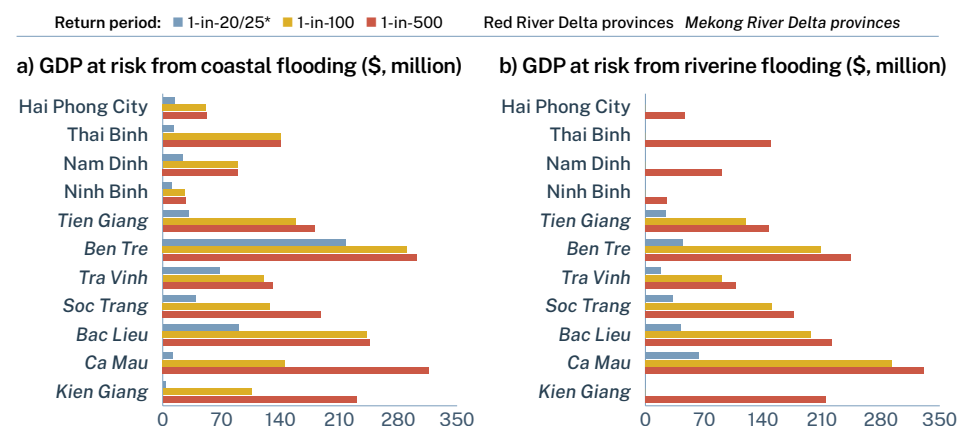
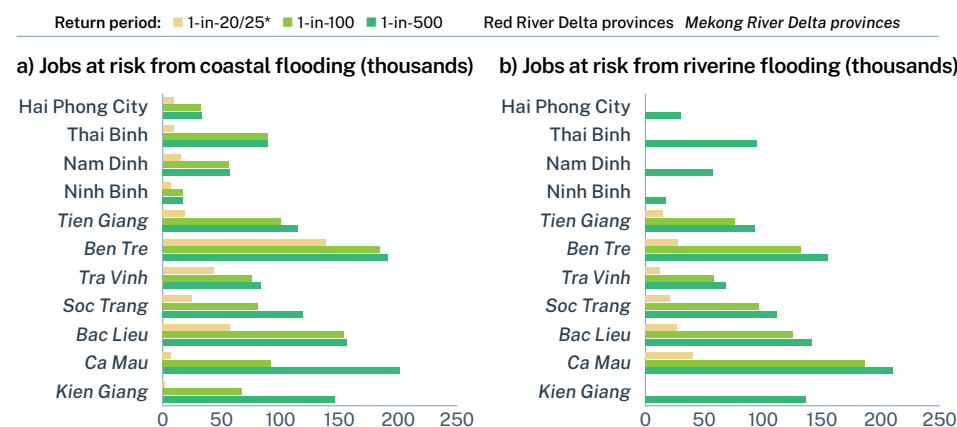


FIGURE 3.18 >>

Production losses translate into jobs at risk, which are significant in the Mekong and Red River Deltas

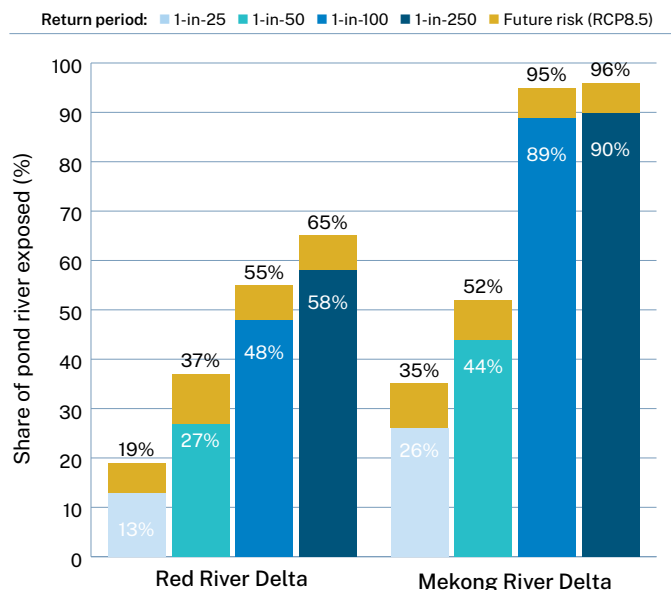


Source: Based on data from General Statistics Office of Vietnam.¹¹ Note: Calculations assume unchanged economy and do not consider losses from smaller, yearly recurring flood events. *For coastal flooding, a 25-year return period has been used; for riverine flooding, a 20-year return period.

FIGURE 3.19 >>

Sea level rise increases the share of ponds exposed to flood risk in the Red River and Mekong River Deltas

Sources: Based on data from Fathom (flood data)² and JAXA EORC 2018 (aquaculture ponds).



3.3 >>

Tourism is crucial to Vietnam's coastal economy, but subject to natural stressors

Vietnam's tourism sector is growing fast, and coastal regions are hotspots for visitors.

Between 2007 and 2017, the number of international visitors to Vietnam tripled to 12.9 million and domestic travelers quadrupled to 73.2 million.⁶ In 2017, tourism contributed \$10.3 billion (9.4 percent) to national GDP and provided direct employment for about 2.5 million workers (WTTC 2018).¹² As hotels and restaurants employ

many low-skilled and rural workers, the sector's growth disproportionately benefits people at the lower end of income distribution (Norman 2014).

This trend is set to continue, as Vietnam builds its reputation as a prime tourism destination. While the COVID-19 pandemic has caused a severe reduction of tourism in 2020, the sector could be well placed to meet the government's ambitious growth objectives up to 2030 (Political Bureau 2017).

Coastal regions are already crucial for Vietnam's booming tourism sector. From the world-famous Ha Long Bay in the north to the old port town of Hoi An in the center and the beaches of Nha Trang further south, natural beauty, diversity, rich history and culture span the whole coastline. Because tourism flows are not concentrated in one area, they can be well distributed to benefit all regions. Outside of Vietnam's two main metropolitan areas—Hanoi and Ho Chi Minh City—coastal provinces already account for around 45 percent of national tourism revenue (estimates based on WTTC 2018). But there is still major potential for growth, provided that natural risks and stresses are managed effectively (World Bank and Ministry of Planning and Investment of Vietnam 2016).

Tourism growth is putting stress on ecosystems and overloading local infrastructure.

The environmental impacts of this rapid growth in tourism are increasingly visible. In Ha Long Bay, for example, pollution from plastic waste and tourist boat emissions

NINH BINH >>

Tourists travel in small boat
along the Ngo Dong River.

iStock



pose a significant threat to local wildlife. In the Mekong Delta Region, booming river tourism has increased waste and pollution in the river basin, threatening local species, ecosystems, and local livelihoods. Unsustainable tourism activities reduce a region's attractiveness for visitors and can impact other sectors — such as agriculture and fishery — that rely on ecosystem services (Norman 2014).

Sustainable tourism growth also requires well-functioning transport, electric, water, and drainage and solid wastewater infrastructure. Rapid increases in visitor numbers can overwhelm systems designed for local populations. Exceeding their capacity threatens the natural environment, local communities, and the future of tourism (Norman 2014). This risk is particularly pronounced for secondary tourism destinations: small coastal towns in the central regions where tourism has been limited in the past that may experience a rapid increase in visitor numbers beyond their capacity.

Coastal erosion is a serious threat to growth in the tourism sector.

Outside Hanoi and Ho Chi Minh City, beach recreation is one of the main attractions for domestic and international tourists. While cultural and economic hubs tend to have a diverse range of touristic assets, in many secondary

coastal towns, intact beaches and natural ecosystems form the main element of their touristic offering. But many of these beaches are threatened by rapid coastal erosion, which has a wide range of natural and artificial causes.

Coastal erosion is affecting towns' ability to continue to attract tourists and thus the viability of local tourism industries. This report generated and analyzed a dataset of coastal hotels in Vietnam to systematically quantify this risk. Figure 3.20 shows the location of the 5,658 hotels in the dataset — around one-fifth of the country's tourist accommodation.¹³ Of these, 27 percent are within five kilometers of the coast.¹⁴

The analysis shows that coastal hotels in Vietnam are highly exposed to coastline changes. Studying satellite imagery to track coastline change from 1988–2015 for the Mekong Delta and 1990–2015 for the rest of the country, the analysis evaluated erosion at the nearest coastline segment for each hotel located within 5 kilometers of the coast.⁵ Almost one-fifth had experienced more than 20 meters of coastal erosion; for more than one-fifth, the nearby coastline had been affected by accretion (sediment build-up) of more than 20 meters (figure 3.21).

When considering erosion levels per province (figure 3.22), those in the North Central Coast and Southeast Regions

75% » Coastal hotels in Quang Nam and Khanh Hoa that experience strong to moderate erosion of their beaches.

FIGURE 3.20 >>

Coastal hotels in Nha Trang are concentrated where the beach has experienced strong erosion

Left: Hotel locations in Vietnam. Right: Hotel locations and coastal sediment changes in Nha Trang between 1990 and 2015



Sources: Based on data from OpenStreetMap (hotel locations),¹⁴ Deltares et al. 2017 and VNDMA (erosion data).³ *Disclaimer:* The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE 3.21 >>

Coastal hotels in Vietnam are highly exposed to sediment changes

Share of hotels within 5 kilometers of the coast experiencing coastal sediment changes

Sources: Based on data from OpenStreetMap (hotel locations),¹⁴ Deltares et al. 2017 and VNDMA (erosion data).³

Note: Sediment changes were evaluated at the section of coastline closest to each hotel.

Photo: iStock



are estimated to have the most hotels exposed to erosion. Assuming that tourism revenue is strongly related to beach quality, observed levels of erosion are affecting about 22 percent of tourism’s contribution to GDP, or approximately \$3.6 billion per year. Current erosion levels affect 23 percent of employees directly working in tourism, or 556,000 jobs in total.

Many hotels are vulnerable to flooding, posing a threat to the economic contribution of tourism.

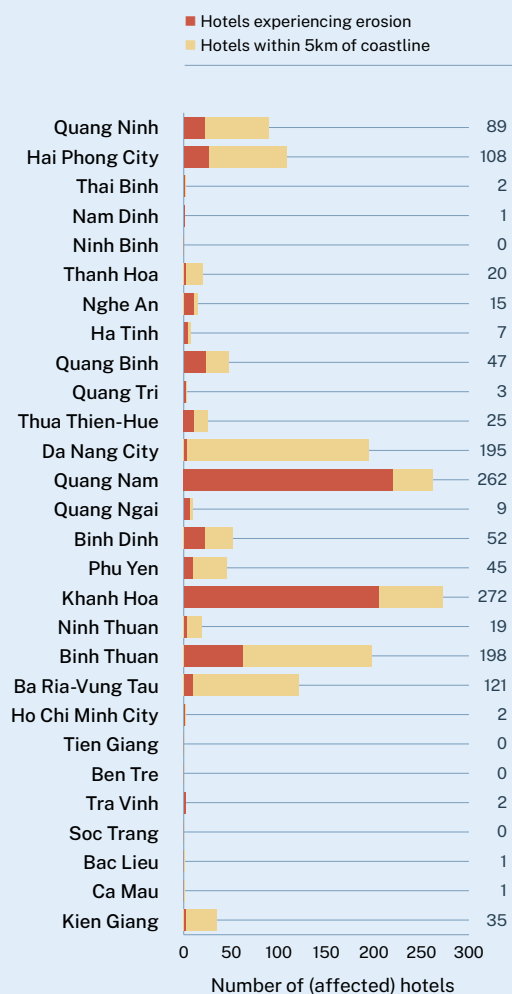
While erosion has an indirect effect on the tourism industry by reducing the Vietnamese coast’s attractiveness to tourists, flooding can destroy natural and cultural heritage

sites that attract tourists and cause direct physical damage to accommodation facilities (figure 3.23). Hotels are particularly exposed to flooding, as 46 percent of all examined hotels in coastal provinces are within 5 kilometers of the coast. Estimates from our analysis suggest that 1,727 hotels—almost one-third of the dataset—are exposed to riverine flooding with a 100-year return period. Similarly, 937 hotels are directly exposed to the threat of coastal flooding with the same return period.⁸

Alongside the physical threat floods pose to accommodation facilities, they can have a catastrophic effect across the sector, reducing the influx of tourists, which would lead to a drop in hotel revenue and occupancy

FIGURE 3.22 >>

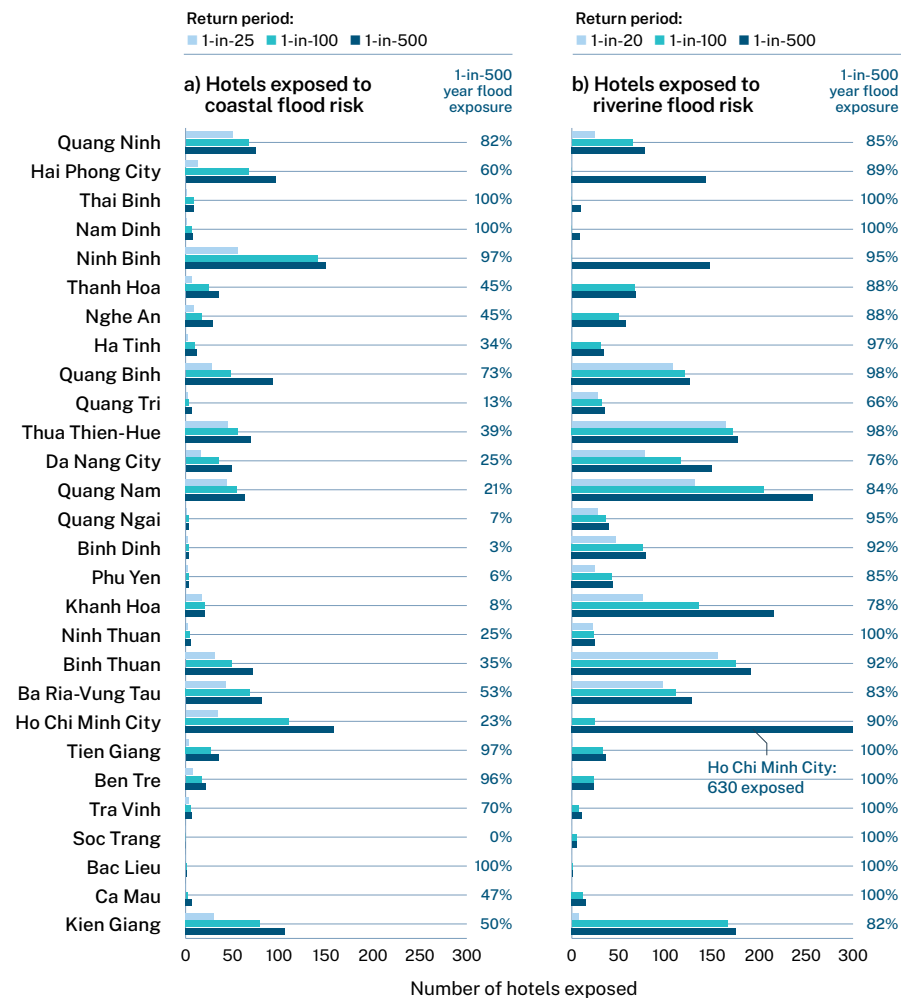
Many of Vietnam's coastal hotels are exposed to erosion



Sources: Based on data from OpenStreetMap (hotel locations),¹⁴ Deltares et al. 2017 and VNDMA (erosion data).³ Note: Data callouts reflect the total number of hotels contained in this dataset that lie within 5 kilometers of the coastline. Sediment changes were evaluated at the piece of coastline closest to each hotel.

FIGURE 3.23 >>

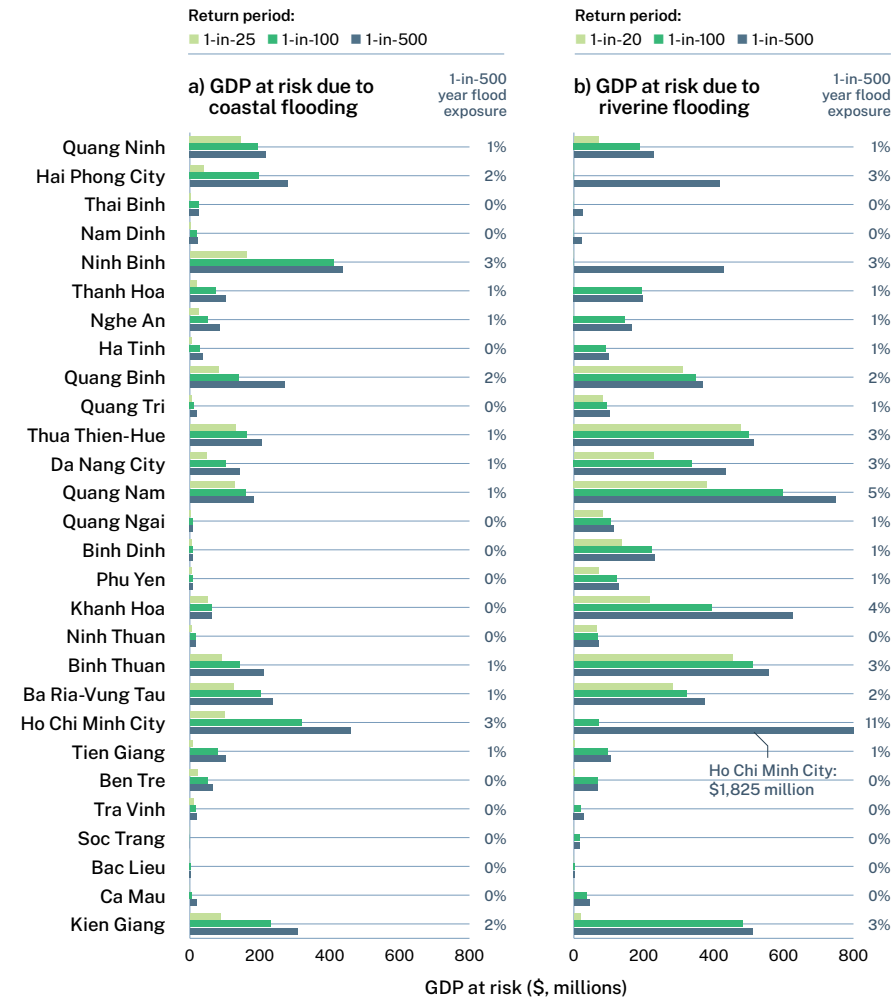
Many coastal hotels are exposed to coastal and riverine flood hazards



Sources: Based on data from OpenStreetMap (hotel locations),¹⁴ Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).² Note: Shown percentages are share of total provincial hotels threatened by a 1-in-500-year flood.

FIGURE 3.24 >>

Impact of coastal and riverine floods on the tourism sector



Sources: Based on data from OpenStreetMap (hotel locations),¹⁴ Braese et al. 2020 (coastal flood data), Fathom (riverine flood data),² World Bank¹ and WTTC (economic indicators).¹² Note: Shown percentages are share of national tourism GDP threatened in case of a 1-in-500-year flood. Calculations assume unchanged economy and do not consider losses from smaller, yearly recurring flood events.

and tourism-related retail sales. Although it is difficult to quantify the economic extent of these impacts, it is possible to speak of threatened tourism GDP and jobs as the negative effects of flooding ripple through the sector.

By interpreting the share of exposed hotels as a proxy for the tourism sector's overall exposure, it is possible to estimate the order of magnitude of risks. Around 3 percent of national GDP (\$5 billion) and 753,000 workers who are directly employed in the tourism sector are estimated to be exposed to 1-in-100-year riverine flooding. Coastal flooding of the same intensity would cause half the economic exposure (\$2.7 billion, 1.6 percent of national GDP and 409,000 workers). This is mainly because a large share of the hotels are in the central coastal provinces (60 percent of all hotels between Nghe An and Nihn Thuan Provinces), which are most severely threatened by riverine flooding (Figure 3.23).⁸

3.4 >>

Industrial activity is increasing in exposed coastal regions

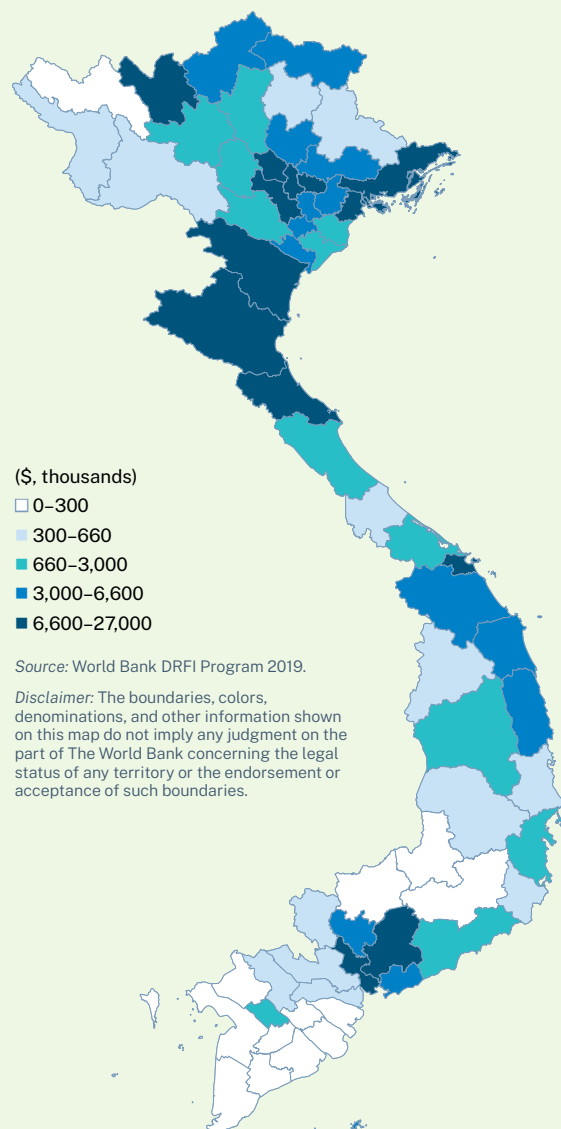
The coastline is an important hotspot of industrial activity.

Industry is an increasingly important part of Vietnam's economy. In 2016, the industry and construction sector accounted for one-third of GDP (General Statistics Office of Vietnam 2018). In the same year, 325 industrial zones — designated areas where multiple industrial firms

FIGURE 3.25 >>

Industrial asset losses are especially large in the central coast and the two main metropolitan areas

Annual average loss of industrial assets to flooding, typhoons, and earthquakes, by province



are located—have hosted \$110 billion in cumulative foreign direct investment flows, generating \$100 billion in export revenues, and creating some 2.9 million jobs (ASEAN Secretariat and UNCTAD 2017). If recent growth continues, the sector will contribute 40 percent of GDP by 2030, in line with government industrial development goals. Acknowledging the threat of natural disasters to the country's industrial assets, the goals also call for industrial development strategies to incorporate natural disaster prevention (Vietnam News Agency 2018).

While most firms are based in Hanoi and Ho Chi Minh City, the whole coastline has become a hotspot for industrial activity. The number of firms has grown in almost all regions over the past decade. Outside of the metropolitan areas, the highest growth rates are observed in the North Central Coast Region (World Bank 2020). For firms, coastal locations offer clear advantages: the proximity to freight ports offer access to international markets and value chains, the coastal population offers a strong labor force, and proximity to other firms has virtuous network effects that increase productivity and supply chain efficiency.

Natural hazards have major costs in terms of industrial assets exposed.

A catastrophe risk model by the World Bank's Disaster Risk Finance and Insurance (DRFI) Program offers an idea of the large exposure of Vietnam's industry to natural hazards. Average annual losses to industrial assets amount to approximately \$264 million. With industrial assets representing 18 percent of national direct asset losses

but only 12 percent of overall assets, the sector seems disproportionately exposed. Losses on the central coast and in the two main metropolitan areas are especially significant, as shown in figure 3.25 (World Bank DRFI Program 2019).

Flood risk is significant in many industrial zones.

The country's industrial zones are particularly important for industrial development and attracting foreign direct investment. Being close together has several advantages for firms, including shared benefits from investments in high-quality infrastructure or knowledge spillovers. For example, Ba Ria-Vung Tau Province has 15 industrial zones, covering 8,510 hectares in total, that have attracted

294 projects with combined registered capital of \$14.7 billion (Ministry of Planning and Investment Vietnam 2017). The firms in the industrial zones create jobs for people from surrounding areas and are important hotspots of socioeconomic activity.

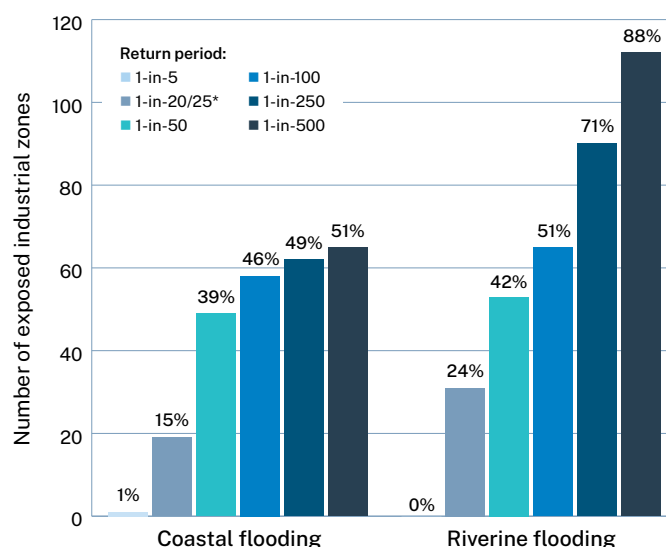
An analysis of 372 countrywide industrial zones revealed that 127 (34 percent) are in coastal provinces. Figure 3.26 shows that the risk of flooding in these areas is significant. About half of all industrial zones in coastal provinces are directly exposed to the threat of 1-in-100-year coastal or riverine flooding and about 88 percent are exposed to 1-in-500-year riverine flooding. The delta provinces are most at risk of coastal flooding, whereas central coastal provinces are also threatened by riverine flooding.

FIGURE 3.26 >>
Industrial zones in coastal provinces are heavily exposed to flood risks

Share of industrial zones in coastal provinces exposed to coastal flooding (left) and riverine flooding (right) of various return periods.

Sources: Based on data from World Bank 2020 (industrial zone locations), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).⁵

*Note: *Riverine: 1-in-20-year flood; coastal: 1-in-25-year flood*



Disaggregating the analysis to coastal provinces shows that industrial zones in almost all of these provinces are at risk of flooding. Those in the delta provinces are most exposed to coastal flooding, and those in the central provinces, to riverine flooding. The Red River Delta's riverine protection system protects industrial zones against floods up to a 100-year return period, but cannot withstand stronger floods (figure 3.27).

When industrial zones are affected by flooding, the consequences are real—not just because assets are destroyed, but because livelihoods and jobs are affected. For example, the analysis conducted for this report suggests that a 1-in-100-year riverine flood in Ba Ria-Vung Tau Province could threaten about \$280 million dollars' worth of infrastructure in 9 out of 14 industrial zones,¹⁵

putting industrial goods production, services, investments, and some 34,000 jobs at risk. A coastal flood of same intensity, on the other hand, would threaten \$62 million in infrastructure and 8,000 jobs in the same in province.⁸

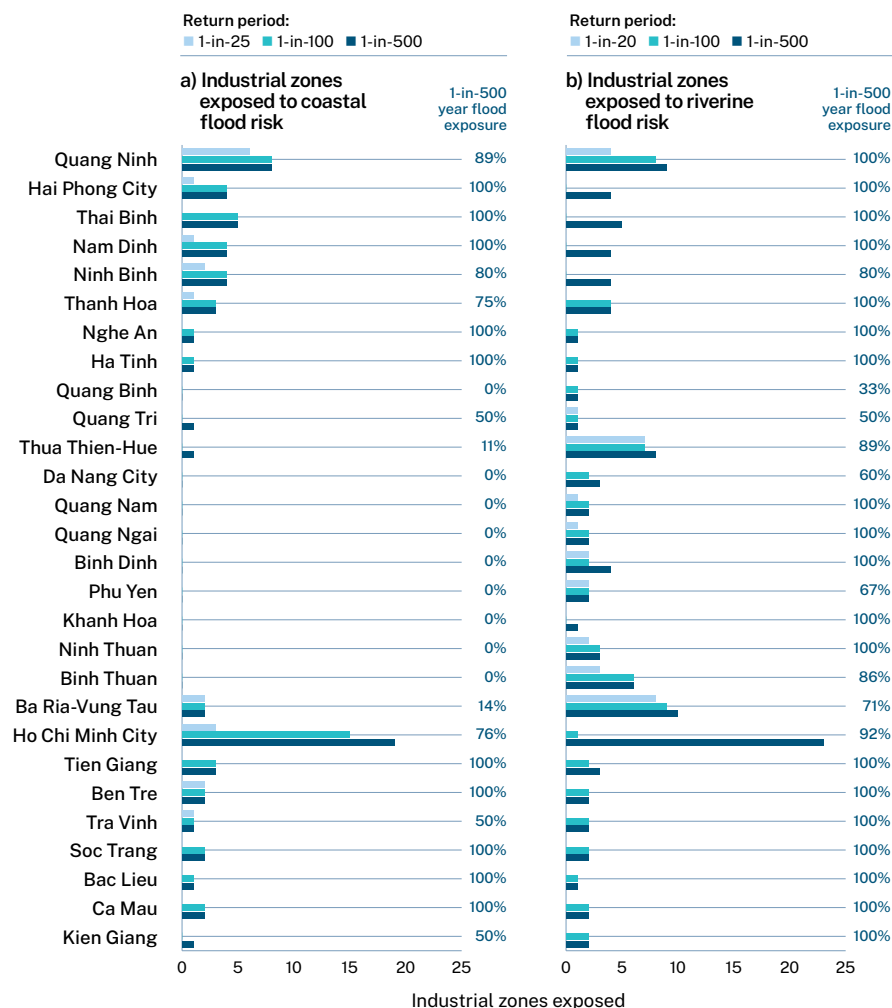
Overall, the level of exposure of Vietnam's coastal economy—both in terms of production value and jobs at risk—highlights why risk mitigation and management measures will be so essential for safeguarding continued development. Part 3 provides concrete recommendations for how risk-informed spatial and sectoral planning policies can contribute to the resilience of coastal communities and their livelihoods.

Endnotes

1. Information from World Bank Open Data, <https://data.worldbank.org/>
2. Information from Fathom Global, <https://tinyurl.com/sfzgo7z>
3. Based on historical damage data for 1999–2018 provided by the Vietnam National Disaster Management Authority (VNDMA).
4. Crops refer to all lands covered by temporary crops, which expose bare soils after a harvest. Orchards describe land with trees or shrubs that are maintained for several years for food production.
5. For a more detailed explanation of the data sources and analytical methodology used in this report, see the technical background paper to this report by Braese et al. (2020).
6. Information retrieved from General Statistics Office of Vietnam, <https://tinyurl.com/tq3s66s>
7. This analysis only covers crops, rice paddy and orchards. Although these crops constitute most cultivated crops, they do not cover the entire cultivated crops sector.
8. Detailed results for different agricultural sub-sectors, provinces, flooding types and hazard intensities (5, 20/25, 50, 200 and 500-year return periods) are provided in the technical annex to this report (De Vries Robbé et al. 2020).

FIGURE 3.27 >>

Industrial zones in the Red River and Mekong Deltas are most exposed to coastal flooding



Sources: Based on data from World Bank 2020, Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).²
Note: Shown percentages are the share of industrial zones threatened by a 1-in-500-year flood.

9. RCP8.5 (strong climate change scenario) assumes an increase of greenhouse gas emissions to reach radiative forcing of 8.5 watts/m² in 2100, continuously increasing to 13 watts/m² by 2200 and stabilizing thereafter. RCP4.5 (moderate climate change scenario) is a scenario in which radiative forcing is stabilized shortly after 2100.
10. Data on aquaculture ponds and saline intrusion in the Mekong River Delta where obtained from Southern Institute of Water Resources Research (SWIRR) in Hanoi, Vietnam.
11. Estimates are based on 2017 data from the General Statistics Office of Vietnam, <https://tinyurl.com/tq3s66s>
12. The World Travel & Tourism Council (WTTC) estimate includes direct contributions — from economic activity generated by hotels, travel agents, airlines and other passenger transportation services (excluding commuter services) — and indirect contributions, which include wider effects from investment, supply chain and induced-income impacts. Direct contributions alone are estimated at 5.9 percent of GDP.
13. Information from Vietnam National Administration of Tourism, Tourist accommodation establishments (2000–2018), retrieved from <https://tinyurl.com/y7sn22eh> on November 19, 2019.
14. Information retrieved from OpenStreetMap on November 19, 2019.
15. The dataset used only included 14 of the province's 15 industrial zones.

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Natural hazards threaten essential public services

Health care and education systems are essential public services that support the quality of life and prosperity of communities. Having achieved universal primary education and working towards achieving universal secondary education and health coverage, Vietnam has made significant progress in providing these services. However, this progress is being threatened by natural hazards, especially in coastal areas. As well as posing direct physical threats to health care facilities, natural hazards can indirectly obstruct health care provision and emergency services by disrupting roads or electricity supply, hindering access and the ability to operate. Estimates for this report show that 26 to 50 percent of all health care facilities in coastal provinces could be exposed to intense flood risk (figure 4.1). Similarly, when schools are affected by shocks, it is not only their ability to fulfill their critical functions for providing education that suffers. Damaged facilities or disrupted access to schools also affect their function as typhoon shelters and the provision of nutrition to students who rely on school feeding programs. This section further examines how natural hazards pose a risk to the health care and education provision in Vietnam's coastal areas.

4.1 >>

Health care facilities are exposed to the risk of flooding

Despite progress in the Vietnamese health care system, challenges remain.

The scope and quality of health care provision in Vietnam have improved markedly in the last decades. Between 1990 and 2017, maternal mortality fell from 139 to 43 deaths per 100,000 live births, and infant mortality dropped from 44 to 17 deaths per 1,000 live births. Life

expectancy has increased from 70.8 years in 1990 to 75.3 years in 2018.²

The government has set a target to achieve universal health coverage by 2035. Currently at 87 percent of the population, it is already higher than the regional average (Cao et al. 2016; World Bank³). In tandem with these achievements, combined public and private health spending is higher than almost any other developing country, at 6 percent of GDP in 2013. Nevertheless, in 2015, people still paid for 49 percent of total health expenditures out of their own pocket, pushing many into poverty (Cao et al. 2016). In addition, Vietnam's cumbersome household registration system, *Ho khai*—

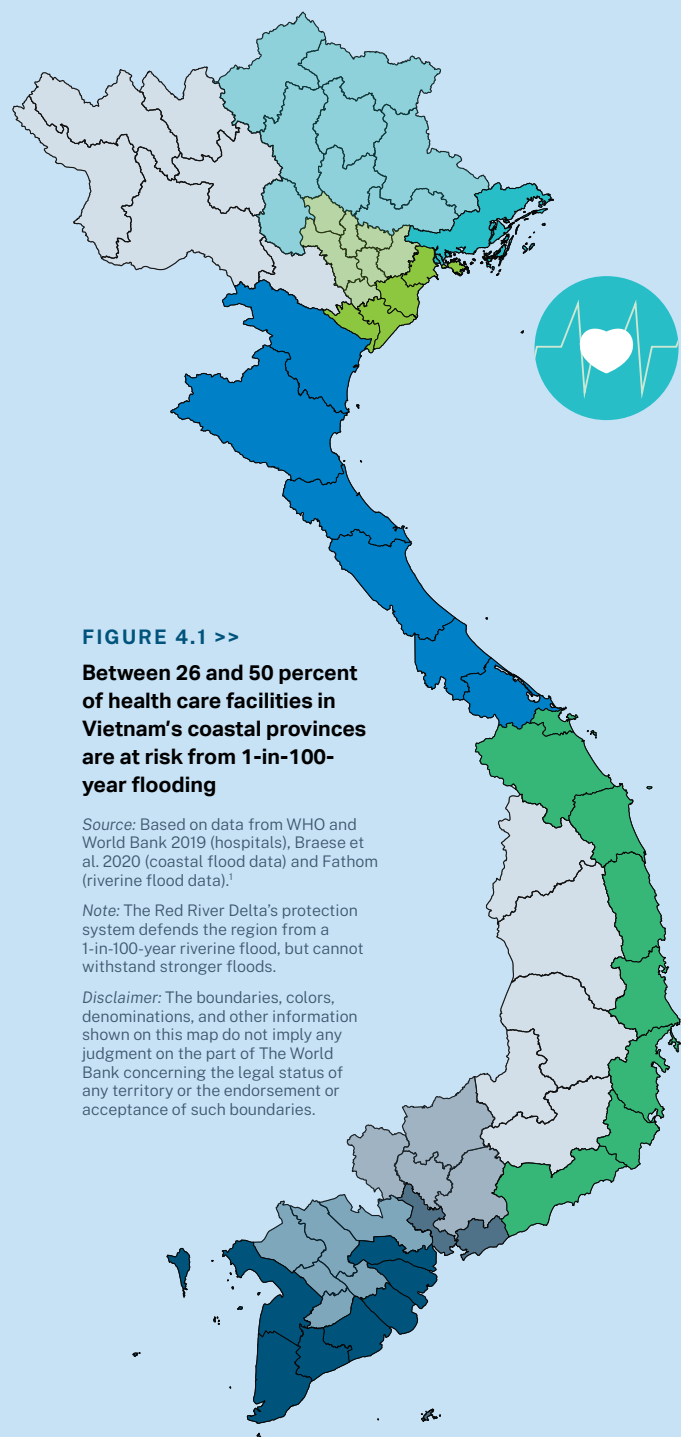


FIGURE 4.1 >>

Between 26 and 50 percent of health care facilities in Vietnam's coastal provinces are at risk from 1-in-100-year flooding

Source: Based on data from WHO and World Bank 2019 (hospitals), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).¹

Note: The Red River Delta's protection system defends the region from a 1-in-100-year riverine flood, but cannot withstand stronger floods.

Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Health care facilities exposed to flood risk with a 100-year return period

Province	Coastal flood risk		Riverine flood risk	
	Number	Share of total	Number	Share of total
NORTHEAST				
Quang Ninh	0	0%	20	77%
RED RIVER DELTA				
Hai Phong City	34	64%	0	0%
Thai Binh	26	96%	0	0%
Nam Dinh	17	85%	0	0%
Ninh Binh	12	60%	0	0%
NORTH CENTRAL COAST				
Thanh Hoa	14	22%	51	78%
Nghe An	6	15%	29	71%
Ha Tinh	9	30%	22	73%
Quang Binh	6	32%	14	74%
Quang Tri	3	20%	12	80%
Thua Thien-Hue	2	10%	16	76%
SOUTH CENTRAL COAST				
Da Nang City	0	0%	6	26%
Quang Nam	0	0%	21	75%
Quang Ngai	0	0%	15	71%
Binh Dinh	1	5%	14	64%
Phu Yen	1	6%	4	25%
Khanh Hoa	4	18%	12	55%
Ninh Thuan	1	7%	9	60%
Binh Thuan	0	0%	12	67%
SOUTHEAST				
Ba Ria-Vung Tau	1	8%	9	69%
Ho Chi Minh City	15	15%	2	2%
MEKONG RIVER DELTA				
Tien Giang	8	38%	15	71%
Ben Tre	9	45%	16	80%
Tra Vinh	5	24%	18	86%
Soc Trang	3	17%	16	89%
Bac Lieu	11	69%	14	88%
Ca Mau	6	29%	13	62%
Kien Giang	4	21%	16	84%
COASTAL VIETNAM				
	198	26%	376	50%

which dictates people's permanent place of residence and provides access to public services via this main address — limits access to public health care for at least 5 million people who lack a permanent address (Vietnam Academy of Social Sciences and World Bank 2016; Cao et al. 2016).

Health care facilities perform a crucial role in post-disaster response.

In the context of natural disasters, a strong health care system is essential, not only to help a society deal with small emergencies, but also to facilitate a response to larger events such as a typhoon, or to provide assistance to victims of pandemics such as COVID-19. In the aftermath of any severe physical shock, hospitals provide critical

emergency services. Their ability to do so depends on health care staff, who are responsible for operating the facility; intact facilities, including hospital buildings; essential infrastructure services such as water, power, and transportation; and the availability of (medical) equipment.

Natural shocks can disrupt the functioning of hospitals and health care facilities by affecting health care workers, who become unable to provide care. Infrastructure disruptions — common with large flood events — can severely hamper care provision when essential services such as water, power, medical supplies or the patients themselves cannot reach health care facilities. If hit by a shock, health care facilities can also become points of vulnerability, leaving communities without health care in the aftermath of a disaster and putting vulnerable existing patients — who might be less mobile and unable to evacuate — in danger.

While natural shocks or deadly disease outbreaks will continue to happen, a strong health system can allow Vietnam to better respond to these hazards, protecting its goal of universal health care and preventing disruption to the economy. Initiatives such as the Greater Mekong Sub-region Health Security Project — a cooperative project between the governments of Vietnam, Cambodia, Laos and Myanmar that aims to address weaknesses in the countries' health care systems to improve preparedness for infectious diseases and other health threats — can serve as examples of effective response to natural shocks.⁴

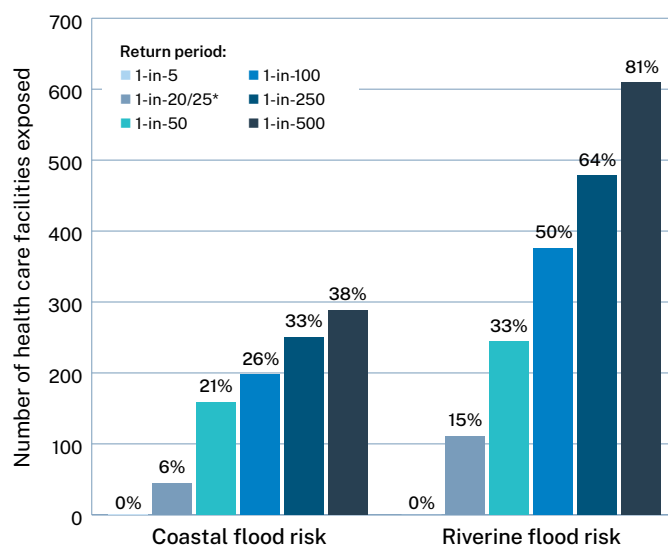
The threat of flooding poses a significant risk to health care facilities in all coastal provinces.

FIGURE 4.2 >>

Health care facilities exposed to riverine and coastal flooding in Vietnam's coastal provinces

Sources: Based on data from WHO and World Bank 2019 (hospitals), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).¹

Note: *Riverine flood risk: 1-in-20-year flood; coastal flood risk: 1-in-25-year flood



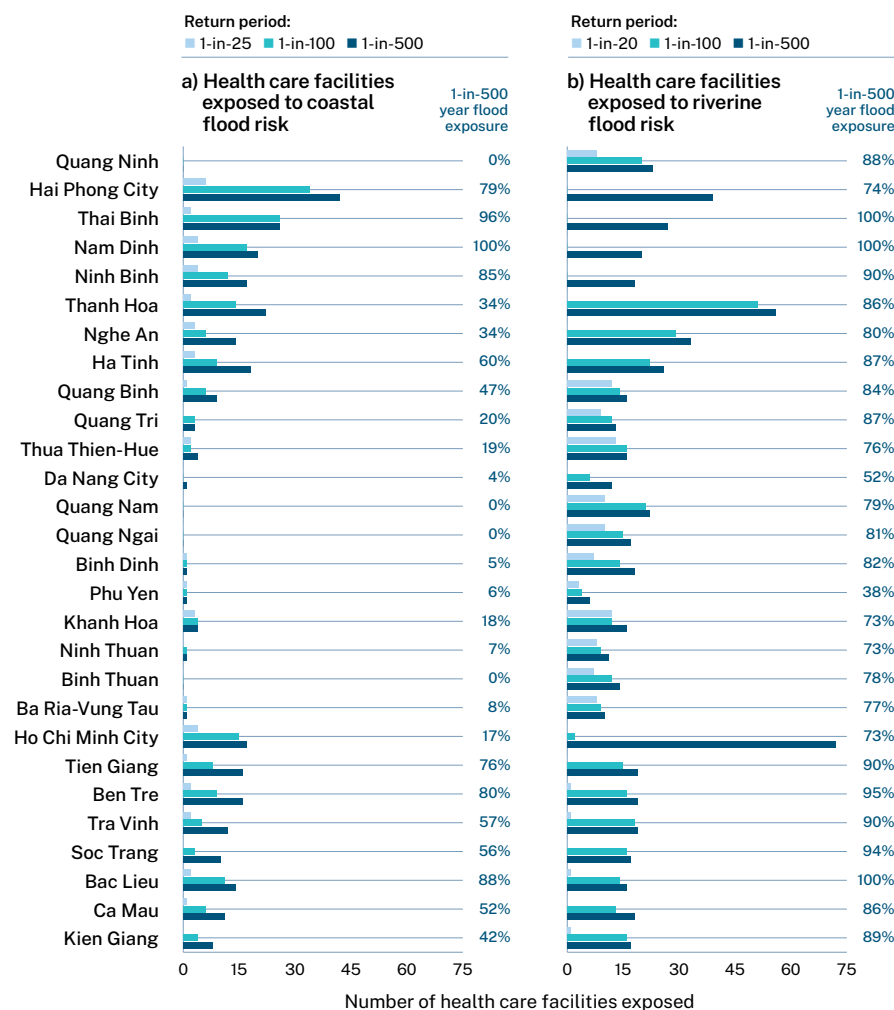
This report offers new estimates of the potential exposure of hospitals to flood risk, based on a dataset of 1,583 geocoded public hospitals and district health centers across Vietnam. Of these, 750 are in coastal provinces and represent 12 percent of all hospitals and medical service units in these provinces (WHO, World Bank and Government of Vietnam 2019).⁴ Estimates show that 26 percent of these facilities would be exposed to a 1-in-100-year coastal flood. This risk almost doubles to 50 percent for riverine flooding of the same return period, and further increases with the severity of flooding (figure 4.2).

In the Red River Delta, the risks from riverine flooding are less pronounced, as the existing protection system prevents health care facilities from flooding in events with up to a 100-year return period. However, as figure 4.3 shows, the system would be overwhelmed by more extreme flooding and the total number of health care facilities exposed increases dramatically for 1-in-500 year flood.⁶

These estimates offer a sense of the magnitude of the risks to which health care provision in coastal Vietnam is exposed. However, it is important to note that the analysis focuses only on the physical flood exposure of health care facilities. While this can act as a proxy for the overall risk to the health care system, it does not explicitly take into account the natural risks to health care supply chains, to medical staff, or to the transport systems that provide access to health care facilities. To ensure that they can endure shocks, case-by-case stress-testing of facilities will be essential to identify and manage different dimensions of risk (Chapter 13).

FIGURE 4.3 >>

Healthcare facilities in the two deltas are particularly exposed to coastal flooding



Sources: Based on data from WHO and World Bank 2019 (hospitals), Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).⁷ Note: Percentages shown are share of total health care facilities exposed by a flood with a 500-year return period.



HO CHI MINH CITY >>

The city's many schools are at risk from riverine flooding.

iStock

4.2 >>

Natural hazards threaten access to education

Over the past decades, Vietnam has made significant progress in providing universal access to quality education, achieving universal primary education from age five and working towards universal lower-secondary education (Patrinos et al. 2018). The socioeconomic development plan for 2016–2020 and socioeconomic strategy for 2021–2030 both seek to advance human capital development through higher education, vocational training and modernizing the education system to meet the country's industrialization demands. The government also aims to reorganize the schooling system to achieve a better balance between public and private schools and support disadvantaged groups (Government of Vietnam 2016 and 2020).

When natural shocks disrupt schools, the effects can be severe and long-lasting.

Natural hazards threaten education provision if schools become inaccessible or are damaged and forced to close. In 2019, coastal provinces like Thanh Hoa and Ca Mau reported that persistent rainfall forced school closures, and that school supplies, tables and chairs were swept away by flooding, impacting 1,100 students in Ca Mau alone. While buildings and equipment were being restored, education had to continue under improvised conditions in communal buildings or private homes.⁷ But even temporary

disruptions of education curricula during disasters can have long-term impacts on children's educational attainment and incomes (Rentschler 2013).

When schools are affected, there are other, immediate impacts that go beyond access to education. For students relying on school feeding programs, it can imply disruptions to their daily nutrition intake. Family welfare might also be affected as children—particularly girls—who are forced to stay home become subject to domestic violence, which may increase in the aftermath of disasters (Devries et al. 2013; Ellsberg et al. 2015). A pause in education may also mean that some vulnerable students never return to schooling, threatening the country's efforts to achieve equity in education.

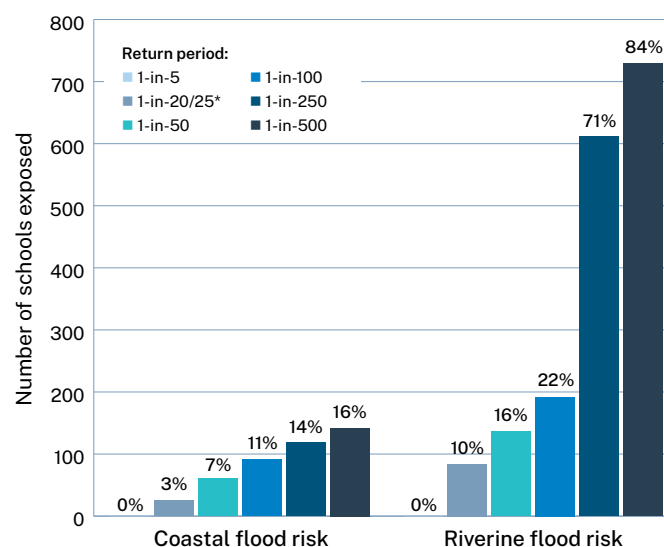


FIGURE 4.4 >>

Schools in coastal provinces are exposed to riverine and coastal flooding, a threat that increases drastically for severe riverine flooding

Sources: Based on data from OpenStreetMap 2019 (schools),⁸ Braese et al. 2020 (coastal flood data) and Fathom (riverine flood data).¹

Note: *Riverine flood risk: 1-in-20-year flood; coastal flood risk: 1-in-25-year flood

Natural hazards pose an additional risk to schools serving as shelters during emergency situations.

Various projects in Vietnam build dual-use schools that provide regular education on normal days and are used as emergency shelters for residents and their most valued possessions in emerging natural disasters. Such buildings are often elevated structures that are safe from flooding. By protecting residents and the school's equipment, they ensure the immediate security of the village and its chance for future prosperity (National Guard;⁹ Kirsch-Wood 2017). When facilities are damaged, critical evacuation activities are also obstructed. Even when the buildings themselves are not damaged, flooding can damage roads, cutting off people's access to these shelters. Infrastructure disruptions also pose a threat to the provision of fresh water, electricity and communication to the shelters, compromising the safety of their residents.

Coastal schools are particularly exposed to flood risks.

An exposure analysis conducted for this report used a dataset of 864 schools to assess the risk that flooding poses to schools in coastal provinces.¹⁰ According to these estimates, about 22 percent of these schools are exposed to 1-in-100-year riverine flooding. This increases significantly for events with lower probabilities and higher intensities. Similarly, 11 percent of schools are exposed to 1-in-100 year coastal flooding (figure 4.4). With 7.6 million students accessing general education in coastal provinces,¹¹ over 1.5 million pupils could be directly exposed to and affected by such flood risks.

A breakdown of results reveals that provinces with the largest share of schools exposed to coastal flooding are in the South Central Coast Region, while riverine flooding puts schools in provinces along the entire coast at risk.⁶ Ho Chi Minh City, with its large number of schools, is particularly at risk.

Systematically assessing and ensuring the resilience of education and health care facilities will be crucial for resilient and sustainable socioeconomic development in Vietnam's coastal regions. Part 3 will explore which immediate measures can be taken to address these challenges.

Endnotes

1. Information from Fathom Global, <https://tinyurl.com/sfzgo7z>
2. Information retrieved from World Bank Open Data, <https://data.worldbank.org/>
3. Information retrieved from World Bank, <https://tinyurl.com/stqpoyh>
4. Information retrieved from Asian Development Bank, <https://tinyurl.com/y9lbo87d>
5. Regional polyclinics, commune health centers and private sector facilities are not included in the dataset.
6. Detailed results for different flooding types and hazard intensities (5, 20/25, 50, 200 and 500-year return periods) are provided in the technical annex to this report (De Vries Robbé et al. 2020).
7. Information retrieved from Relief Web, <https://tinyurl.com/ya9b9yot>
8. Information retrieved from OpenStreetMap on November 19, 2019.
9. Information retrieved from National Guard, <https://tinyurl.com/yd3tdl86>
10. The dataset was constructed from volunteer-contributed data from the OpenStreetMap project (2019) and should not be interpreted as a complete representation of schools in Vietnam. The schools in the dataset represent 6.5 percent of total general education schools in coastal provinces. For a provincial breakdown, see Braese et al. (2020). Given the incompleteness of the source data, these results should be interpreted as indicative only.
11. Information retrieved from General Statistics Office of Vietnam, <https://tinyurl.com/tq3s66s> on April 5, 2019.

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Infrastructure systems are vulnerable lifelines

Reliable and resilient infrastructure systems are an essential foundation for economic development and prosperity. When infrastructure fails, it affects not only households, but also businesses' ability to deliver goods and services, and provide the jobs on which people depend (Hallegatte et al. 2019). Vietnam's coastal infrastructure is highly exposed to such disruptions. The transport corridor stretches along the coast to connect north to south, but proximity to the coast exposes it to various natural hazards. Typhoons frequently damage electric transmission and distribution lines, leading to significant economic losses. Drought and floods both affect water supply and sanitation, which are crucial for people and businesses. Annual average losses to the transport and energy sector are large (figure 5.1). This section examines how natural hazards affect transport, power, water supply, and sanitation in Vietnam.

5.1 >>

The transport network connects people

Despite a well-developed transport network, concentrated traffic flows mean potential for substantial disruptions.

Reliable and efficient transportation infrastructure is an important foundation for most production-centered economies. The World Bank's Logistics Performance Index, which measures countries' quality and ease of trade logistics, rates Vietnam as the best-performing lower-middle income country. For quality of road, rail, water, and air infrastructure, it ranks 47th of 160 countries (Arvis et

al. 2018). Opportunities for improvement exist primarily in national transportation networks. Improving connectivity between rural and urban areas could spur higher economic performance, especially in the agricultural sector. Further development of railways and inland waterways could lead to more multimodal freight transport and relieve stress on existing road networks (World Bank and Ministry of Planning and Investment of Vietnam 2016).

Road transport flows within Vietnam concentrate around the metropolitan areas of Hanoi and Ho Chi Minh City. These primary economic centers are connected by a busy highway and expressway corridor along the eastern coastline (figure 5.2). Within the provinces, a small set of routes through a few communes carry most of the transport burden, leading

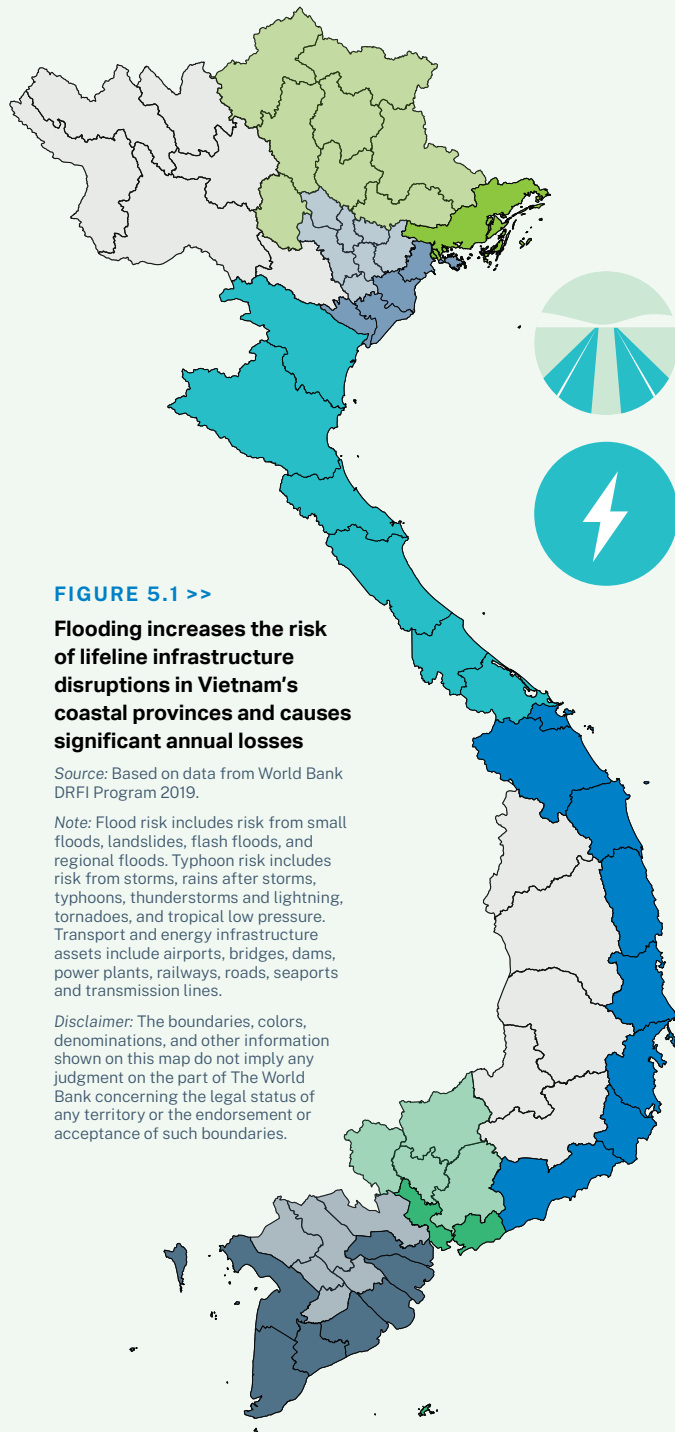


FIGURE 5.1 >>

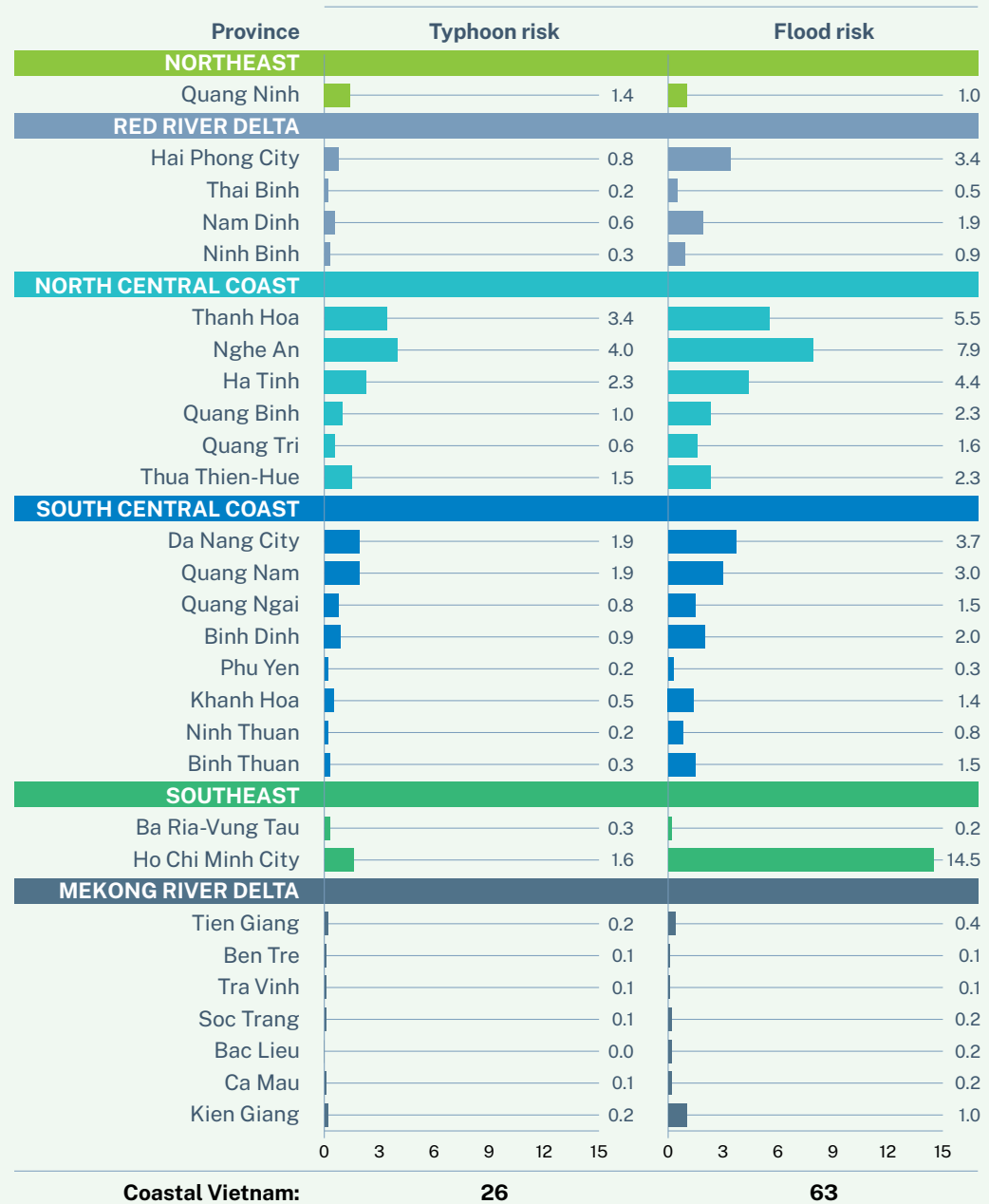
Flooding increases the risk of lifeline infrastructure disruptions in Vietnam's coastal provinces and causes significant annual losses

Source: Based on data from World Bank DRFI Program 2019.

Note: Flood risk includes risk from small floods, landslides, flash floods, and regional floods. Typhoon risk includes risk from storms, rains after storms, typhoons, thunderstorms and lightning, tornadoes, and tropical low pressure. Transport and energy infrastructure assets include airports, bridges, dams, power plants, railways, roads, seaports and transmission lines.

Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Average annual losses for transport and energy infrastructure systems (\$, millions)





\$280 million >>

Utilization losses incurred by firms due to transport disruptions per year.



to high concentration and potential for disruption. The crucial Hanoi-Ho Chi Minh City route is also serviced by railway, although most railroad transport is in the north. Inland waterways have some importance within both the north and south, while domestic maritime transport mostly provides cross-country connections (Pant et al. 2019).

Flood-related transport disruptions are well known to people across Vietnam. The country's strong reliance on its transport networks means that the costs of such disruption are substantial. When supplies required for production do not arrive on time, firms cannot operate. When clients cannot be reached, sales are stalled, and firms cannot fulfill their potential. Based on firm-level data, it is estimated that in Vietnam, utilization rate losses from transport disruptions amount to \$280 million every year (Rentschler et al. 2019a).

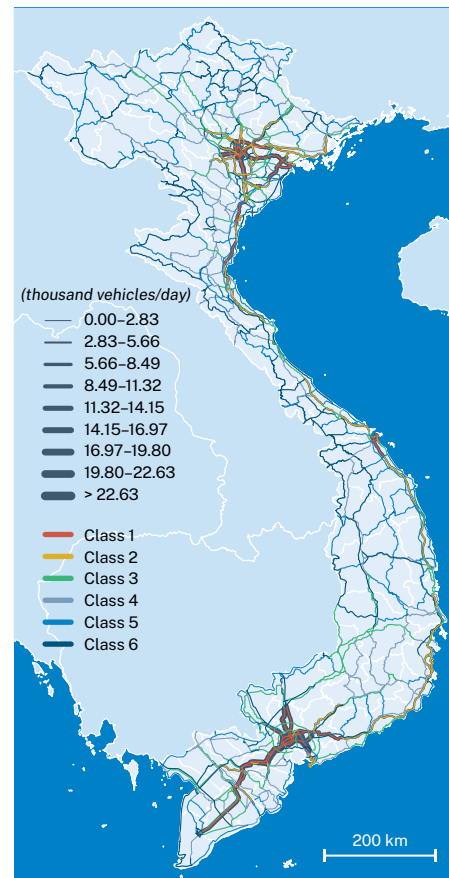
The road network is particularly exposed to natural hazards along the coastline.

Vietnam has significant transport infrastructure along the length of its coast, which is highly exposed to natural hazards. Vietnam has one of the world's highest absolute expected annual damages to transport infrastructure, ranking fifth after the United States. It has the highest expected annual damage per kilometer of infrastructure, with a mean of \$1,750 per kilometer (Koks et al. 2019). An assessment of the exposure of Vietnam's road, rail, water, and air transportation infrastructure to landslides, typhoon-induced storm surges, flash flooding, and river flooding found that flash floods and other natural hazards

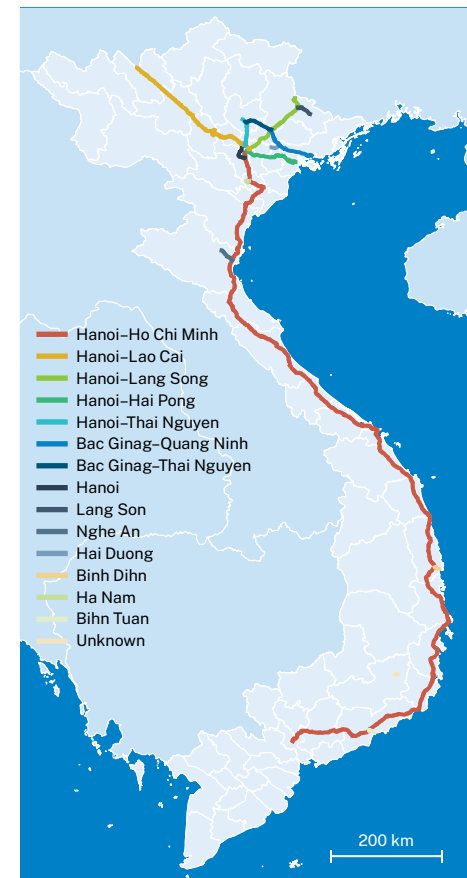
FIGURE 5.2 >>

National road and train transport flows in Vietnam

a) National road network and average annual daily traffic (AADT)



b) National rail network

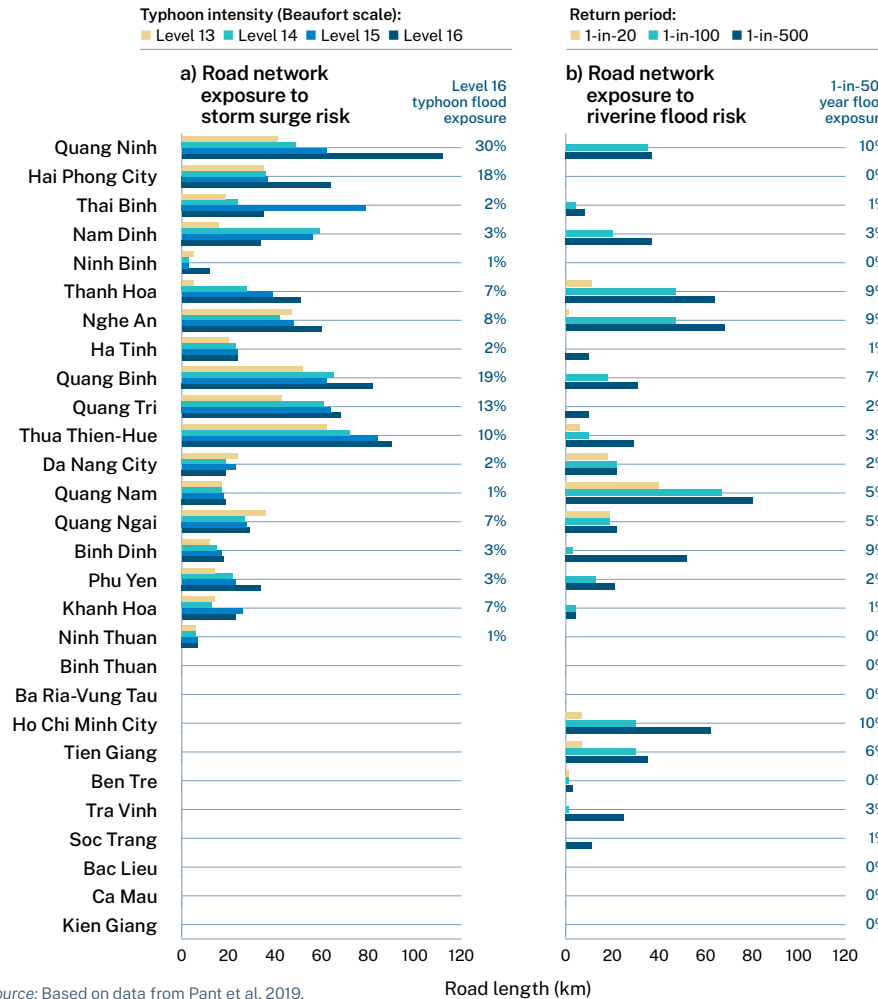


Source: Pant et al. 2019.

Notes: AADT counts refer to the estimated numbers of commercial vehicles on an average day between road network locations. Color of lines indicate the road class, which depend on the volume of average daily vehicle traffic and are classified as follows: Class 1 = over 6,000 vehicles, Class 2 = 3,000-6,000 vehicles, Class 3 = 1,000-3,000 vehicles, Class 4 = 300-1,000 vehicles, Class 5 = 50-300 vehicles, and Class 6 = under 50 vehicles. Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE 5.3 >>

The coastal road network faces significant exposure to typhoons and flooding



Notes: The coastal analysis only includes 18 of the 28 coastal provinces and excludes provinces south of Ninh Thuan. Percentages included are share of the total road network in each province exposed to Level 16 typhoon flooding and 1-in-500-year riverine flooding. Typhoon intensity is determined by wind speeds based on the Beaufort scale, where Level 13 = 134–149 kilometers per hour (km/h); Level 14 = 150–166km/h; Level 15 = 167–183km/h; and Level 16 = 184–201km/h. Only areas with flood depths of over one meter were considered in the analysis. Riverine refers to fluvial flooding in this case.

disproportionately endanger road infrastructure in coastal districts (Pant et al. 2019). Around 2–4 percent of national roads are exposed to extreme fluvial flooding, but some provinces have coastal flood exposure rates of 30 percent (figure 5.3). Annual average damages to the rail network from floods, typhoons, and earthquakes are estimated at \$700,000 (World Bank DRFI Program 2019).

Direct damage costs from natural shocks are substantial.

Coastal areas face significant damages and losses from the exposure of transportation infrastructure to natural shocks. When floods affected the South Central Coast Region between October and December 2016, about 1,782 kilometers of road and 585 bridges were damaged or eroded. The cost of this damage to the transportation sector was estimated at \$70 million, with repairs and reconstruction costing a further \$143 million (Government of Vietnam 2017).

Unfortunately, such losses are not rare outliers. When modeling damages to public transportation infrastructure caused by floods, typhoons, and earthquakes, average annual losses add up to about \$144 million. At \$136 million, damages to roads make up the largest share of annual average losses to the sector (World Bank DRFI Program 2019). Floods are the primary cause of this damage, followed by typhoons, and roads comprise over 90 percent of all damaged transportation infrastructure assets (World Bank DRFI Program 2019). Figure 5.4 shows that the estimated public losses — contingent liability — to

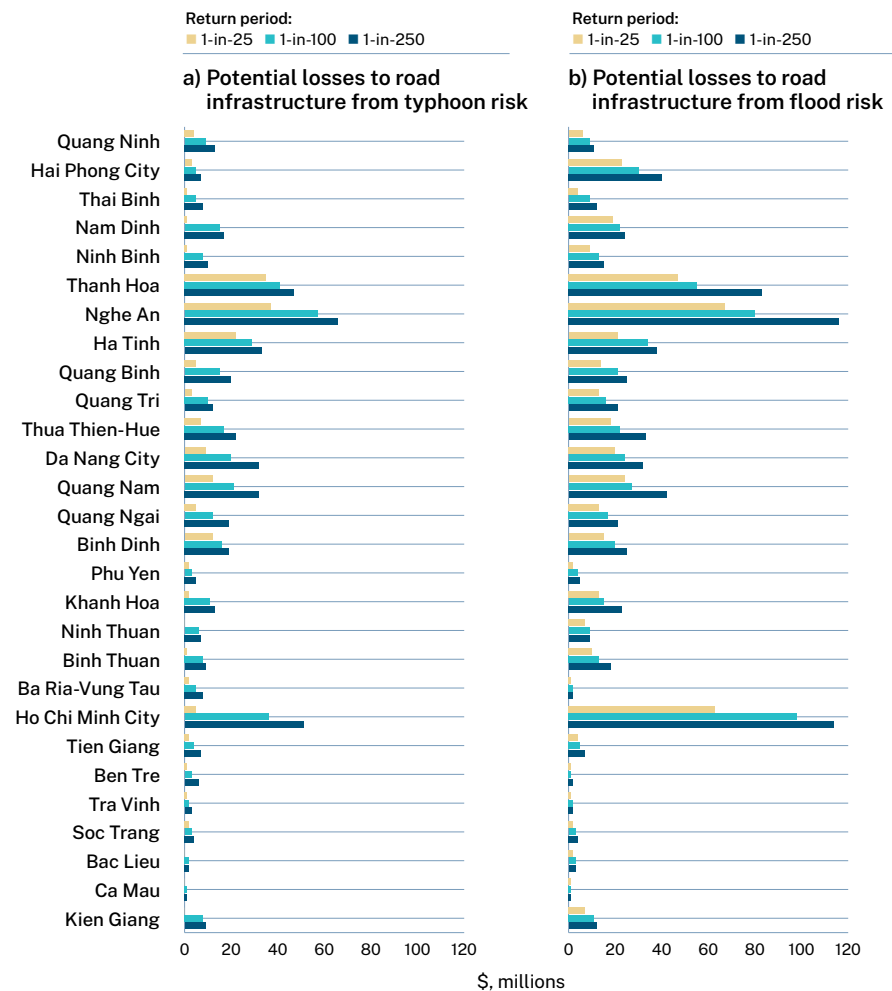
roads resulting from flooding is about twice the foreseen losses from typhoons in coastal provinces.

Besides causing direct damage to the transportation network, natural shocks also disrupt commodity flows and create freight redistribution costs. Economic losses are the costs to the economy caused by lost commodity flows, while redistribution costs arise when freight must take longer or more expensive routes to reach its destination. A province-level disaggregation of these costs shows that disruptions in Vietnam's coastal provinces, along with those in Hanoi and Ho Chi Minh City, cause the greatest average annual losses (World Bank DRFI Program 2019). Figure 5.5 shows province-level annual average economic losses and worst-case freight redistribution costs due to disruptions from natural hazards. These losses are estimated for the loss of public transport infrastructure due to typhoons, floods, and earthquakes and the associated economic impacts of identified road disruptions. The results show that transportation networks along the coast are highly exposed, disrupting transport networks. The lack of alternative north-south routes leads to large rerouting costs when major coastal highways such as National Route 19 – or *Quoc lo 19* – are inaccessible (Pant et al. 2019).

Total daily economic impact for fluvial flooding with a 100-year return period is estimated at \$12–31 million (figure 5.6), in the hypothetical case that the event causes a nationwide disruption of the network. In reality, events tend to be restricted to a certain geographical space. The uncertainty range is mainly caused by fluctuations in the

FIGURE 5.4 >>

Potential losses to road infrastructure from flooding are about twice the foreseen losses from typhoon risk



Source: Based on data from World Bank DRFI Program 2019.

Note: Flood risk includes risk from small floods, landslides, flash floods, and regional floods. Typhoon risk includes risk from storms, rains after storms, typhoons, thunderstorms and lightning, tornadoes, and tropical low pressure.

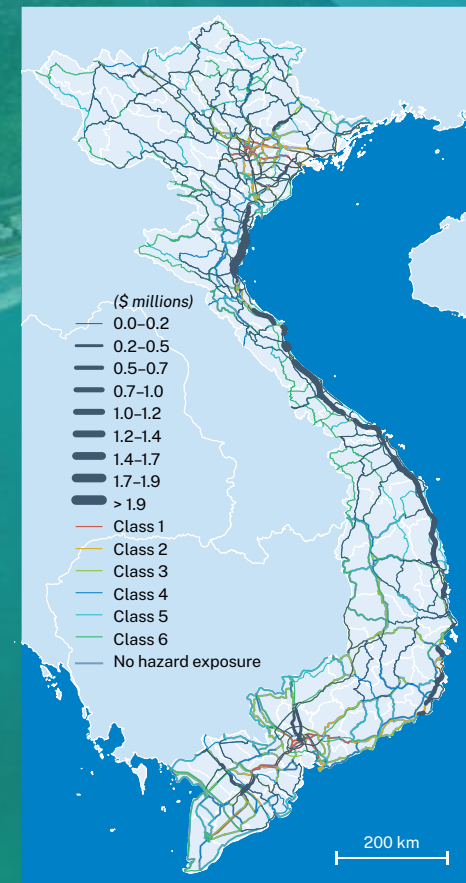
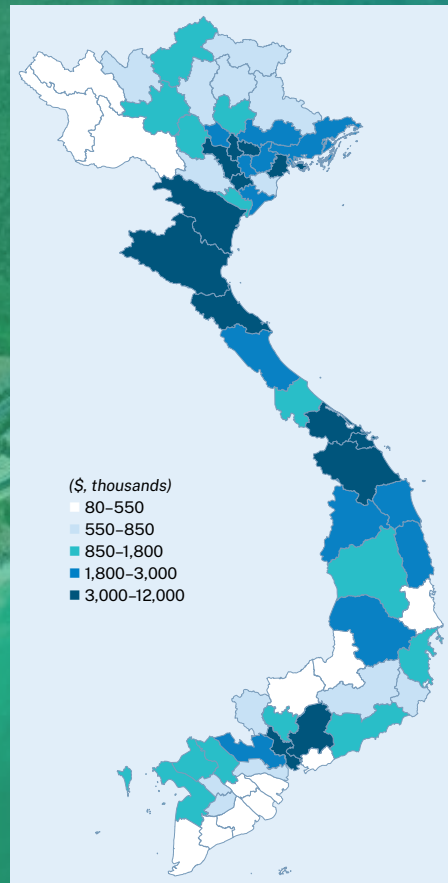


FIGURE 5.5 >>

Hazard-related direct and indirect losses affecting Vietnam's transportation infrastructure

a) Annual average loss of public transport infrastructure due to natural hazards

b) Maximum daily economic losses due to damaged transport infrastructure



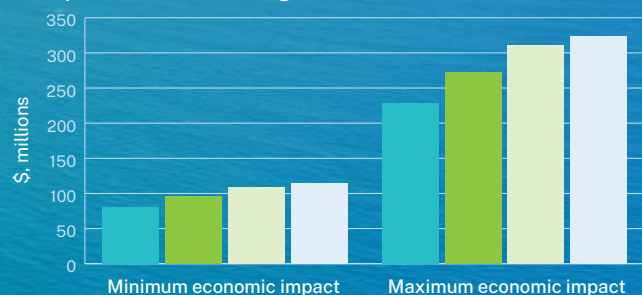
Sources: Based on data from a) World Bank DRFI Program 2019 and b) Pant et al. 2019. Notes: a) Natural hazards include flooding, typhoons, and earthquakes, by province. Color of lines in (b) indicate the road class, which depend on the volume of average daily vehicle traffic and are classified as follows: Class 1 = over 6,000 vehicles, Class 2 = 3,000–6,000 vehicles, Class 3 = 1,000–3,000 vehicles, Class 4 = 300–1,000 vehicles, Class 5 = 50–300 vehicles, and Class 6 = under 50 vehicles. Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE 5.6 >>

Storm surge risk has the potential to disrupt a large part of the road network, causing large economic losses

Typhoon intensity (Beaufort scale):
■ Level 13 ■ Level 14 ■ Level 15 ■ Level 16

a) Daily economic impact from storm surge risk in an event of 100-percent disruption of affected road segments



Return period:
■ 1-in-5 ■ 1-in-25 ■ 1-in-50 ■ 1-in-100 ■ 1-in-250 ■ 1-in-500

b) Daily economic impact from riverine flood risk in an event of 100-percent disruption of affected road segments



Source: Based on data from Pant et al. 2019.

Note: The minimum and maximum values refer to the range of origin-destination flows and transport costs on the networks, mainly caused by the fluctuations in rice freight flows. Riverine flooding refers to solely to fluvial flooding in this case.

network rerouting of rice flows due to the seasonality of rice cultivation. The daily economic impact from typhoon flooding would be \$80–228 million for a Level 13 typhoon with wind speeds of 134–149 kilometers per hour and \$114–324 million for a Level 16 typhoon with wind speeds of 184–201 kilometers per hour (Pant et al. 2019).

In the absence of investments into resilient infrastructure, climate change will have a costly impact.

Climate change is likely to increase the exposure of the road network to natural shocks. Poor data availability limits national-scale forecasts of the transportation impacts of climate change, but there is some evidence of moderate increases in river flood exposure (Pant et al. 2019). Additional damage costs to Vietnamese road infrastructure due to changes in temperature, precipitation, and flooding have been estimated at \$4–55 billion for 2010–2050. While the exact scale of the impacts is uncertain, even the lower end of the estimated range is significant (Chinowsky et al. 2015).

5.2 >>

Energy infrastructure powers coastal development

Electricity supply provides the basis for livelihoods and economic development.

It is hard to imagine a modern society functioning without electricity. The quality of life of private households is

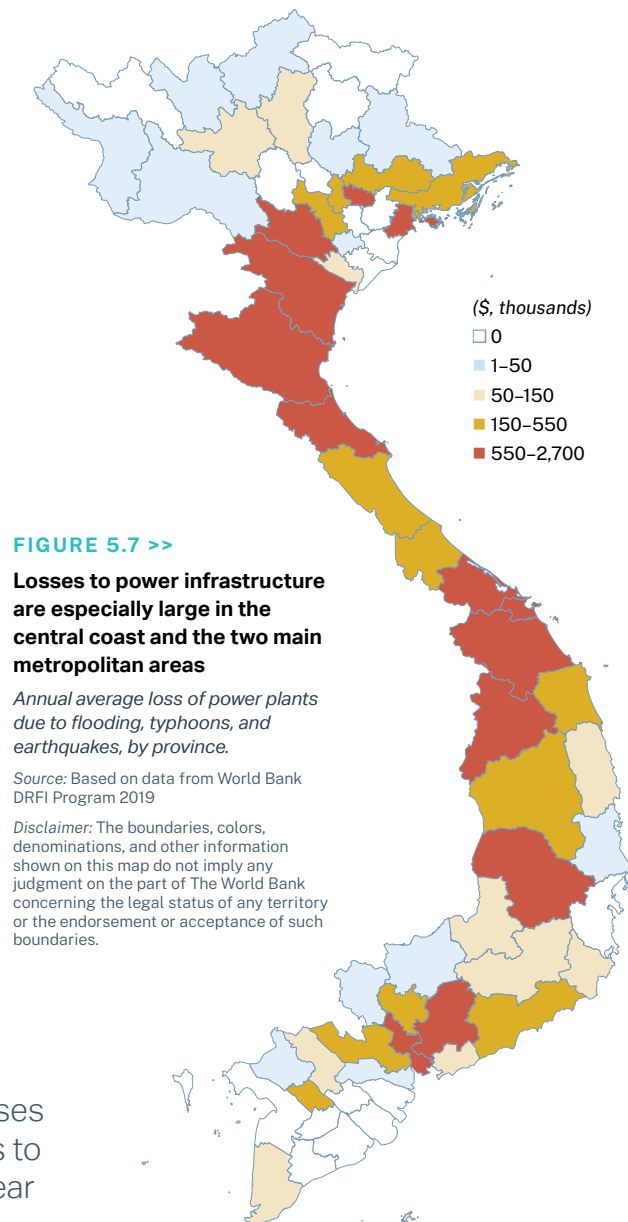
improved beyond measure by the ability to refrigerate food, provide lighting, or charge essential devices. In Vietnam, rapid improvements in electrification over the last two decades have given most households access to modern electricity (World Bank and Ministry of Planning and Investment of Vietnam 2016).¹ And businesses also need electricity to thrive. Almost all types of economic production are enabled by electricity, which powers everything from computers in travel agencies to machines in sawmills. For Vietnam's energy agency, keeping up with the energy demand of economic development, while ensuring sustainable and resilient supply will be a key challenge in the coming decades.

When the lights go off, costs soar.

The country's widespread reliance on electricity means there are large costs when power fails. These can be direct damages, such as the food in a refrigerator spoiling. There are other, less obvious, but highly significant indirect costs. A sawmill unable to produce goods without functioning machines, for example, will forego sales and may be unable to pay workers' wages. If power outages are a regular occurrence, firms will face additional costs as they are forced to invest in backup generators.

\$72 million »

Costs to Vietnamese businesses for running backup generators to mitigate power outages per year



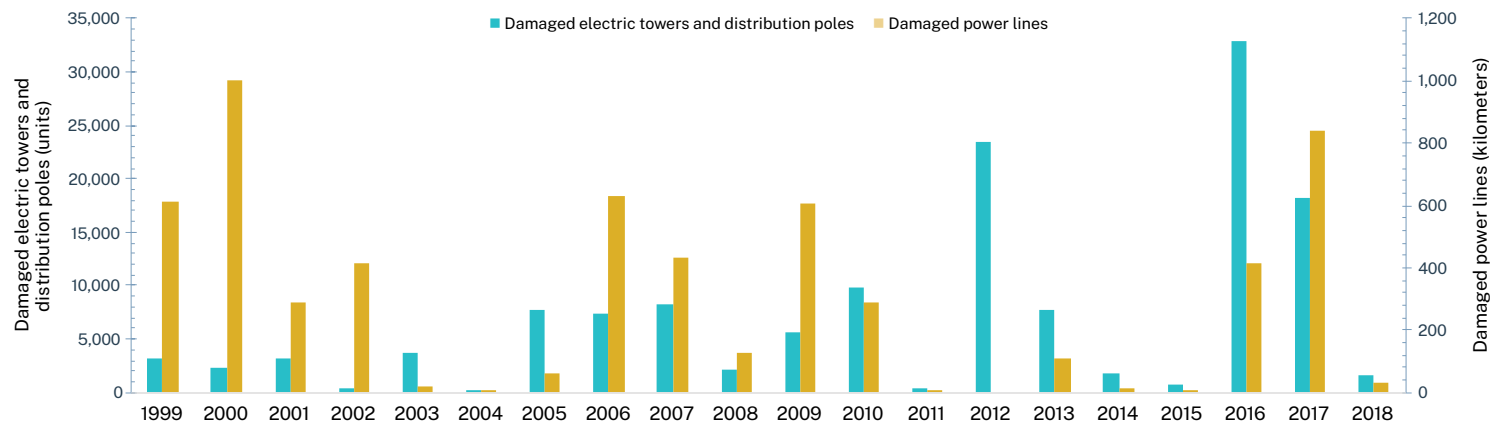


FIGURE 5.8 >>
Damage to electric transmission infrastructure from natural disasters, 1999–2018

Source: Based on historical damage data provided by the VNDMA.

Electricity service quality in Vietnam is still unreliable compared to other middle-income countries. According to the World Bank’s Enterprise Surveys, Vietnamese businesses experience several power outages per year, each lasting over seven hours on average. A quarter of firms report having invested in backup generators. In another survey, 57 percent reported experiencing power outages, estimating that about 9 percent of these were caused by flooding (Sagris et al. 2017). The economic consequence of such outages is huge. It is estimated that in 2014, Vietnamese businesses missed out on sales amounting to about \$670 million due to electricity outages. Investing in backup generators also cost businesses about \$72 million a year, while power outages halted production and lowered equipment utilization rates, causing further damages of about \$30 million (Hallegatte et al. 2019).

Natural disasters cause significant damage to power infrastructure assets.

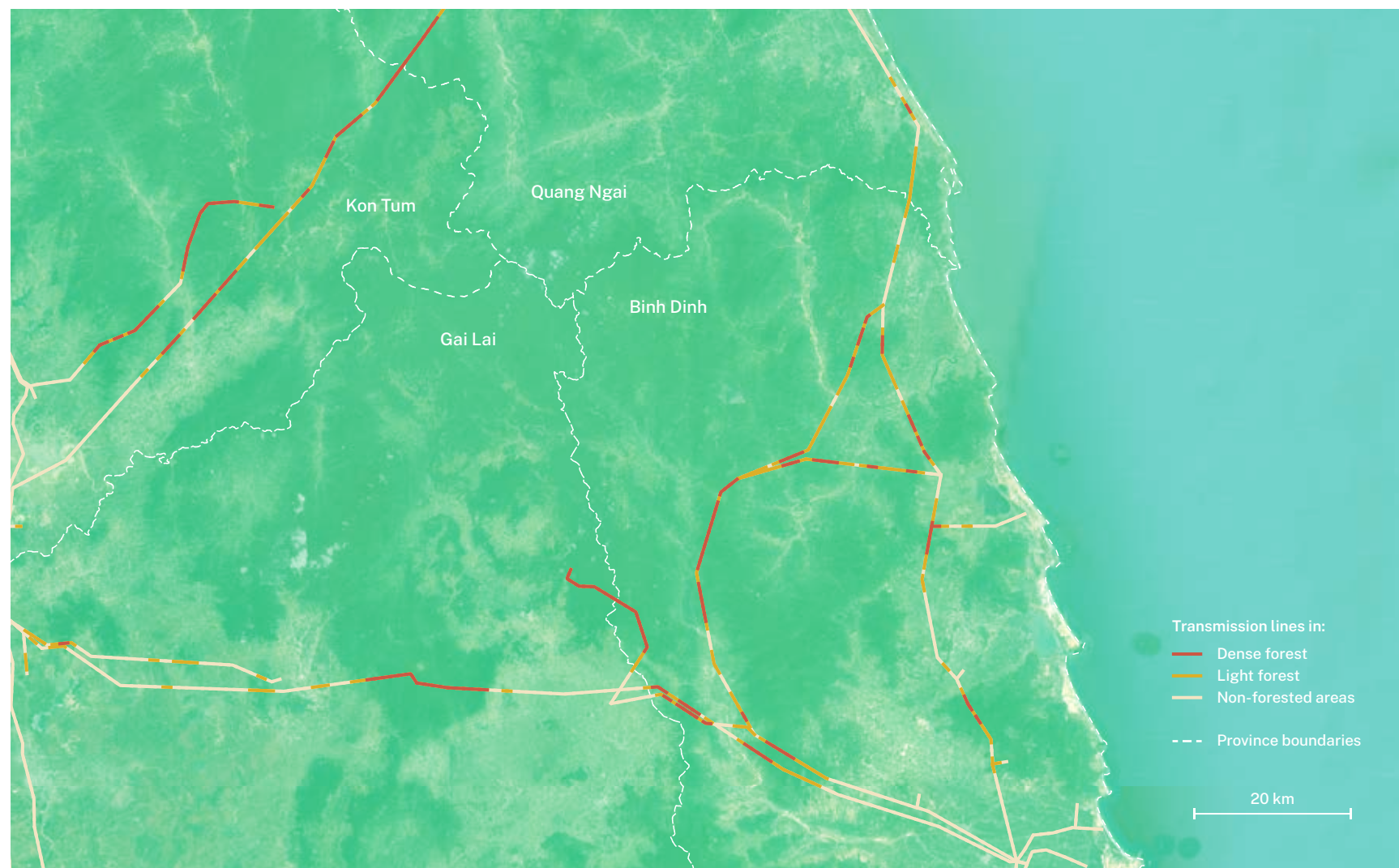
The impact of natural hazards on the power sector is measurable through service disruptions and direct asset damages. Since 1989 damages to energy infrastructure—primarily driven by flooding—have amounted to \$330 million per year on average, predominantly due to damages to transmission and distribution lines (Figure 5.7, World Bank DFRI Program 2019).

However, these estimates of annual average losses hide the fluctuations in the amount of electricity infrastructure damaged by natural shocks from year to year. While impacts might be minor one year, a large shock can deprive many people of electricity the following year. Indeed, historical government data aggregated for this report show substantial volatility in the number of electric poles and length of power line damaged by natural disasters every year (figure 5.8).

In 2017, Typhoon Damrey damaged over 800 kilometers

FIGURE 5.9 >>

Transmission lines in forested areas are at risk during storms



Sources: Based on data from World Bank 2016 (transmission lines data) and JAXA EORC 2018 (forest data). *Disclaimer:* The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

of power lines while in other years, natural disasters have had little impact on the power sector. It is important to consider this temporal component of damages to electricity infrastructure when planning emergency services to restore network functionality after a shock. Significant peaks in restoration work are to be expected when many people lose access to electricity at the same time.

Typhoons pose a threat to transmission infrastructure, especially in forested areas.

Typhoons bring high wind speeds that pose a risk to electricity transmission infrastructure. Poles topple over, or trees are uprooted and fall onto transmission and distribution lines. Evidence from electricity systems around the world confirms that nearby vegetation (and a lack of maintenance and pruning) significantly increases the risk of damage to transmission and distribution grids during storms (Rentschler et al. 2019b). In Vietnam, several coastal provinces with high typhoon exposure have a significant share of their grid located in forested areas (figure 5.9).

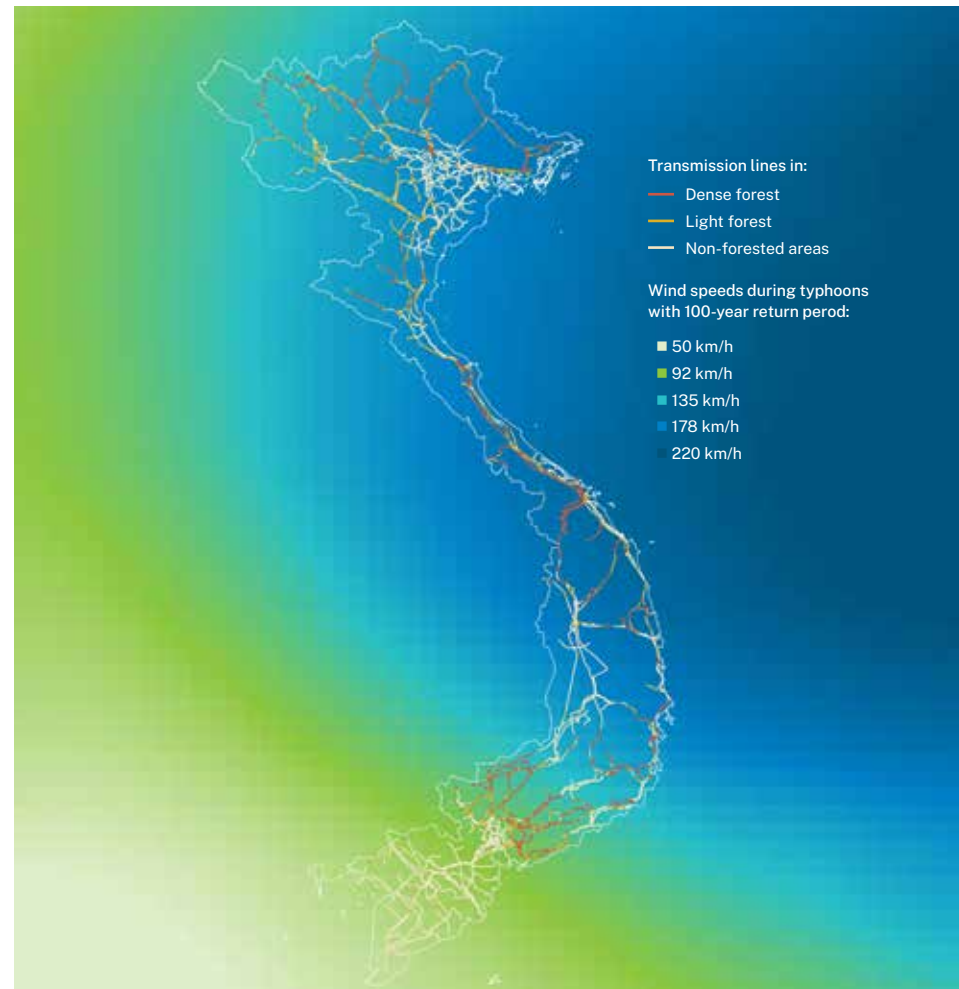
To systematically quantify the extent of this threat, this report analyzed Vietnam's electricity transmission infrastructure in conjunction with wind speed data, using a global model of cyclone winds and a spatial representation of Vietnam's electricity transmission network (UNDRR 2015; World Bank 2016).

Figure 5.10a shows that the central and northern coasts are most threatened. Typhoons arriving from the sea hit

FIGURE 5.10A >>

A significant fraction of Vietnam's electricity grid is at risk from typhoons

Transmission lines in Vietnam and modeled peak wind speeds



Sources: Based on data from UNDRR 2015 (typhoon wind speeds) and World Bank 2016 (energy). Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE 5.10B >>

A significant fraction of Vietnam's electricity grid is at risk from dense forest cover

Exposed transmission lines

Source: World Bank 2016 (transmission grid).

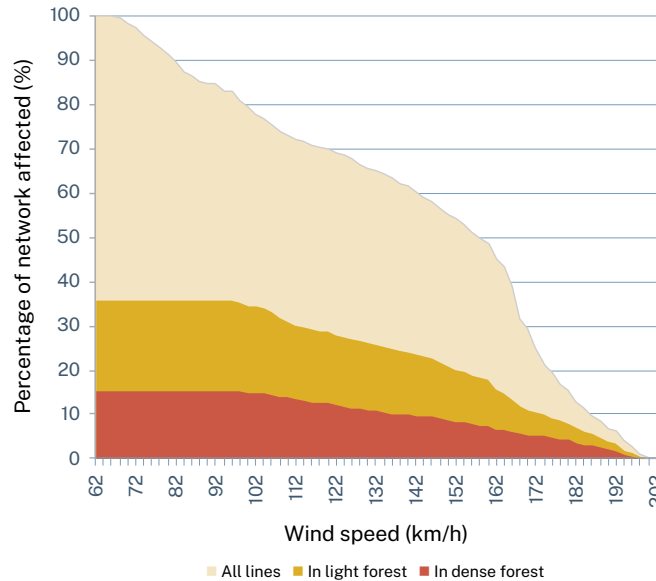
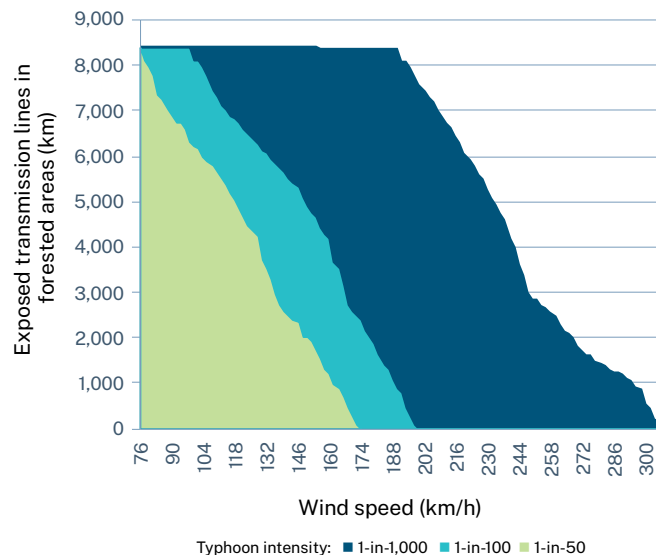


FIGURE 5.11 >>

Exposure to extreme wind speeds of Vietnamese power lines in forested areas

Exposed transmission lines

Sources: Based on data from UNDRR 2015 (typhoon wind speeds) and World Bank 2016 (transmission grid).



these coasts at full force, exposing the infrastructure that services coastal settlements to extreme wind speeds. However, high wind speeds do not have the same effect everywhere. In some areas, their disruptive impact on the power grid is mediated by forests: outages during storms are often caused by trees that fall onto transmission lines and take out a section of the grid (Rentschler et al. 2019b). This means that in forested areas, even relatively low wind speeds can damage the grid, especially when recent droughts have resulted in dead vegetation.

Overall, 36 percent of Vietnam's transmission grid is in forests, and 15 percent is in densely forest areas. Figure 5.10b shows the exposure of Vietnam's transmission lines to peak wind speeds in a typhoon event with a 100-year return period. Almost all power lines in forested areas would be exposed to wind speeds of 100 kilometers per hour.

Figure 5.11 shows that transmission lines in forests need to be able to withstand extreme winds. Wind speeds of 150 kilometers per hour would affect about 2,000 kilometers of power lines in forests in a 1-in-50-year typhoon; almost 5,000 kilometers in a 1-in-100-year typhoon; and more than 8,400 kilometers in a 1-in-1,000-year typhoon. The severity of storms highlights the importance of resilient construction and regular maintenance. With a sizeable portion of the grid located in forested areas, trimming trees near power lines is a necessary and effective measure. Given the current cost of vegetation control practices in Vietnam, the total annual cost of maintaining transmission and distribution lines in forested areas would amount to \$4.1–16.5 million (Chapter 13).³

Flooding threatens power plants and substations across Vietnam.

Natural hazards are known to pose significant risks to electricity generation and transmission. Using a geospatial dataset of Vietnam's power sector assets, this report assesses the exposure of power plants and substations to natural hazards (Global Energy Observatory et al. 2019).

The analysis found that over 70 percent of power plants in coastal provinces are exposed to riverine flooding with a 100-year return period and 23 percent to coastal flooding of the same intensity (figure 5.12). Many of these power plants are equipped with flood protection measures and would probably withstand most floods without considerable harm. But even with appropriate protection measures, flooding can disrupt transportation infrastructure, and therefore access and fuel supply to the plants. The high proportion of plants in flood zones highlights the need for protective features and their upkeep.

While large power plants may have advanced flood protection measures, this is rarely the case for other parts of the power grid. Electrical substations are a critical component of the power system that convert the voltage of transmitted electricity for local distribution to end users. Damages to these substations can cut off large consumers and cause malfunctions in other parts of the grid. And unlike power plants, these substations are often less equipped with flood protection measures. This study analyzed coastal and riverine flood hazards for Vietnam's 864 electricity substations, 384 of which are in coastal

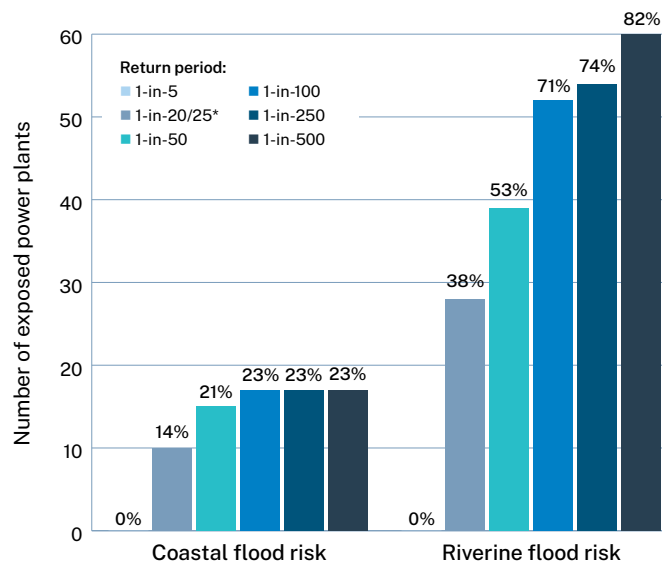


FIGURE 5.12 >>

Exposure of power plants to riverine and coastal flooding

Sources: Based on data from Global Energy Observatory et al. 2019 (power plants), Braese et al. 2020 (coastal flood maps) and Fathom (riverine flood maps).⁴

Note: *Riverine: 1-in-20-year flood; coastal: 1-in-25-year flood.

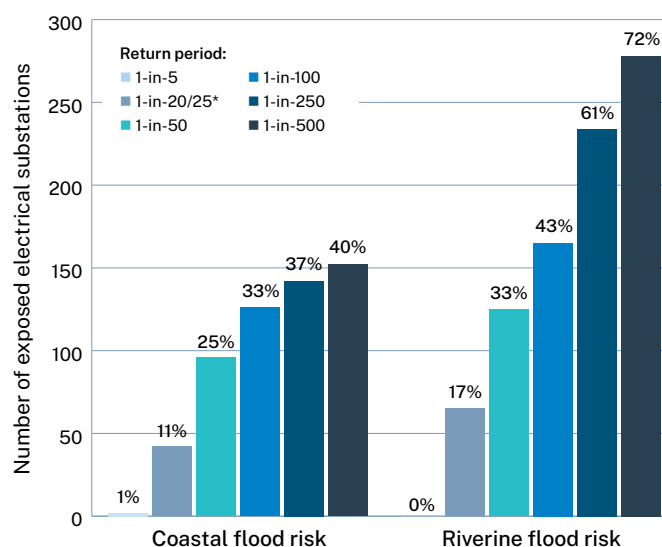


FIGURE 5.13 >>

One-third of Vietnam's electrical substations are at risk from a 1-in-100-year flood

Sources: Based on data from World Bank 2016 (electrical substations), Braese et al. 2020 (coastal flood maps) and Fathom (riverine flood maps).⁴

Note: *Riverine: 1-in-20-year flood; coastal: 1-in-25-year flood

provinces (World Bank 2016). The results show that one-third of substations are exposed to coastal flooding with a 100-year return period, and 43 percent to riverine flooding (figure 5.13). As with power plants, systematically inspecting and strengthening flood protection measures of electrical substations could help to reduce disruptions to power supply.

5.3 >>

Water supply and sanitation infrastructure

Reliable water supply is an essential, yet vulnerable, infrastructure service.

Vietnam, with its great number of river basins and wetlands, has an abundance of surface and freshwater resources. Nevertheless, building and maintaining reliable water supply, irrigation, and wastewater treatment infrastructure can pose significant challenges to regional and national operators. Over 75 percent of households in Vietnam are estimated to have access to clean water and modern sanitation, although there are strong regional differences (World Bank and Ministry of Planning and Investment of Vietnam 2016). Overall, coastal provinces tend to have higher access rates and more developed water supply and sanitation infrastructure than peripheral regions.

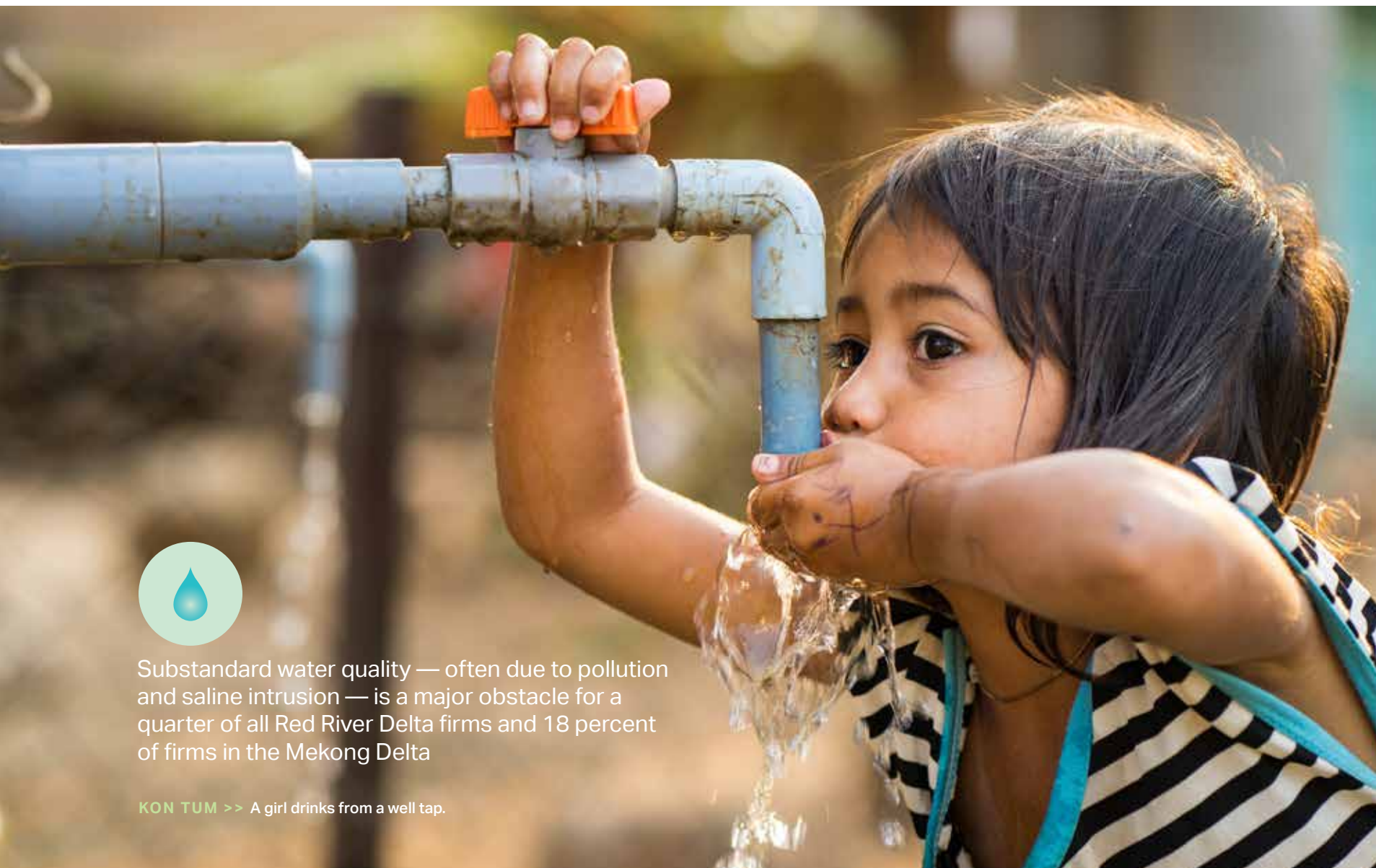
Many industrial firms depend heavily on water as an input for production. Hence, reliability and quality of water supply are critical for their operations. Compared to global and regional averages, the reliability of Vietnam's water

supply infrastructure scores relatively high. According to a nationally representative survey, only about 8 percent of firms experience water outages, amounting to about 17 days without water per year.² Averages are higher in the East Asia Pacific region, at 10.6 percent; globally, they are at 14.7 percent (Hyland et al. 2019).

However, within Vietnam, there are significant regional differences. In the Mekong River Delta, 27 percent of firms report outages, compared to 17 percent in the North and South Central Coast regions and only 5 percent of firms in the Red River Delta and Southeast regions. Although some firms seem to have adapted to frequent water outages by acquiring pumps, tanks and other equipment, these outages impose a serious burden on many firms, increasing operational costs by more than 8 percent for each day without water (Hyland et al. 2019). Investments in such backup equipment can be prohibitively expensive, especially for smaller and informal firms.

Pollution and saline intrusion are compromising water supply quality.

Substandard water quality is a bigger challenge for many businesses than water outages. Indeed, 14 percent of firms report that poor water quality is a major obstacle to their business. The share of firms reporting water quality challenges is particularly high in the Mekong Delta (18 percent) and the Red River Delta (25 percent). For them, water quality challenges are estimated to reduce sales by an average of 48 percent compared to less or non-affected firms. This impact is even bigger in the services sector,



Substandard water quality — often due to pollution and saline intrusion — is a major obstacle for a quarter of all Red River Delta firms and 18 percent of firms in the Mekong Delta

KON TUM >> A girl drinks from a well tap.

Shutterstock

where affected firms report a 63 percent fall in sales. Linked to saline intrusion and high levels of agricultural and industrial pollution, firms in the Red River and Mekong River Delta Regions report the worst water quality (Hyland et al. 2019). By 2035, it is estimated that deteriorating water quality and mounting pollution will cost 4.3% of GDP annually (World Bank 2018a).

Overexploitation of groundwater is causing land subsidence in the Mekong River Delta.

Unregulated groundwater extraction is depleting aquifers and causing land subsidence, reducing paddy yields and leading to the loss of agricultural land and saline intrusion, especially in rural parts of the Mekong River Delta. Here, development and pumping are largely unregulated and almost every household owns at least one groundwater well. In Ca Mau Province alone, 138,000 wells are producing 400,000 cubic meters of water daily. As a result, the water table is dropping by 0.2–0.4 meters a year across the delta, with the worst depletion in Long An, Ca Mau, and Tra Vinh Provinces, at 0.5–0.9 meters per year. Between 2007 and 2010, land subsidence was at 1–3 centimeters across the Mekong Delta. In Ca Mau Province, subsidence rates were at 1.9–2.8 centimeters each year (World Bank 2018a). In 2035, land subsidence caused by groundwater extraction

is expected to reach 0.24–0.9 meters. The effect of paddy land loss on GDP will be a ten times larger impact than the effect of sea level rise alone (World Bank, 2018b).

Natural hazards affect water availability and can damage water-related infrastructure.

Water availability and the adequacy of sanitation systems are likely to be a growing challenge in the coming decades. Today, the agricultural sector uses 80 percent of Vietnam’s water resources and relies heavily on irrigation to grow water-intensive crops like rice. However, the country’s irrigation system provides only about half of its designed capacity and operates at high costs compared to other Southeast Asian countries.

Wastewater treatment infrastructure is not adequate for the country’s growing needs. Only 46 percent of urban households are estimated to be connected to modern drainage systems; more than two-thirds of industrial wastewater and livestock waste goes untreated, leading to environmental pollution and adverse effects on downstream farmers (Hyland et al. 2019; Sagris et al. 2017; World Bank 2018a). Rising water demand from agriculture and industry, coupled with climate change-induced variability in water levels will likely increase water stress.

Severe droughts, as experienced in 2015–16, have shown how drastically access to freshwater can be compromised. Such events have disastrous consequences for households that rely on natural aquifers for their main water supply, and for agricultural producers who need to irrigate their

90 cm >> The extent of subsidence expected in the Mekong River Delta by 2035

crops (UNDP 2016). Industrial firms in Vietnam estimate that about 10 percent of the water outage they experience is caused by droughts (Sagris et al. 2017).

Natural shocks damage irrigation and water treatment infrastructure.

Natural hazards can also directly damage water infrastructure assets. Historical damage data collected by the government shows that between 2000 and 2018, about 460,000 meters of irrigation canals have been damaged every year. But damages vary greatly from year to year, from minor damage in some years to drastic impacts on agricultural productivity in others. Typically, these damages are caused by flood waters that wash away earthen irrigation canals, or debris from typhoons that damage and obstruct canals.

Impacts on water systems are not limited to agriculture. Authorities have often struggled to increase their wastewater treatment capacity in line with rising demands from residents and industry — especially in rapidly growing coastal cities. Flooding can exacerbate the challenges in this sector. In Hai Phong, for example, inadequate wastewater treatment and insufficient drainage capacity have had severe consequences. Seasonal floods have caused polluted and toxic surface water to overflow into agricultural land, residential areas, and the sea, creating significant environmental and health risks (OECD 2016).

The lack of a georeferenced dataset of water supply, wastewater treatment, and drainage systems means



CHAU DOC >>

A farmer works in a rice field.

Agriculture accounts for 80 percent of Vietnam's annual freshwater usage.

that no systematic risk assessment of these assets could be conducted for this report. Developing such an asset inventory will be essential for assessing and improving the resilience of water systems (Chapter 13).

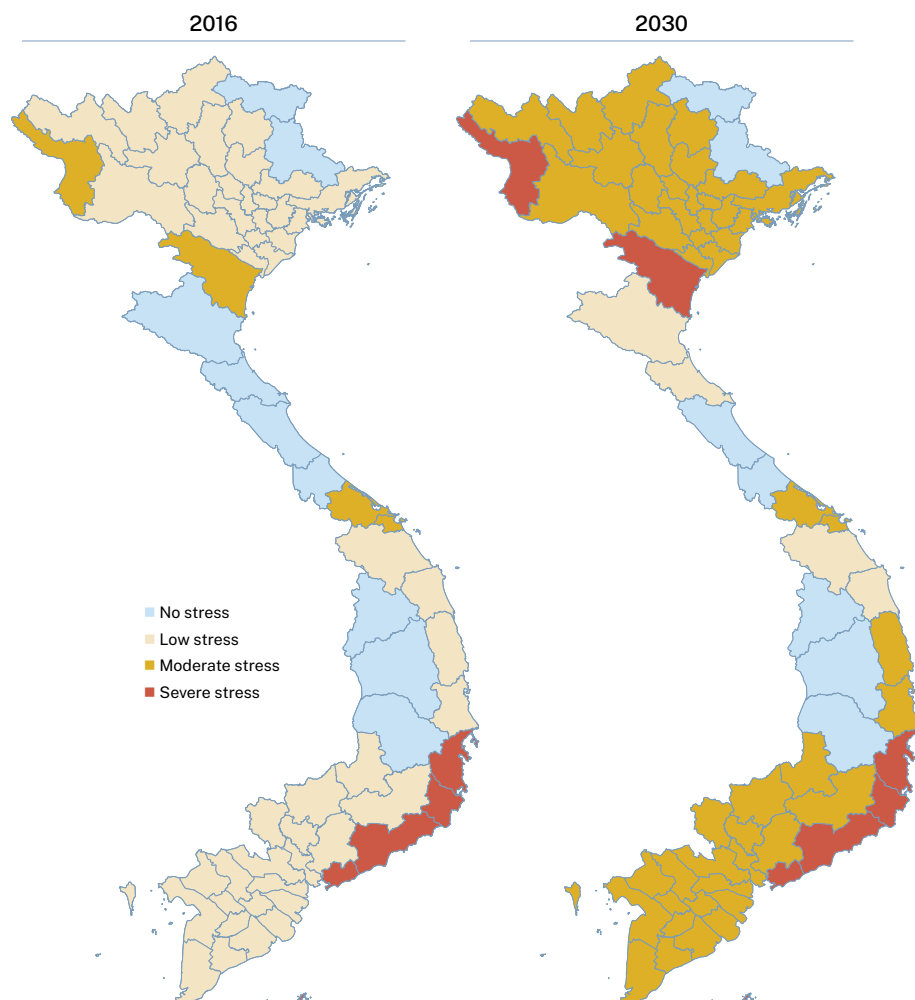
Socioeconomic change will add to climatic stressors on water and wastewater services.

Water availability and infrastructure services for water supply, irrigation and sanitation are subject to a wide range of influencing factors. On the demand side, ongoing socioeconomic development and demographic growth are likely to further increase water needs, exacerbating

FIGURE 5.14 >>

Socioeconomic and climate-induced changes will increase dry season water stress levels

Dry season water exploitation index for 2016 and 2030, by province



Source: Based on data from Sagris et al. 2017. *Note:* River basin water stress levels are represented at the province level. *Disclaimer:* The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

potential water stresses. Increasing water demand in the municipal, agricultural, and industrial sectors could aggravate the stress on water resources in almost all coastal provinces. Natural shocks will continue to impact essential water and sanitation systems, especially if no measures are taken to increase the resilience of water systems. Although the effects of climate change are difficult to predict in the long term, it is already affecting precipitation patterns and is likely to play an increasing role in water availability.

In this context, planning and investment decisions can have major implications. Building dams in river deltas can create water sharing conflicts between irrigation and power generation, while also impacting river sediment transportation and migratory fish routes (Sagris et al. 2017; World Bank and Asian Development Bank 2018). Provinces in the Mekong Delta could also be impacted by developments occurring in up-stream countries, as climate change impacts, infrastructure developments, or increased water extraction along the Mekong River's entire catchment area could influence groundwater levels, freshwater availability, or flood hazards.

Combined with climate change, these trends are expected to increase levels of water stress. Especially in the South Central Coast Region and Thanh Hoa Province in the north,

52/63 >> Number of provinces that could depend on water-stressed river basins by 2030

communities could experience increasingly severe water stress (figure 5.14). Provinces in the four river basins — the Red River, Mekong River, Dong Nai River and South East River cluster — that generate about 80 percent of Vietnam's GDP, are all expected to be water stressed in the dry season by 2030 (Sagris et al. 2017).

Endnotes

1. In order of importance, Vietnam's electricity is generated by hydropower, coal, and gas (EVN 2018).
2. Information from World Bank Enterprise Surveys: Vietnam, <https://tinyurl.com/ydxksyuy>
3. This is based on a total transmission and distribution line length of 23,608 kilometers, of which 35% is in forested areas, and vegetation control costs ranging between \$500 and \$2,000 per kilometer of transmission line.
4. Information from Fathom Global, <https://tinyurl.com/sfzgo7z>

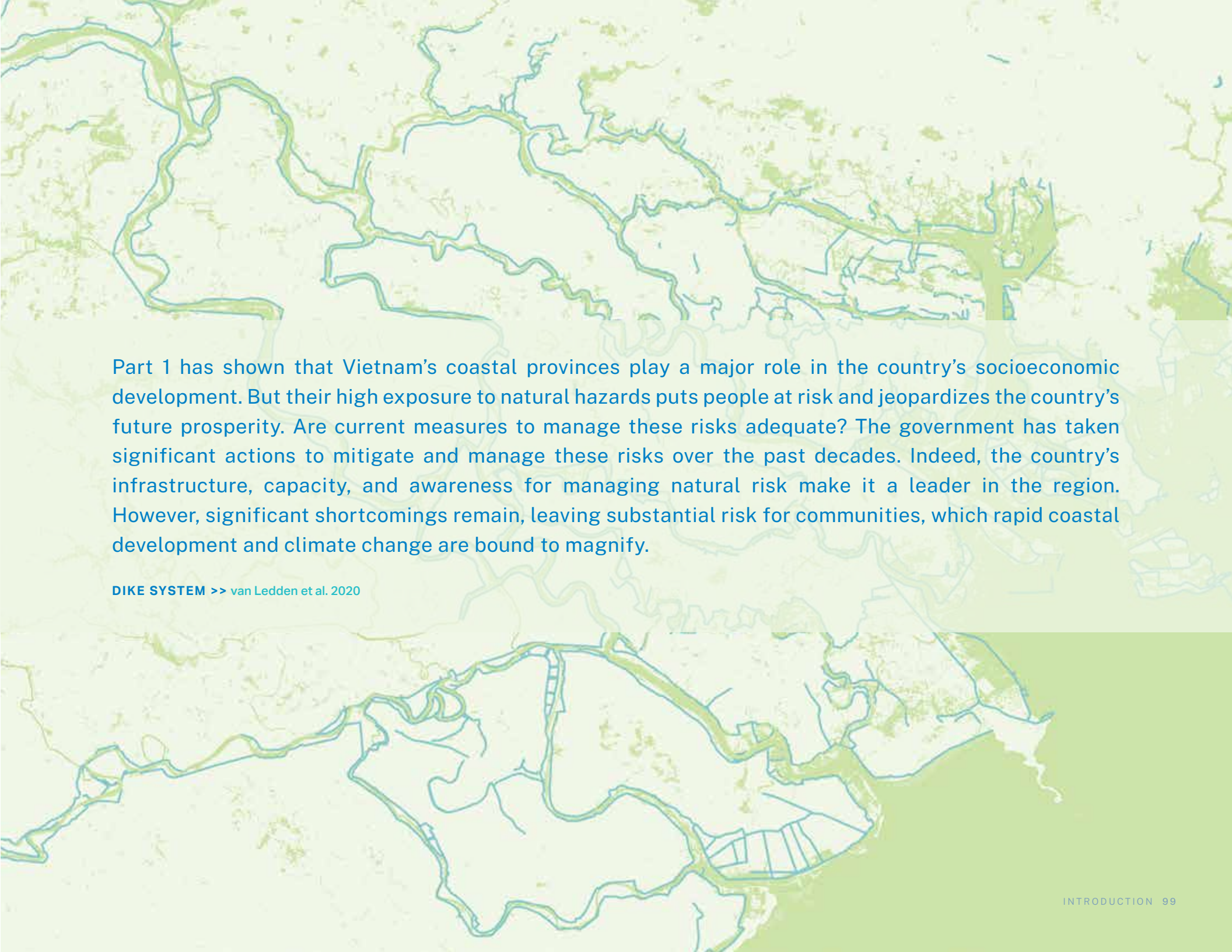
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PART 2 >>

STOCK TAKE

A REVIEW OF VIETNAM'S
EXISTING MEASURES FOR
MANAGING NATURAL RISKS



Part 1 has shown that Vietnam's coastal provinces play a major role in the country's socioeconomic development. But their high exposure to natural hazards puts people at risk and jeopardizes the country's future prosperity. Are current measures to manage these risks adequate? The government has taken significant actions to mitigate and manage these risks over the past decades. Indeed, the country's infrastructure, capacity, and awareness for managing natural risk make it a leader in the region. However, significant shortcomings remain, leaving substantial risk for communities, which rapid coastal development and climate change are bound to magnify.

DIKE SYSTEM >> van Ledden et al. 2020

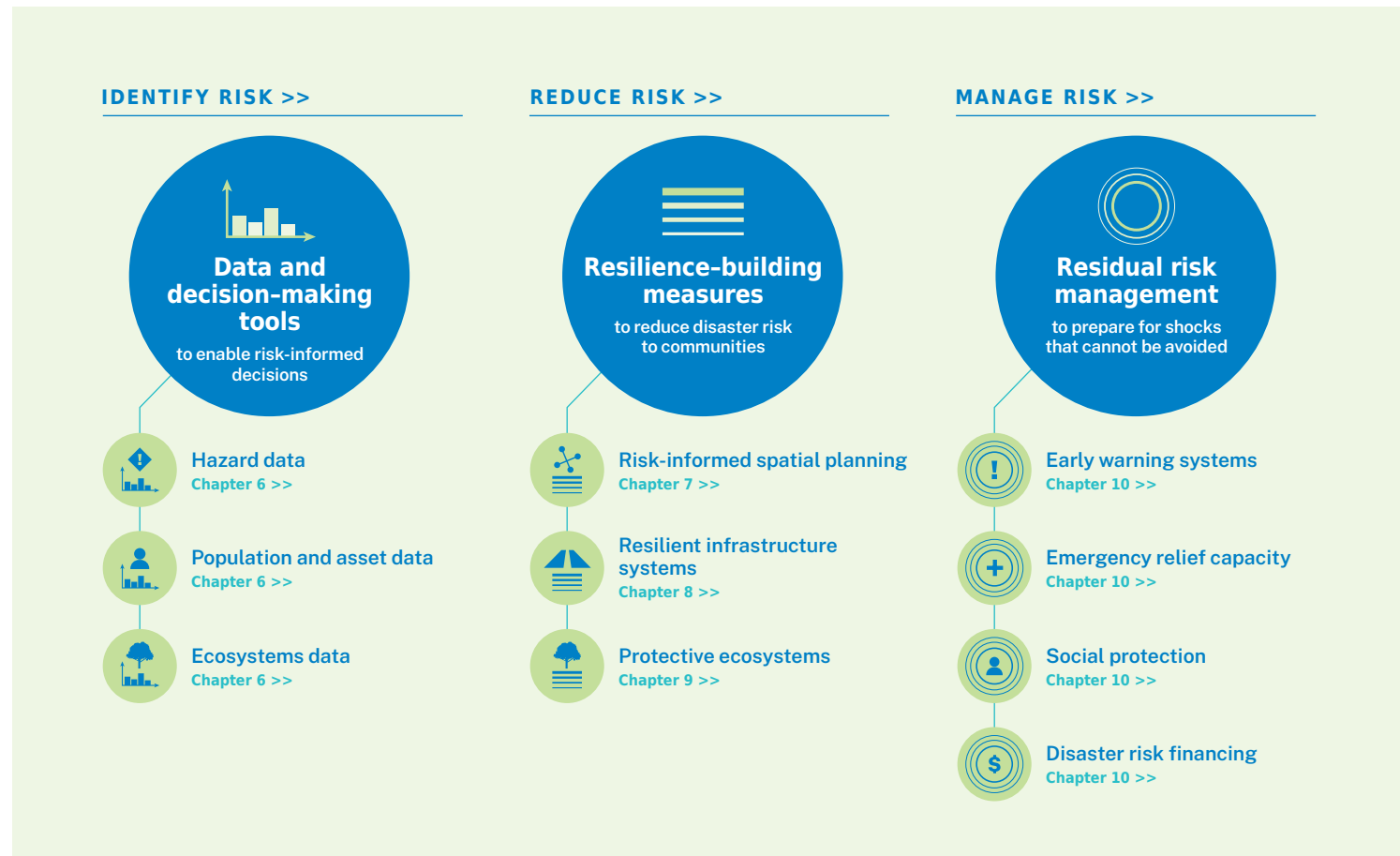
Part 2 of this report systematically takes stock and reviews the risk management measures that are in place in Vietnam today. It assesses whether these measures are adequate, considering the levels of risk in coastal Vietnam identified in Part 1. It also considers whether measures that are established on paper are effectively and systematically implemented in

practice. It reviews and explores the effectiveness of the budgetary implications and institutional arrangements of the country's risk management architecture.

Overall, this stock take shows that, despite its many advances in building the resilience of coastal areas,

FIGURE P.2 >>

Stock take: A review of Vietnam's existing measures for managing natural risks



Vietnam's risk management framework still faces significant challenges. And while they leave serious vulnerabilities today, the risks are bound to increase as rapid development in coastal areas and climate change intensify the urgency of these challenges.

Strengthening resilience in these dynamic and rapidly developing coastal zones is a complex task. A range of actors will need to work together to balance economic development, environmental protection and sustainability while also preparing adaptive, resilient coastal measures to combat the impacts of natural hazards and climate change.

Part 2 provides a comprehensive diagnosis of the status and challenges of Vietnam's efforts to manage coastal risks and increase resilience. Building on original analysis, evidence from the literature, and government consultations, it provides an overview of the current risk management measures and identifies the main gaps. Part 3 offers concrete recommendations to address these gaps and to strengthen the resilience of Vietnam's coastal areas.

This part is structured around three central risk management functions (Figure P.2):



Identifying risk with data and decision-making tools:

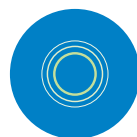
Accurate, complete and accessible data on hazards, infrastructure assets, and ecosystems are the foundation for targeted risk management measures and risk-informed development more generally. Decision-making tools

and analytical capacity are essential for mainstreaming resilience into planning and investment decisions, especially in the context of deep uncertainty.



Reducing risk with resilience-building measures:

A range of measures can help reduce the risks faced by coastal communities. Risk-informed spatial planning in coastal zones guides new development into safe zones, while identifying and protecting people and assets that are already in risk zones. Resilient infrastructure systems—including coastal dikes, transport, water and energy systems—help mitigate the impact of natural shocks on people, reduce disruptions, and improve living standards. Natural ecosystems—such as coral reefs, mangroves, and dune systems—can complement the protective function of dikes, while also contributing to coastal livelihoods. Together, these measures can reduce the risk of disasters and their associated impacts on people and the economy.



Managing risk through residual risk management:

Even with effective risk reduction systems in place, not all disasters can be avoided, especially those associated with rare and extreme shocks. Effective emergency response and recovery capacities can help reduce losses and suffering when these shocks occur and speed up the relief and recovery process. Early warning systems, emergency response, relief and recovery plans, social protection systems, and disaster risk financing strategies are all key for managing residual risks.

Hazard and risk information is fragmented and incomplete

Reliable hazard and risk information is essential for disaster risk management, socioeconomic planning and sustainable development in coastal areas. Although hazard and risk maps have been developed for some strategies and policies, comprehensive risk information for key public and private sector institutions is fragmented and largely under-developed. This includes data on natural hazards, infrastructure systems and ecosystems, and refined estimates of the potential economic and well-being impacts of disasters. Moreover, public and private decision makers do not always account for the deep uncertainty associated with long-term hazard projections, and so do not apply robust decision-making tools. To find sustainable, targeted solutions to reduce risk in coastal zones, Vietnam must strengthen its risk information and decision-making tools.

Hazard data and protection mapping are essential for identifying physical and socioeconomic risks.

To understand the probabilities, severities, and spatial distribution of natural hazards, detailed data is essential. In Vietnam, such information needs to cover storm surges, riverine flooding, saline intrusion, drought risk, typhoon tracks, and coastal erosion. Other hazards—such as earthquakes and tsunamis—also pose real risks and should not be ignored. Such data can be derived from models that capture Vietnam’s topographic, geological, hydrological, and climatic characteristics. It is crucial they are not derived from rough global models; to support location-specific planning and investment decisions, they must be tailored to local needs. Besides hazard models, a carefully maintained historic record of disasters and their associated losses is essential to inform probabilistic estimates of asset and economic losses.

But hazard data alone only tell one part of the story. Protection infrastructure can substantially reduce risk levels that are estimated by hazard maps. For instance, dikes and drainage systems can mitigate the risk of flooding to a large extent, if they are built and maintained to a high standard. So, having complete information on the location, design standard, and maintenance status of protective assets is key for understanding gaps in current risk management and prioritizing upgrades.

Even with hazard data available, a key question remains: What is the likely impact of natural shocks on livelihoods, well-being, and economic activity? Historic data can go some way in answering this question, but only if such disasters have previously occurred in a similar setting and with a similar intensity. For planning purposes, hazard impacts need to be expressed systematically in economic terms that



DAK LAK >> Dikes and drainage systems can mitigate the risk of flooding if built to high standard.

iStock

convey the value of current and future assets at risk, as well as potential indirect effects on consumption and livelihoods (Hallegatte et al. 2016). This requires economic modeling of asset losses and the associated impacts on well-being for a wide range of disaster scenarios and policy intervention. In turn, such modeling can help simulate the cost-effectiveness of different policy options and inform decision making, as demonstrated by modeling exercises for Sri Lanka and the Philippines (Walsh and Hallegatte 2019a and 2019b).

The government of Vietnam has made efforts to develop and consolidate hazard data.

After Vietnam's National Action Plan for Disaster Risk Management identified strengthening hazard and risk mapping for coastal provinces as a key need, a series of government decisions were passed to develop detailed hazard maps for different regions.¹ Other legal frameworks — such as the National Disaster Risk Management Strategy, the National Target Programme to Respond to Climate Change, and the Decision on Community-Based Disaster Risk Management — also prioritize developing hazard maps at different levels, including conducting commune-level vulnerability and capacity assessments. In an effort primarily led by the Ministry of Agriculture and Rural Development (MARD) and the MONRE with support from various international partners, Vietnam has started collecting hazard and risk information and mapping nationwide, provincial and district-level hazards, vulnerabilities, and risks.

The Law on Natural Disaster Prevention and Control² reflects the need for a disaster information system to inform

policy design, particularly for disaster risk management (DRM). The country has developed several DRM data systems at national, provincial and commune level (box 6.1). Some provinces — including Thua Thien-Hue, Ho Chi Minh City, Long An, and Bac Lieu — have also developed DRM websites for sharing information at provincial level.

Hazard data and socioeconomic risk models are fragmented and incomplete.

Despite these efforts, comprehensive hazard data for key public and private sector institutions continues to be fragmented and largely under-developed. The national risk assessment (Part 1) and hotspot analyses carried out for this report (Appendix A) highlighted that available information for assessing hazards and risks is incomplete and often of unreliable quality. For example, detailed and validated storm surge and wind hazard maps are only available from global hazard models. Their resolution and accuracy are rarely good enough for site-specific assessments and they have not usually been validated with local data. While some local flood maps have been developed and distributed to local authorities, these are not made publicly available — for example, to decision makers in the private sector. Similarly, coastal erosion and saline intrusion maps exist only for specific locations or years, and do not cover the whole coastline. Although this study carried out detailed modeling to fill these gaps for six hotspots, the nationwide risk assessment had to rely on global data sources. Existing hazard data also tend to be scattered across various ministries and held by local authorities with limited central government oversight.

BOX 6.1 >>

An overview of previous efforts to assess and map hazards, vulnerability and risk in Vietnam

2011	2012	2013	2014	2017
In 2011, the United Nations Development Programme (UNDP) supported MARD to implement a nationwide risk assessment to identify 6,000 vulnerable communes for the national community-based disaster risk management (CBDRM) program. This produced national, provincial and district-level maps of hazard potential, coping capacity and hazard exposure, as well as an integrated risk index for all 11,112 communes and wards.	The Vietnam Institute of Meteorology, Hydrology and Climate Change in the MONRE completed downscaled climate change and sea level rise scenarios to serve as a basis for future risk assessments at different levels. It updated the scenarios in 2016 and these are being used for socioeconomic development planning (box 3.1).	Following Typhoon Haiyan in 2013, the government instructed the Committee for Flood and Storm Control (CCFSC) to develop superstorm surge risk maps and response schemes. Central and local-level agencies can use these maps to develop action plans to respond to future superstorms.	MARD approved official guidance materials for undertaking commune-level vulnerability assessments and developing CBDRM plans in line with the national CBDRM program. It developed these materials in partnership with key civil society organizations — including the Viet Nam Red Cross and Women's Union — and started work to roll the process out in more than 6,000 high-risk communes across the country.	Some local-level assessments have focused on the most vulnerable populations. In 2017 for example, 28 disability-inclusive community-based disaster risk assessments were conducted in Quang Tri and Quang Ngai provinces.

An integrated mapping of Vietnam's dike systems conducted for this report can help to inform local decision making. However, there are no similar asset inventories for other infrastructure types, including transport, water, sanitation, and energy. This means there is little information available that systematically describes the maintenance status and resilience standards of these assets. The exact location and status of many crucial natural protection systems—such as dunes, mangroves, and coral reefs—is not systematically documented and monitored, either. This report is the first to produce a

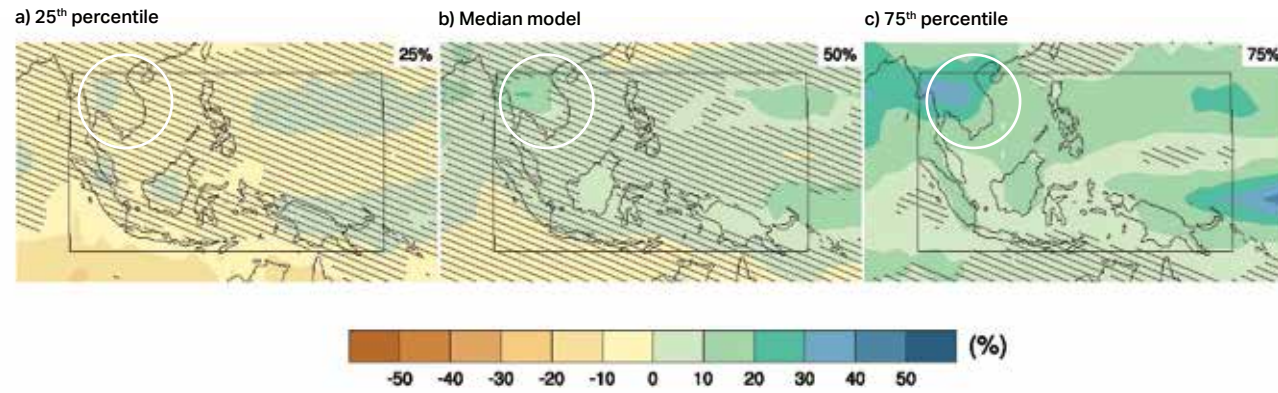
systematic hazard exposure analysis of all urban areas in coastal Vietnam. More detailed local-level exercises are yet to be conducted to mainstream risk assessments in urban planning processes.

Central government collects historic disaster data, which offer some estimates of the magnitude of province-level losses over the years. While these data disaggregate losses along a range of monetary and non-monetary variables, large fluctuations cast some doubt on the completeness of data collection. The World Bank's DFRI program has

FIGURE 6.1 >>

Climate models cannot make conclusive projections about future precipitation in the region

Precipitation change in a RCP4.5 scenario in 2081 to 2100 (October to March) for 25th, 50th, and 75th percentile of projections



Source: IPCC.⁴

Note: The driest 25 percent of models (a) project a decrease in precipitation, the median model (b) projects a slight increase, and the wettest 75 percent of models (c) project an increase. RCP4.5 refers to a medium climate change scenario (box 3.1). Hatching denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

worked closely with the Vietnamese government to better understand the contingent liabilities that are associated with disasters by conducting a probabilistic risk modeling exercise.³ Although this model highlights potential asset losses from different natural hazards, disaggregated by asset type and province, more detailed economic analyses of how asset losses translate into consumption and well-being losses—using, for example, the World Bank’s *Unbreakable* socioeconomic resilience model (Hallegatte et al. 2016)—are yet to be conducted.

Despite deep uncertainty, there is a lack of usage of robust decision-making tools.

For some of the natural hazards facing Vietnam’s coastal zones, even the most sophisticated hazard models cannot provide reliable estimates. And modeling the long-term

effects of climate change is tricky. Many well-respected models are in use, and each takes different assumptions and scenarios into account. The International Panel on Climate Change’s summary of projections from these models (figure 6.1) shows the large variability across models. The driest 25 percent of models show a decrease in precipitation for Vietnam, the wettest 25 percent project an increase in precipitation, and the median model projects a slight increase in precipitation (around 15 percent).

Despite this uncertainty, the government and private developers in Vietnam’s coastal zones continue to rely on a predict-and-act approach. However, long-term development decisions that assume a wetter future may be completely inadequate in a drier future scenario, and thus fail to promote resilient development. Overconfidence in a wetter scenario may lead to large investments in flood

protection, when droughts may pose a larger threat in the long term.

Robust decision-making tools are available that can help develop solutions in the face of deep uncertainty, which would improve the likelihood of decisions performing well in a variety of future scenarios (Kalra et al. 2014). It will be crucial for decision makers in Vietnam's coastal zones to make better use of such robust approaches that can adapt to the changing needs of the future (Chapter 11).

The lack of comprehensive hazard and risk information is hindering effective and systematic risk reduction in coastal zones. This information is key to identifying and prioritizing the areas that are at risk now and in the future. This study's hotspot analyses (Appendix A) also show that the lack of adequate information makes it difficult to define the location and size of adequate structural and non-structural measures. The lack of reliable information is also resulting in a limited understanding and awareness of risks among the wider public and private investors. Developing an adequate hazard and risk information base will be a high priority to enable more effective risk management measures, and more risk-informed planning and investment decisions. Concrete actions to address this challenge will be discussed in Recommendation 1: Strengthen data and decision-making tools (Chapter 11).

Endnotes

1. Particularly the Prime Minister's Communication 171/TB-VPCP on April 23, 2014 and Communication 410/TBVPCP on October 13, 2014 for developing flood mapping for strong storm and storm surge.
2. Law No. 33/2013/QH13.
3. For more on the World Bank DRFI Program, see <https://tinyurl.com/yctdngbl>
4. IPCC Fifth Assessment Report (AR5) <https://www.ipcc.ch/assessment-report/ar5/>

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Institutions and policies for coastal zone management lack enforcement

Vietnam has developed an institutional and legal framework to manage its coast through integrated coastal zone management (ICZM). It uses planning tools — including integrated coastal resource management programs, marine spatial and land use planning, coastal setback lines and resettlement and relocation programs — to strengthen the coast’s resilience against natural hazards. But a lack of guidance and enforcement at national level and capacity and funding at lower government levels means that progress in implementing these tools has been slow. This has created an environment of uncontrolled risks in the coastal zone that will become increasingly difficult to reverse and manage.

7.1 >>

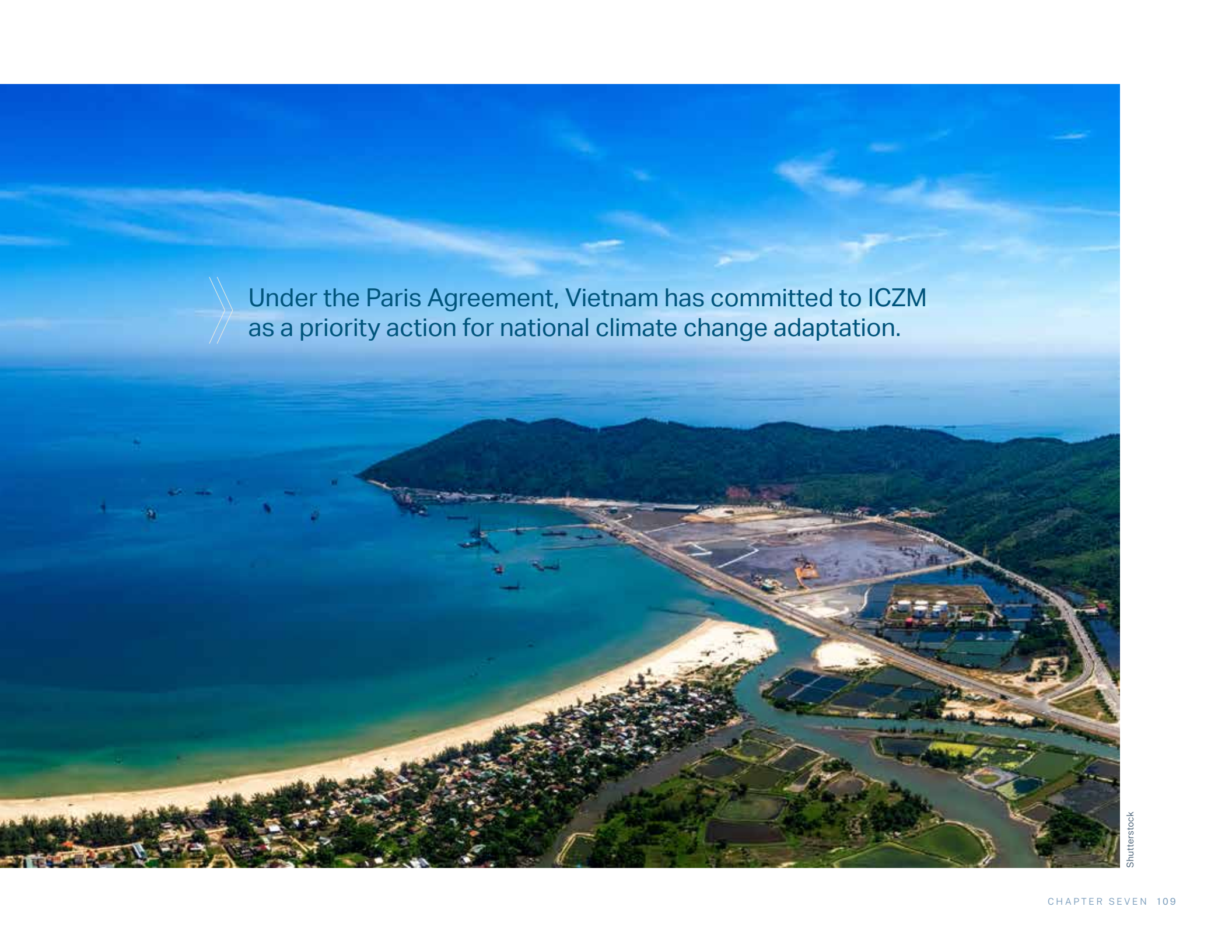
Vietnam has made significant progress in integrated coastal zone management

Vietnam is moving from a sectoral to an integrated planning approach.

Detailed socioeconomic development plans—at both national and provincial levels—set out Vietnam’s vision and objectives for future development. With ambitious targets for growth rates and investment programs, these plans are testament to the country’s potential. The government has developed detailed plans for most coastal zone areas and economic sectors, including fisheries, aquaculture, forest management, water resources, tourism, transport and industry. In line with these plans, profound transformations

are underway along the coast, with small-scale agriculture transforming into agro-industrial production, villages into towns, and fishing harbors into international trading hubs.

However, responsibility for implementing long-term sectoral development plans typically overlaps several stakeholders, including different administrative levels of government. A lack of coordination between them and competing demands from different sectors has resulted in conflicts between economic development, urbanization, disaster risk management, and environmental preservation needs. At the same time, local authorities do not always have the budgets and planning capacity required by ambitious sectoral plans. Having recognized the challenges of this sectoral approach, the government is undertaking measures to increase the consistency and alignment of sectoral investment and planning decisions.

An aerial photograph of a coastal region. In the foreground, a sandy beach curves along the shoreline, with a small town and residential area just inland. To the right, there are several rectangular ponds or aquaculture tanks. A large, dark, forested hill dominates the background. The water is a deep blue, and the sky is a clear, vibrant blue with some light clouds. The text is overlaid on the upper left portion of the image.

Under the Paris Agreement, Vietnam has committed to ICZM as a priority action for national climate change adaptation.

Since the early 1990s, Vietnam's policymakers have moved towards a more comprehensive and integrated approach addressing climate risks in coastal areas, creating the basis for adopting ICZM. One milestone on this pathway was establishing a formal institutional framework to ensure the effective implementation of ICZM in Vietnam. Two administrative documents in 2009 and 2012 formalized the implementation of the national ICZM approach, but they lacked the full weight of law and policy. Since then, the government has taken several steps to address this situation, introducing new legislation and strategies to strengthen ICZM (box 7.1).

The 2014 National Strategy on ICZM, the 2015 Law on Marine and Island Resources and Environment, and the 2016 National Coastal Zone Action Plan provided a framework for ongoing ICZM activities. The Law mandated the People's committees of coastal provinces to establish a coastal protection corridor (setback zone). The ICZM National Strategy and Action Plan mandates the implementation of the provincial-level Integrated Coastal Resources Management Program as one of its main outputs. MONRE has issued technical guidance to provinces and cities focused on implementing ICZM programs, which includes:

BOX 7.1 >>

Institutional and legal framework for implementing ICZM in Vietnam

The governance of coastal and marine environments is shared across multiple ministries, including national defense, foreign affairs, construction, transport, agriculture and rural development, industry and trade, planning and investment, science and technology, natural resources and environment and culture, and sports and tourism.

At central level, the National Assembly is the highest legislative body to contribute to ICZM. The government has the biggest role in ensuring ICZM laws are executed

and adhered to, and in 2008, established the Vietnam Administration of Seas and Islands (VASI) to ensure effective ICZM implementation across different areas and sectors. Working under the MONRE, VASI assists and advises the Minister of Natural Resources and Environment in implementing and ensuring the integrated and unified state management and coordination of all seas, islands and coastal areas. In 2017, a Coordination Committee was established, with representatives of all the coastal provinces, to coordinate multidisciplinary activities.

At provincial, district and commune levels, coastal and marine governance is shared by local agencies, including Departments of Natural Resources and the Environment (DONREs); Departments of Agriculture and Rural Development (DARDs); Departments of Industry and Trade; Departments of Construction; and Departments of Planning and Investment. The DONREs are in charge of coastal planning and management, including ICZM. District and commune people's committees also provide administrative and logistical support for implementing ICZM activities.

- Developing and institutionalizing a multi-sector coordination mechanism for ICZM implementation
- Preparing and implementing communication schemes to raise awareness on ICZM
- Strengthening financial and technical capacity at the local level
- Developing and implementing local co-management models for coastal resources
- Establishing corridors for local coastal protection

ICZM implementation is rolling out.

In its Nationally Determined Contribution (NDC) to the Paris Agreement, Vietnam committed to implementing ICZM as a priority action for national climate change adaptation by 2030. Its first ICZM project — the Vietnam-Netherlands ICZM Project — ran from 2000 to 2006 with bilateral cooperation. Today, ICZM is being implemented along about 36 percent of the country's coastline and developed in two-thirds of its coastal provinces. This includes Quang Ninh Province, Hai Phong City and Nam Dinh Province in the north; all 14 coastal provinces in Central Coast Regions, from Thanh Hoa to Binh Thuan; and Ba Ria-Vung Tau, Soc Trang and Kien Giang Provinces in the south. The government is also in the process of expanding Program 158 — which focuses on strengthening capacities for the management, exploitation and efficient use of natural

resources and the environment — from the 14 initial coastal provinces to all 28 coastal provinces and cities.

Enforcement remains a major challenge.

ICZM implementation faces significant challenges, as coastal provinces struggle to develop and implement provincial-level integrated coastal resource management programs due to their lack of legal basis. One of the laws — the Master Plan for Sustainable Exploitation and Use of Coastal Resources¹ — is currently at task construction stage and has been sent for consultation with ministries, sectors and coastal provinces. The MONRE is expected to submit the master plan to the government by 2021, while the ICZM Action Plan tasks must be implemented by 2020. The 2015 Law on Marine and Island Resources and Environment does not mention the ICZM strategy, stipulating only the Strategy of Sustainable Exploitation and Use of Coastal Resources.² This creates some inconsistencies that further confound task implementation in coastal provinces.

The lack of funding for Coordination Committee activities also limits the implementation of the integrated coastal resource management programs. Although established in 2017, the Office of the Permanent Agency, which assists the committee, has not been allocated any funding for guiding, inspecting and monitoring local task performance. The committee helps coordinate activities around coastal functional zoning, a main component of the master plan.³

7.2 >>

Spatial planning tools are scarcely implemented

Vietnam uses coastal zoning to manage continuous change in coastal communities.

Vietnam's coastal areas have undergone significant land cover changes over the last few decades. Significant wetland and forested areas have been converted to agriculture lands (Funkenberg et al. 2014; Tran et al. 2015). Mangroves have been cut down to make space for shrimp farms and other aquaculture practices (Binh et al. 2005; Sakamoto et al. 2009; Tong et al. 2004). Urbanization has increased considerably, and an expanding road network connects these fast-growing settlements, cities and industrial areas (Karila et al. 2014; Tran et al. 2015). Other large-scale changes in the coastal zone include increased flood control through extensive dike systems, particularly in the Mekong Delta system (Triet et al. 2017); widespread groundwater resource exploitation (Wagner et al. 2012); sand mining activities, particularly in the central regions' dune system; and reduced sediment supply due to upstream dams (Kummu and Varis 2007; Kondolf et al. 2014).

In response to these trends, the government has moved towards implementing coastal zoning or spatial planning practices, to better plan the development and management of coastal and surrounding areas. Vietnam has a clearly defined institutional framework for

implementing these practices, progressively establishing and reflecting it in legal documents that regulate the organization, accountability, functions and tasks of specialized agencies (box 7.2). The government uses three main tools—marine spatial planning (MSP), land use planning, and coastal protection corridors or setback lines—to implement coastal zoning.

Marine spatial planning is under way, but progress is slow.

The government has progressively promoted MSP as a practical tool for strengthening coastal area management by adopting an ecosystem-wide approach to planning, minimizing conflicts in marine space exploitation and use, and reducing exposure to natural hazards and climate risk (World Bank 2019). It aims to apply functional zoning to efficiently exploit and use natural resources, protect coastal areas to meet sustainable socioeconomic development needs, adapt to climate change, and ensure national defense and security.

The 2017 Law on Planning⁴ provides a legal basis for MSP. It requires the development of a national marine spatial master plan to ensure the efficient and sustainable use and exploitation of marine and island resources on a multisector planning and management basis. This plan is expected to provide for more detailed and integrated multisector planning, essentially replacing the need for individual sector plans. The planning scope includes all coastal waters with an outer boundary of six nautical miles from the coast and all communes, wards and towns

BOX 7.2 >>

Institutional and legal framework for coastal zoning and spatial planning in Vietnam

National jurisdiction over coastal land management, land use and spatial planning or zoning falls under the MONRE. According to the Law on Marine and Islands Resources and Environment (2015), the ministry is responsible for formulating the Master Plan for the Sustainable Exploitation and Use of Coastal Resources and the Integrated Coastal Resource

Management Program, and for establishing coastal protection corridors.

Within the MONRE, VASI — the state management agency for the total unification of sea and islands — is responsible for developing marine policy, laws and legal documents; submitting them to the government for

approval; developing coastal, marine and island use planning and management; and identifying, monitoring and inspecting coastal protection corridors. The General Department of Land Administration (GDLA) assists the MONRE in land use planning and management.

The provincial people's committees (PPCs) are

responsible for state coastal area management. According to the Law on Marine and Islands Resources and Environment,⁵ the PPCs are responsible for setting up and managing coastal protection corridors. The DONREs support the PPCs by managing and issuing licenses for exploiting coastal resources in their provincial authorized boundary.

adjacent to the sea in the 28 coastal provinces and cities directly under the central government. By allowing for a more ecosystem-based approach to planning, identifying and mitigating user conflicts in marine space, the master plan will help protect, maintain and restore ecosystems, endemic species, natural resources, environmental quality and cultural heritage in coastal areas and reduce their exposure to climate risk.

Developing a national marine spatial master plan has been a slow process. By May 2020, it had only been adopted in one province — Ca Mau — and was being developed for eight other coastal provinces as part of the World Bank-

financed Coastal Resources for Sustainable Development Project, in collaboration with MARD.

As a result of this slow process, all other plans — which, according to the provisions of the 2017 Planning Law, need to be based on and aligned with this national marine spatial master plan — are experiencing delays in their completion (The World Bank 2019). This includes the National Master Plan for Sustainable Exploitation and Use of Coastal Resources, still under development by the MONRE, which will need to be streamlined with the national marine spatial master plan and comply with the relevant provisions of the Law on Planning and any subsequent decrees.

IMAGE 7.1 >> Settlements on sensitive coastal dunes in Phu Vang, Thua Thien-Hue province



Source: Google Earth

Urban and land use planning is required by law, but is far from effective.

The government of Vietnam has emphasized the need to establish land use plans that detail the way in which coastal areas are developed and urbanized. The Land Law⁶ requires all areas of Vietnam to develop detailed land use plans. Led by the MONRE, this process produces 10-year land use plans, which are revised every five years. Land use maps, which help delineate the different uses of land, have been developed for the entire coastal zone, including the two deltas (Hua Chien Thang et al. 2011). They are complemented by high-resolution land cover maps derived from satellite imagery.⁷

Some local authorities have started reviewing, modifying and adjusting their land use plans with respect to potential climate change impacts. For example, the Hai Phong and Quang Ngai land use plans take potential climate change impacts into account, while Hai Phong and Phu Yen have restructured or shifted crops and livestock production accordingly. Some provinces—including Quang Ninh, Phu Yen, Khanh Hoa, Ben Tre, Soc Trang and Kien Giang—have started implementing functional zoning practices, including resource exploitation and use, in their coastal areas. Such functional zoning is closely linked to and should be compatible with the Master Plan for Sustainable Exploitation and Use of Coastal Resources. Indeed, local coastal functional zoning would need to be reviewed and adjusted once the national marine spatial master plan has been completed (World Bank 2019).

Despite these efforts, land use planning in Vietnam is far from effective (Hua Chien Thang et al. 2011). While provincial authorities have developed land use plans as required by the Land Law, they tend to use them for land administration, rather than as an effective framework for coastal environmental management and long-term planning. Where land use plans do set out longer-term development objectives, their enforcement has been patchy. In several localities, socioeconomic development has not complied with planning, increasing the risk of disasters (UNDP 2015). The hotspot analyses undertaken for this study (Appendix A) confirm that many land use maps in socioeconomic development plans do not consider natural hazards and risks.

Coastal setback lines are needed.

Given the natural dynamics of erosion and sedimentation, Vietnam's coastal corridor of few hundred meters to the seafront—which includes foreshores and beaches—is particularly sensitive. Settling in these dynamic zones can expose communities to severe risks and harm sensitive ecosystems that play a crucial protective role, such as coastal dunes. Developing coastal setback lines can help address these challenges.

A coastal setback line is a protection corridor that minimizes damage from coastal erosion and flooding to coastal lands. In Vietnam, the concept of coastal setback lines was first regulated in the 2015 Law on Marine and Island Resources and Environment⁸ (Dang Van Bao and Tran Van Truong 2018), which stipulates that all coastal

provinces should have established their coastal setback line within 18 months of the law's promulgation.

Although all 28 coastal provinces have started the process, defining and enforcing the coastal protection corridor has been challenging. Stakeholder consultations with communities and enterprises have been delayed. There are no guidelines on how to define and incorporate high-value ecosystem goods and services in the delineation of setback lines, as highlighted by some local Departments of Seas and Islands (World Bank 2019). By 2019, only Quang Ngai Province had published a list of areas within the coastal protection corridor and setback line boundaries (World Bank 2019). While this slow process unfolds, rapid urban expansion and coastal development continues in sensitive seafront zones, cementing heightened risks to future development.

7.3 >>

Resettlement and strategic retreat require careful planning and safeguards

Strategic retreat offers a solution when risk mitigation is unaffordable or infeasible.

In areas where land and water management strategies are not feasible, planned relocation offers a long-term, alternative adaptation strategy to coastal hazards and environmental change (Entzinger and Scholten 2015). Environmental stress caused by the increased flooding, saline intrusion or the degradation of agricultural lands, among others, has contributed to significant migratory

flows over the last two decades in Vietnam (United Nations Vietnam 2014). As climate change exacerbates the frequency of extreme shocks, the pace of slow-onset stresses, and extent of environmental degradation in coastal areas, the nature and scale of migration has begun to change (United Nations Vietnam 2014).

In line with these overall trends, Vietnam has a long history of resettlement (United Nations Vietnam 2014). The government has used planned resettlement and relocation as part of managed and assisted programs to complement coastal zoning planning and address excessive natural risks in certain locations (box 7.3).

Legal and institutional frameworks guide the resettlement programs.

The government has a well-established legal and institutional framework for resettlement and relocation. Specifically targeting disaster-prone areas, the Living with Floods Program promoted the relocation of 150,000 households and is the country's largest population movement program (UNDP 2015) (box 7.3). The Land Law allows the government to reclaim or recover land for disaster risk reduction purposes—for example, to avert threat to human life (Chun 2015). When this happens, land users are entitled to compensation, support and relocation.

Institutional roles for implementing such measures are well defined, spreading across multiple government agencies. MARD oversees state-managed relocation and the Ministry of Labour, Invalids and Social Affairs (MOLISA) deals with

BOX 7.3 >>

A history of relocation programs in Vietnam

Since at least 1996, the government has made the connection between environmental change and relocation. In response to the catastrophic Mekong River floods in 2000, it introduced the concept of living with floods into its disaster mitigation and management policies (Chun 2015), establishing the Living with Floods Program (Vo and Mushtaq 2011). The program introduced various adaptation strategies to natural hazards and climate change, including resettlement (Entzinger and Scholten 2015), providing safe and permanent residences with access to basic infrastructure such as clean water, schools and health clinics (Chun 2015).

The Living with Floods Program was renewed several times (United Nations Vietnam 2014) and the Master Plan for Urban Planning until 2020 continued the program to relocate people from flood-prone areas of the Mekong Delta and resettle populations that are vulnerable to coastal erosion (UNDP 2015).

In 2006, the prime minister issued the Decision on Approving the Program on Population Distribution in Natural Disaster and Special Difficult Areas, Border Regions, Islands, Areas Inhabited by Free Migrants and Important and Very Important Areas of Protective Forests and Strictly Protected Zones of Special-use Forests,¹⁰ which promoted the relocation of 150,000 households between 2006 and 2015 (table B7.3.1).

TABLE B7.3.1 >> Relocation projects in coastal provinces

Province	Project details
Quang Ninh	• Relocated people from 14 sites impacted by floods to safe areas
Quang Tri	• Built resettlement areas, including in the districts of Dakrong, Hai Lang, Trieu Phong, and Cam Lo
Da Nang	• Established an implementation plan to move residents in Hoa Bac commune, Hoa Phu, Phu Vang District
Quang Nam	• Relocated people from Dai Loc District and Dien Ban town
Quang Ngai	• Moved nearly 400 residential households in areas at risk of landslide and erosion to an emergency resettlement area • Built and used disaster prevention community houses in 93 communes in seven delta districts
Binh Dinh	• Relocated settlements in Tuy Phuoc district • Built resettlement areas and storm shelters
Phu Yen	• Relocated settlements in communes such as Banh Lai on the Ky Lo river

economic migration, including the migration of laborers to new economic zones. MOLISA coordinates with MARD on labor and certain population relocation programs. PPCs at different levels also issue policies and regulations on population and mobility (Chun 2015).

Strong safeguards are needed to avoid potentially adverse impacts on livelihoods.

Although resettlement efforts in Vietnam have yielded many positive results, challenges remain. Relocation can

provide households with safer homes away from risk-prone areas, improved living conditions and better access to public services. But it can also make socioeconomic conditions worse, if people can no longer access their jobs or accrue debt through relocation. If this happens, relocation can exacerbate households' long-term vulnerability, particularly for poor households, calling into question the cost-effectiveness of such an adaptation strategy.

Development trends and climate change impacts will bring additional challenges to resettlement strategies. Rapid economic and population growth in recent decades means that land in general and safe land in particular is becoming scarce (UNDP 2015). Predicted sea level rise scenarios based on the MONRE climate change scenarios also indicate that a significant portion of the population may require relocation, particularly from the Mekong Delta Region.

This means that in the future, relocation may occur over larger distances, sometimes forcing households away from the coast, their sources of income, and their livelihoods. If the new resettlement land does not provide enough opportunities for maintaining a similar economic livelihood, households might be forced to sell the land and seek employment in urban areas or try to return to their original communities. Some could be worse off after relocation, with lower incomes, increased debt and diminished self-sufficiency.

Today, resettlement and relocation programs are well established in Vietnam. For them to remain an effective risk

mitigation strategy, authorities will need to take into account the added challenges of climate change, and strengthen the safeguards and features of existing programs.

Endnotes

1. Paragraph 2, Article 35 of the Law on Marine and Island Resources and Environment.
2. Articles 9 to 11, Chapter II.
3. Execution of this task was implemented under the Planning Law, effective from January 2019.
4. Law No. 21/2017/QH14 (November 24, 2017).
5. Law No. 82/2015/QH13 (June 2015).
6. Law No. 45/2013/QH13 (November 29, 2013).
7. The satellite imagery is retrieved from: JAXA EORC. 2018. *High-Resolution Land Use and Land Cover Map of the Southern Region of Vietnam*. Version 18.09.
8. Law No. 82/2015/QH13 (June 2015).
9. Decision No.193/2006/QĐ-TTg (August 24, 2006).

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Infrastructure systems often lack risk-informed planning and systematic maintenance

With a large share of Vietnam's population and economic activities concentrated in the low-lying coastal zone, infrastructure assets are exposed to flooding, typhoons, rainfall and other hazards. The extensive dike system is a vital asset for managing flood risks, but its design and maintenance standards fall short of the needs for ensuring the resilience of coastal communities. The same holds for lifeline infrastructure systems, including transport, energy, and water and sanitation systems. A lack of consistent resilience standards, risk-informed planning, and maintenance mean that natural shocks often cause costly disruptions. Regulation and enforcement are insufficient to ensure that private assets, such as houses and hotels, are built in line with risk-informed technical standards and building codes. Together, these shortcomings cause costly service disruptions to infrastructure users and result in a lack of resilience in coastal communities.

8.1 >>

An extensive dike system provides protection, but requires more systematic planning and maintenance

The government has long invested in sea dike systems, and today these extensive systems form an essential element of its coastal resilience strategy. Extending over 2,659 kilometers, this estuary and sea dike system is similar in length to those in Bangladesh and the Netherlands. Sea dikes are particularly advanced in the northern provinces (figure 8.1), which often bear the brunt of typhoons and storm surges. But overall, the river dike system provides higher levels of protection. In the Red River and Mekong River Deltas, several provinces have hundreds of kilometers

of dikes each to protect low-lying areas adjacent to rivers from flooding.

The government has invested significantly in the sea dike system, starting in 2009, when it issued a decree on strengthening, upgrading and rehabilitating sea dikes from Quang Ninh to Kien Giang.¹ This national program was divided into three periods, with clear objectives:

- **2009–2012:** Planting mangrove forests parallel to the sea dike system
- **2013–2016:** Upgrading and developing the sea dike system alongside the road network
- **2017–2020:** Building a sluice system to operate the sea dike system in a way that adapts to sea level rise

FIGURE 8.1 >> Extent of the river and sea dike system in Vietnam's Delta Regions

Dike systems in the Red River Delta (left) and Mekong River Delta (right)



Source: Based on data from the VNDMA.

Partly as a result of these efforts, many sea dike systems are shielded by mangrove belts on the seaward side. These play an important role in the flood defense system, dissipating incoming wave energy and reducing erosion rates, decreasing wave-driven, wind-driven and tidal currents, while also contributing to sediment stabilization (Deltares et al. 2017). Mangrove forests are particularly valuable in the delta or river estuary coasts. The government has an active mangrove restoration and protection policy—often combined with sea dikes—and most provinces plant, protect, and restore mangroves for dike protection.

The organizational structure for overall dike system management and maintenance has well-defined roles and responsibilities at various levels of government. The Department of Dike Management, under MARD's VNDMA, is responsible for monitoring, maintaining and improving river and sea dike design and funding for major Grade I to III dikes with high safety standards, while the provincial DARDs are responsible for Grade IV and V dikes.

All provincial dike departments and their subordinate branches systematically evaluate dike safety every year after the rainy season, allowing them to develop plans for maintaining and upgrading the system. However,

although department offices record data on dike incidents and upgrades, these inspections mainly rely on expert judgment and do not use analytical tools or systems.

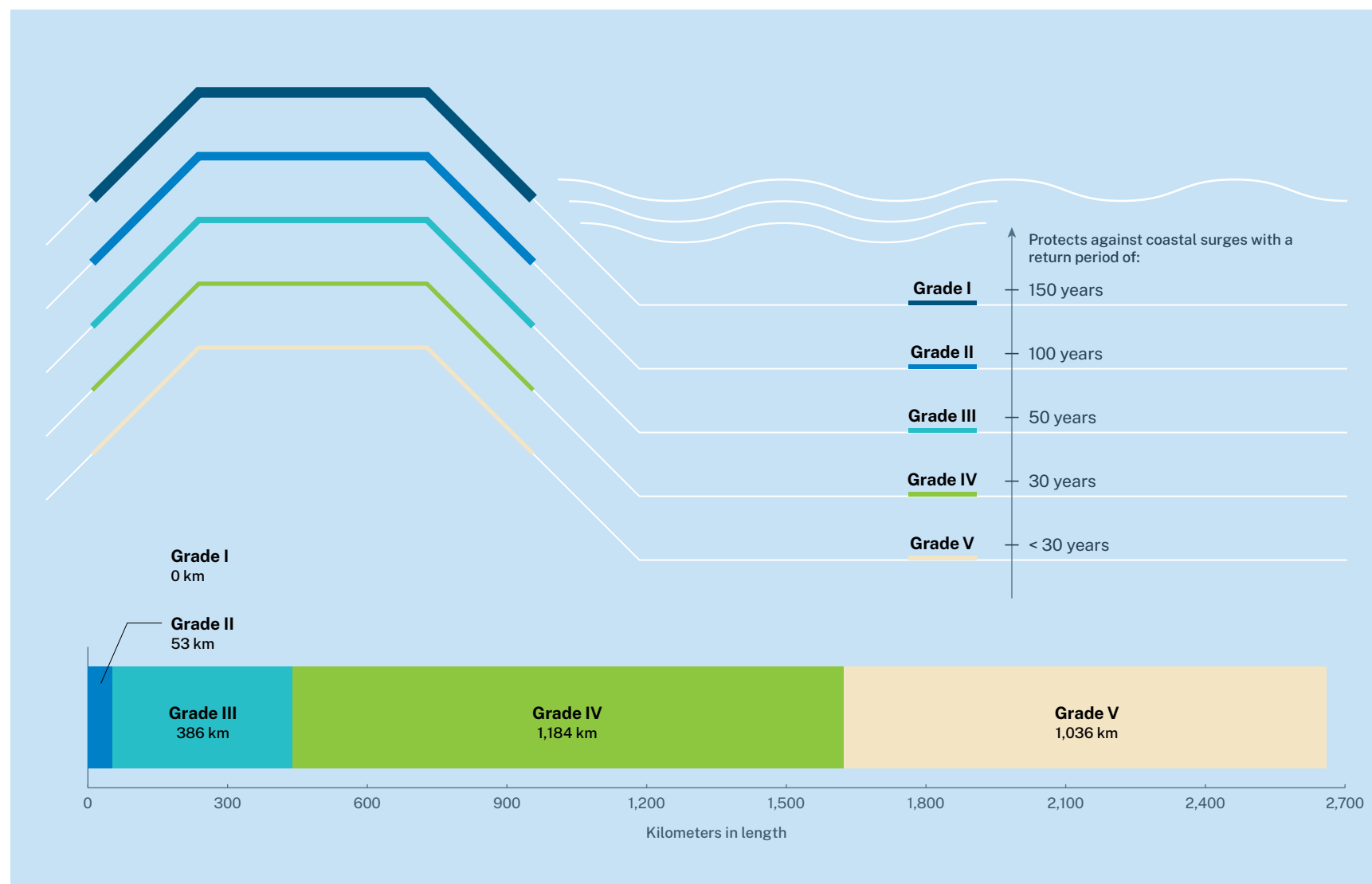
Safety standards prescribe the level of protection.

Different sections of the sea dike system fulfill different protective functions, depending on their location. In densely populated urban areas, they protect the lives and livelihoods of tens of thousands of people, as well as valuable economic assets and public infrastructure; in rural areas, requirements are less stringent. MARD has issued a comprehensive set of guidelines and safety standards for sea dike designs, which distinguish five protection levels or grades (MARD 2012).

In general, the applicable grade for a certain stretch of sea dike is based on the area and number of residents it protects. For areas of industrial and economic importance, safety requirements can be upgraded to a higher grade on a case-by-case basis. Dikes in rural areas with few people have the lowest safety standard (Grade V), designed to withstand storm surges and waves with a return period of under 30 years (figure 8.2).² For large, populous areas of economic importance, a Grade I safety standard applies, which requires protection against storm surges and waves

2,659 km » Length of Vietnam's sea dike system

FIGURE 8.2 >> Sea dike length distribution for different safety standards in Vietnam



Source: van Ledden et al. 2020.

with up to 150-year return period. The grade also defines allowances for sea level rise and an extra uncertainty margin that are added to the design water level.

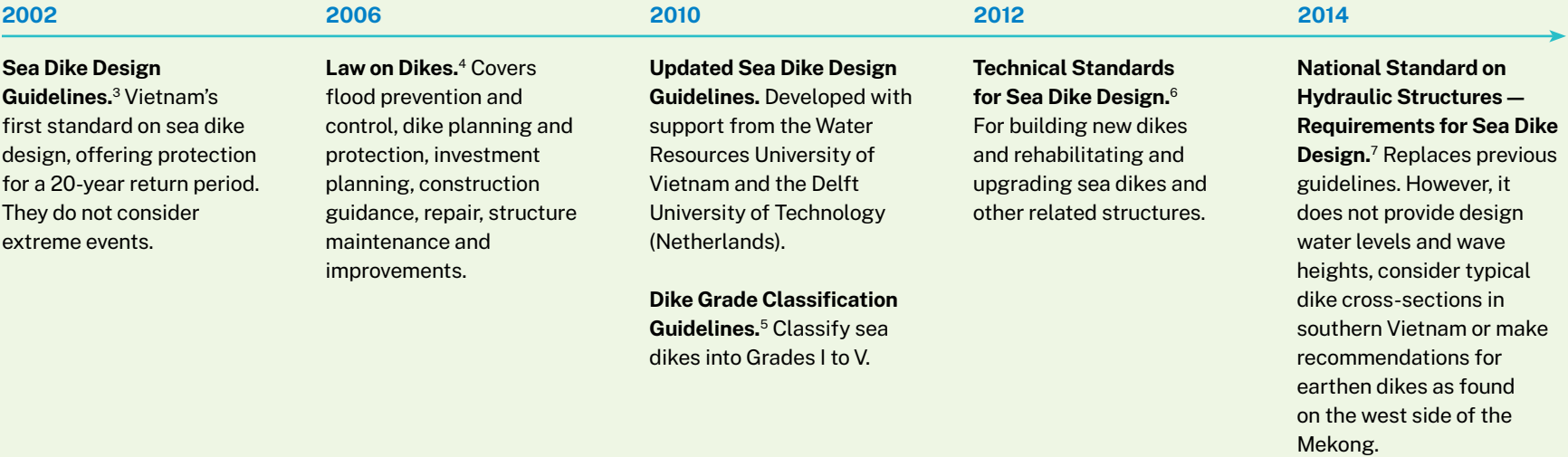
Required safety standards are not only low, but often also not met.

Although target safety standards for dikes vary across the country, they are relatively low in many coastal provinces. About 84 percent of the system is classified as a Grade IV or V, providing protection against coastal surges with a 30-

year return period. The safety level in Vietnam tends to be higher than Bangladesh, where the adopted safety standard is typically 1-in-25 years at most. However, it is significantly lower than the Netherlands, where safety standards are typically between 1-in-250 years and 1-in-10,000 years.⁸ Sea dikes in the Red River and Mekong Deltas also differ considerably. In the Red River Delta, safety standards vary between Grade III (50 years), IV (30 years) and V (10–30 years), crest heights are usually about five meters above sea level and the dikes have seaward slope protection against severe waves. In the Mekong Delta coastal provinces, dikes

BOX 8.1 >>

A history of sea dike design standards in Vietnam



are generally 2–3 meters high, often of earthen construction and offer only Grade IV or V protection.

For densely populated areas, these standards are likely to be too low. Although safety standards tend to be higher in more populous and industrialized areas, the risk to lives, livelihoods and assets remains substantial.

An extensive assessment of Vietnam's entire sea dike system conducted for this report suggests that two-thirds does not meet the prescribed safety standard.⁹ The assessment measured dike crest heights and compared them with current required heights for each dike stretch, as prescribed by the safety standards. However, they do not include safety increment or consider sea level rise. Figure 8.3 shows the results of this assessment for all coastal provinces. Only 35 percent of the country's dike length meets the standard; 38 percent is below standard, and 27 percent is far below. Most of the dikes in the Red River and Mekong Deltas provinces require upgrades.

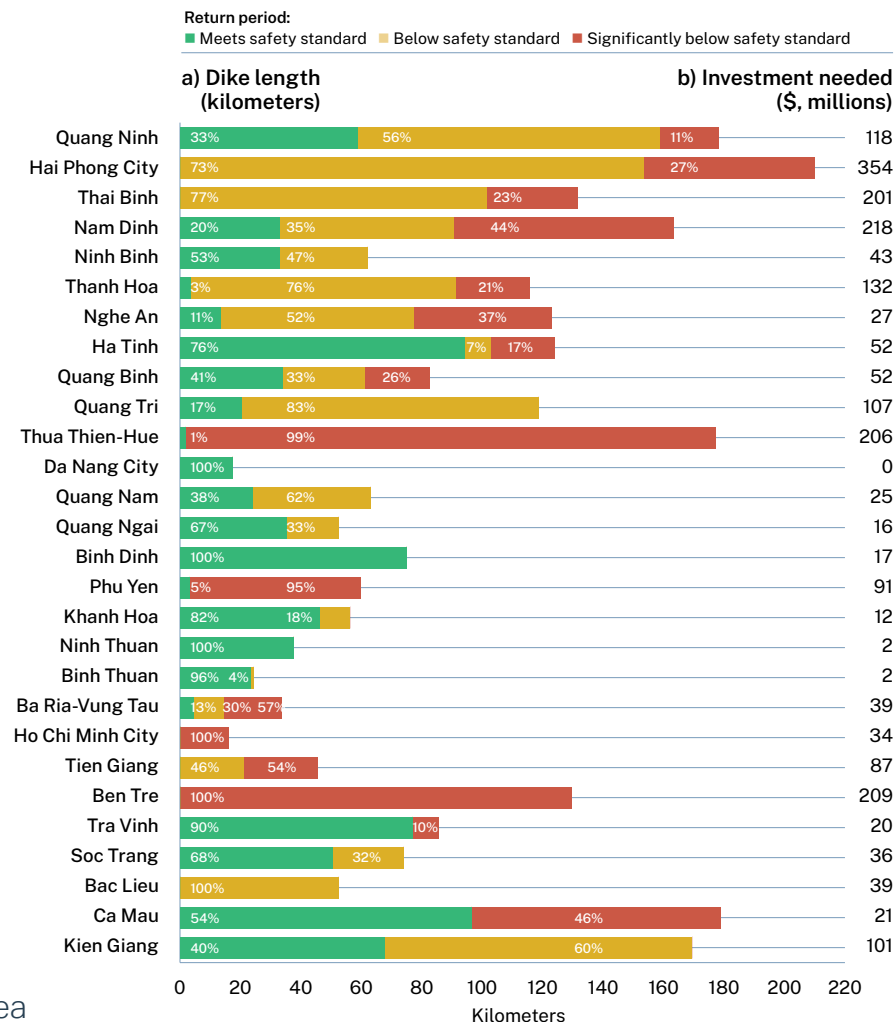
Resources for necessary upgrades and maintenance are limited.

This study estimates that around \$2.3 billion in capital expenditure are needed to upgrade the sea dike system to the current VNDMA safety standards.¹⁰

65% » The percentage of Vietnam's sea dike system that does not meet the prescribed safety standard

FIGURE 8.3 >>

Assessment of existing sea dike system in Vietnam



Source: van Ledden et al. 2020.

Note: Investment needed includes costs to upgrade dike segments to meet prescribe safety standards, making allowance for future sea level rise.

Although substantial, these are lower-bound estimates that do not factor in maintenance costs or economic and demographic growth. As coastal regions continue to develop, the required safety standards are likely to increase—and with them, investment needs. The government will therefore need to prioritize investments in dike upgrades and should revisit current safety standards to ensure that they are adequate for the level of risk local communities face. The exposure analysis in Part 1 offers an overview of the most under-protected provinces and can form the basis for formulating local upgrade and investment plans.

Implementing upgrade and maintenance plans depends on the availability of funding. Based on a yearly evaluation of the dike systems and provincial funding requests, MARD allocates funding to the provinces for maintenance and upgrades. However, the \$50 million annual sea dike maintenance and upgrade budget does not cover the system's needs as described above.¹¹ Annual maintenance costs for a one-kilometer dike stretch are around \$22,000–33,000¹²—that is \$60–90 million in total. This exceeds the current total annual budget and leaves no room for upgrades to achieve the established safety standards.

Given these substantial expenditure requirements, multilateral assistance could be vital in enabling central and

provincial governments to achieve the necessary upgrades. Socioeconomic and climatic changes will further increase protection requirements and spending needs. A long-term development and funding strategy for Vietnam's sea dike system is therefore essential. Chapter 13 recommends concrete actions for addressing these challenges.

8.2 >>

Building codes and design standards for infrastructure assets need to be aligned and enforced

Design standards are barely keeping up with rapid urbanization and infrastructure development.

Vietnam has one of Southeast Asia's highest urban expansion rates (World Bank 2015) and has experienced significant rural-urban migration towards the coast. Expansion areas are often established informally, in disaster-prone areas and without the benefit of risk reduction and guidance from building or land use regulations. Unregulated land use allows settlements in hazardous sites, increasing their exposure to natural hazards, while unregulated construction allows people to build vulnerable structures, compounding the risks for large segments of urban and rural populations in these areas.

\$22K–\$33K >>

The maintenance cost for a one-kilometer dike stretch, which exceeds the current budget and leaves no room for safety improvements

When unplanned informal urban expansion is followed by infrastructure development to provide essential services, unsafe living conditions can be cemented into the far future. These trends highlight the crucial importance of regulations that ensure the resilience of buildings and infrastructure assets, both in terms of design and location choice (Moullier et al. 2015). Forward-looking infrastructure planning can actively guide urban expansion into safe zones (Hallegatte et al. 2019).

A centralized approach to setting safety standards for infrastructure.

The government of Vietnam takes a centralized approach to its construction regulatory system, issuing decrees that the Ministry of Construction converts into building and construction codes. Other ministries — such as health and environment — can also provide input (USAID 2013). The government has adopted and upgraded many technical standards or norms for designing and building assets through this process, including the Sea Dike Design Guidelines, which have been updated and amended over the years (box 8.1).

Safety standards for buildings were applied at a larger scale following the 2012 decision to pilot 700 flood-resilient houses in seven coastal provinces and the 2014 Target Programme to Provide Support Policies and Solutions for Poor Households to Build Storm and Flood-resilient Houses in Central Region.¹³ While safety standards have also been developed for other infrastructure types — such as roads, bridges, flood protection, resilient housing, water

engineering and irrigation systems — these sectors do not systematically enforce risk-informed planning and design.

Resilience is not yet at the heart of infrastructure planning and design.

Building practices in Vietnam still have major shortcomings. This became apparent in the aftermath of Typhoon Damrey in 2017, which caused significant damage and destruction to 300,000 housing units, over 500 kilometers of roads, 1,600 electricity poles, and numerous bridges, irrigation canals, water supply and treatment plants. The typhoon's destructive force was multiplied by a lack of systematic resilience standards in the infrastructure planning and investment process.

Coordination problems can explain some of these shortcomings. Different sectors have developed their own technical standards and building codes with little or no coordination. Despite the recent rapid socioeconomic development and climate change impacts, many have not been updated, leading to inconsistencies, especially around resilience standards for natural hazards. For example, the Master Plan for Water Engineering Development in the Central Region for 2012–2020¹⁴ sets different safety levels across important river basin cities in the region, while the Vietnam Construction Standard¹⁵ regulates a common safety level for cities across the country.

While sea dike or water resource infrastructure planning has always taken natural factors into account, disaster risk management practitioners and other infrastructure

agencies do not. Lifeline infrastructure systems have some mandated resilient construction standards, but these are not systematically enforced, and private developments are not systematically required to assess risks or environmental impacts.

When infrastructure projects are designed without considering natural risks, local communities tend to bear the bulk of the adverse effects and costs; yet these are usually not reflected in investment appraisals (Hallegatte et al. 2019). This has resulted in an infrastructure stock — from homes and hotels, to transport, energy, and water systems — that not only fails to meet the needs of resilient communities, but sometimes exacerbates natural risks. For example, the construction of jetties in several coastal towns has severely aggravated the risks of erosion.

Lack of capacity and the ineffective use of scarce resources at local and municipal levels is another fundamental problem in Vietnam. Regular maintenance is widely recognized to be essential to ensure the resilience of infrastructure systems such as power grids, but responsibility rests with local authorities. Central oversight of maintenance activities is limited. Likewise, local authorities rarely have the resources or guidance they need to ensure the systematic maintenance and upkeep of assets. Chapter 13 recommends four concrete actions to streamline the way infrastructure systems and buildings can be made more resilient to better serve Vietnam's coastal communities.

Endnotes

1. Decree No. 667/QĐ-TTg (May 2009).
2. The dike assessment for this report applies a 20-year return period for Grade V. For more details on the technical standards in sea dike design, see van Ledden et al. (2020).
3. Technical Code 14TCN 130-2002.
4. Law No. 79/2006/QH11 (November 29, 2006).
5. Official Note CV 4116/BNN-TCTL; Decision No. 4116/BNN-TCTL (December 13, 2010).
6. Decision No. 1613/QĐ-BNN-KHCN (July 9, 2012).
7. TCVN 9901:2014.
8. These are exceedance frequencies of storm surge and waves which the Netherlands used until recently. Their new safety standards use inundation frequencies of dike segments, but these are — by definition — not comparable with the exceedance frequencies used in Vietnam.
9. For detailed methodology on calculating required crest heights, see van Ledden et al. (2020).
10. The estimate used a unit price of \$1 million per kilometer of dike length and per meter of dike reinforcement based on reviews of dike reinforcement programs in Hai Phong and Nam Dinh (Hillen 2008) and unit price reference from the literature that typically uses \$0.7–1.2 million per kilometer dike length and per meter dike reinforcement. The upgrade costs were calculated by determining the difference between the required and actual crest heights for each dike segment. For detailed methodology, see van Ledden et al. (2020).
11. Based on information from MARD.
12. Estimation by the Department of Dike Management based on Hillen (2008) and Mai et al. (2008).
13. Decisions 716/QĐ-TTg (June 14, 2012) and 48/2014/QĐ-TTg respectively.
14. Decision 1588/QĐ-TTg (2012).
15. QCXDVN 01:2008/BXD (2008).

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Protective ecosystems are under pressure from development and over-exploitation

The dunes, mangrove forests and coral reefs along Vietnam's coastline provide extraordinary biodiversity and economic value to coastal communities. These ecosystems also play a significant, yet undervalued, role in protecting coastal areas, reducing the impact of typhoons by absorbing wave energy, blocking storm surges and stabilizing sediments to help reduce erosion. In the last decades, they have been considerably degraded by urbanization, coastal development, tourism, land use intensification, overexploitation, water pollution, and other factors. Despite some successful restoration efforts, ecosystem degradation is impacting the services they provide, resulting in biodiversity loss and reducing their role in coastal protection.

9.1 >>

The coastal dune system

Much of Vietnam's central coastline is characterized by a large coastal sand dune system (CDS) that offers essential protection against typhoons, storm surges, wave action, and coastal floods (figures 9.1 and 9.2). Serving as a natural dike, the dunes are an important complement to the sea dike system and help control coastal erosion, mitigate climate change-related impacts such as sea level rise, and perform regulating services such as protecting groundwater from saline intrusion.

As well as protection, the CDS provides freshwater and other resources, offers spaces for tourism, recreation, education and research, and supports high biological diversity, which forms the basis of secure livelihoods in coastal communities.

As important habitats for marine and non-marine animals and nesting and stop-over sites for migratory birds, they also contribute significantly to biodiversity conservation.

But despite providing these important protection and ecosystem services, the CDS is systematically underestimated and undervalued, leading to poor conservation and management, and significant deterioration over the past decades. The level and efficiency of protection the CDS offers depends on its height, width, shape, continuity and ecological status. All are being compromised, putting coastal communities at increasing risk.

A lack of effective regulatory and legal frameworks.

There is no policy or legal framework to guide CDS use and conservation; instead, the dunes are treated as a geo-ecosystem, hampering their integrated management.

FIGURE 9.1 >> The coastal dune system in Nui Thanh District, Quang Nam Province, with schematic profile



Sources: Based on Nehren et al. 2017 (schematic profile); Google Earth (background image).

FIGURE 9.2 >>

Vietnam's coastal dune system extends over 500 kilometers, reaches 30 meters in height, and stretches up to 25 kilometers inland



Source: Vietnam Academy for Water Resources. Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Existing regulations focus on either the sand or the vegetation cover, treating them separately. National jurisdiction over CDS is shared between the MONRE and MARD, with the former responsible for land and mineral resources and the latter for vegetation cover (protecting forests). Although more general regulations on land and vegetation use and protection—such as the Land Law (2013), Mineral Law (2010) and Law on Forest Protection and Development (2004)—apply to the CDS, the dunes are not managed and protected as an essential link in the coastal buffer system against natural hazards.

Most of the CDS has been lost or diminished as a result of improper or unsustainable management, overexploitation, urbanization and agricultural expansion. The dense network of roads and paths that connect the small settlements dotted across the dunes has fragmented the CDS, and monoculture has cleared or replaced many sections since the 1990s. Shrimp farming has also had an impact: since the government allowed farmers to transform coastal saline rice fields into shrimp farms,¹ the sector has expanded rapidly (Nehren et al. 2017).

Sand extraction has aggravated (and continues to aggravate) this degradation. People extract sand to build roads and houses and for export to other areas. Demand for rare metals, such as titanium, has further increased international demand for sand from these areas. Quang Binh and Binh Thuan provinces have been significantly exposed to this practice. In the Mekong and Red River Deltas, sand mining is changing the natural sediment transport, causing severe erosion and environmental degradation.

Severe coastal erosion has reduced the width of the CDS from the seaward side, threatening the population, assets, and economic activities such as tourism. Well-known hotspots of coastal erosion are Hoi An, Cat Hai and Phan Thiet. Studies indicate that 800–920 kilometers of Vietnam’s coastline show an erosive tendency, with an annual mean erosion rate of 6–10 meters (Tien et al. 2003). The causes of coastal erosion are often a complex mixture of natural and human-induced mechanisms at different temporal and spatial scales (Deltares et al. 2017). These include seasonal wave regimens, changes in sediment transport, sea level rise, and storms.

Action to restore, protect, and manage dunes is urgent.

This lack of integrated management and protection has led to fragmentation, soil sealing, pollution, erosion and the introduction of invasive plant and animal species. Degradation patterns are widely visible along the length of the coast but are most present in central Vietnam (Nehren et al. 2017). In the worst cases, dunes have been completely removed. In others, they have been partially destroyed through human activity and/or structural erosion on the seaward side. This degradation reduces communities’ adaptive capacity to deal with disaster risk by increasingly eroding the important buffering function against natural hazards and other essential ecosystem services the dunes perform to support local livelihoods. Without action, the projected effects of climate change (particularly sea level rise) will further compound these impacts, increasing pressure on coastal areas and the CDS.

9.2 >>

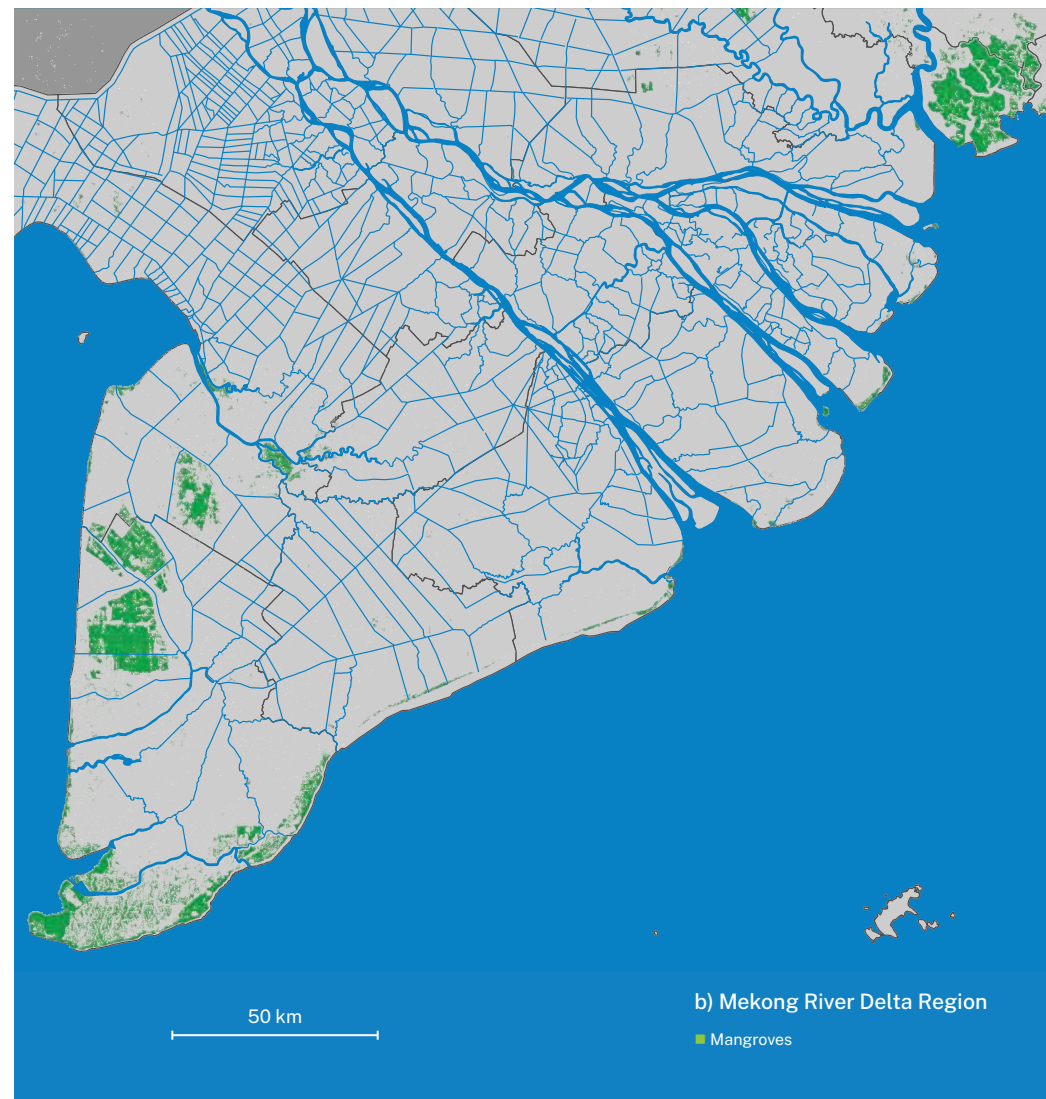
Mangrove forests

Mangroves contribute to resilience and coastal development.

Mangrove forests provide valuable services to Vietnam’s coastal communities. Stretching along much of the coastline from Quang Ninh to Kien Giang, they are most concentrated around the Northeast, Red River,



FIGURE 9.3 >> Mangroves grow along the whole coast, but are concentrated in the Northeast Region and the two major deltas



Source: JAXA EORC 2018.

and Mekong River Delta Regions (table 9.1). Vietnam's mangrove forests are among the world's most productive and biologically and economically important ecosystems, providing a range of services, from habitats for many species to economic opportunities for local communities. They also play a significant role in coastal protection, helping stabilize coastlines and providing a natural barrier against natural hazards.

Vietnam's mangroves protect around 7 million people, more than any other nation, and have an estimated annual economic value of \$9,000–72,000 per hectare (Nguyen et al. 2010). They protect more than 3,000 square kilometers of land and about \$6.5 billion worth of property from flooding (Menéndez et al. 2020). The mangrove forests also play an essential role in protecting the sea dike system from erosion, significantly reducing maintenance and coastal protection costs.

A major carbon sink.

Mangroves help mitigate climate change by storing massive pools of sequestered carbon dioxide in their biomass and the soil (Hutchison et al. 2014). Residing mostly in the sediments, this 'blue carbon' can be released into the atmosphere when the ecosystems are converted or degraded. An assessment of the total carbon stock in Vietnam's mangrove forests shows that 321,264 hectares of mangroves store 84 million Mt of carbon dioxide, almost 30 million of which is stored in Cau Mau province (Sanderman et al. 2018). And yet, many of the largest carbon reservoirs are unprotected from development and over-exploitation.

TABLE 9.1 >>

Geographical distribution of mangrove areas and percentage used for protection services

Region	Total area (hectares)	% of total	% used for protection services
Northeast Region (mainly Quang Ninh Province) and Red River Delta	37,651	18	82
North Central Region	1,885	1	71
South Central Region	2	0	0
Southeast Region	41,666	20	92
Mekong Delta Region	128,537	61	35
Total Vietnam	209,741		55% (115,950)

Source: Hawkins et al. 2010.

Degraded mangroves cannot protect people.

Prioritizing short-term economic gains in the decades after the Vietnam War, a lack of awareness of the value of mangrove forests, and government policies that encouraged development and aquaculture in mangrove areas, have all led to the considerable degradation of mangrove ecosystems. The historical lack of regulatory mechanisms for protecting mangroves has also contributed to this loss.

Mangrove systems have been increasingly compromised in recent decades, diminishing their capacity to protect against erosion and flooding. Intact mangroves can attenuate waves: a 100-meter-wide mangrove belt can reduce wave height by 13–66 percent; a 500-meter-wide belt can reduce them by 50–100 percent (Beck and Lange 2016). Mangrove systems have a critical minimum width to offer effective coastal protection and effectively attenuate flooding while

remaining stable and promoting sedimentation (Phan et al. 2014). For the southeastern and eastern Mekong Delta, the critical minimum width ranges from 30 to 250 meters, with an average of 140 meters, depending on location. Attenuating storm surges, however, requires much greater widths of mangrove, as they can penetrate up to one kilometer into the forest (Phan et al. 2014). Many mangrove belts along Vietnam's coastline are well below their critical minimum width and have lost the capacity to successfully attenuate waves and offer coastal protection (figure 9.4).

Over the last 30 years, Vietnam has lost half its mangroves, mainly to deforestation and clearing for shrimp ponds. This is a widely observed trend across Southeast Asia, where mangroves have been lost to aquaculture, agriculture and urban expansion (Richards and Friess 2016). As mangrove systems deteriorate, their ability to function as a natural protection system diminishes. Climate change exacerbates this deterioration, leading to storms with more powerful waves (Reguero et al. 2019), sea level rise and increased erosion, damaging these forests.

An advanced legal and institutional framework for mangrove protection is in place.

The government of Vietnam has developed a legal framework that emphasizes the importance of mangrove

protection and conservation, increasingly using these ecosystems as risk reduction measures that can contribute to carbon fixation and socioeconomic development. The government has issued or revised key laws governing forest use and management, including the Law on Forest Protection and Development (2004); the Law on Biodiversity (2008); the Law on Land (amended in 2013); the Law on Environmental Protection (2015); and the Law on Marine and Island Resources and Environment (2015). National policies regulate a wide range of activities to help coastal areas manage mangroves, prevent exploitation and protect geographical characteristics. Local government policies that allocate mangroves for coastal protection and livelihood improvement—for example, in Kien Giang Province—allow households to protect and earn a living directly from the mangrove forests, which they plant and protect (Nguyen et al. 2017).

The government has also issued national strategies to guide mangrove management and development. The National Forestry Strategy 2006–2020 set the goal of increasing the country's overall forest cover to 47 percent by 2020, including 5.68 million hectares of protection forest and 2.16 million hectares of special use forest. The National Strategy on Environment Protection to 2020 with Vision to 2030 details solutions to regenerate natural ecosystems (especially mangroves), increase forest coverage and improve forest quality, to respond to climate change and ensure sustainable national development. The National Strategy on Biodiversity Conservation towards 2020 and Vision to 2030 focuses on conserving and sustainably managing important forest ecosystems and

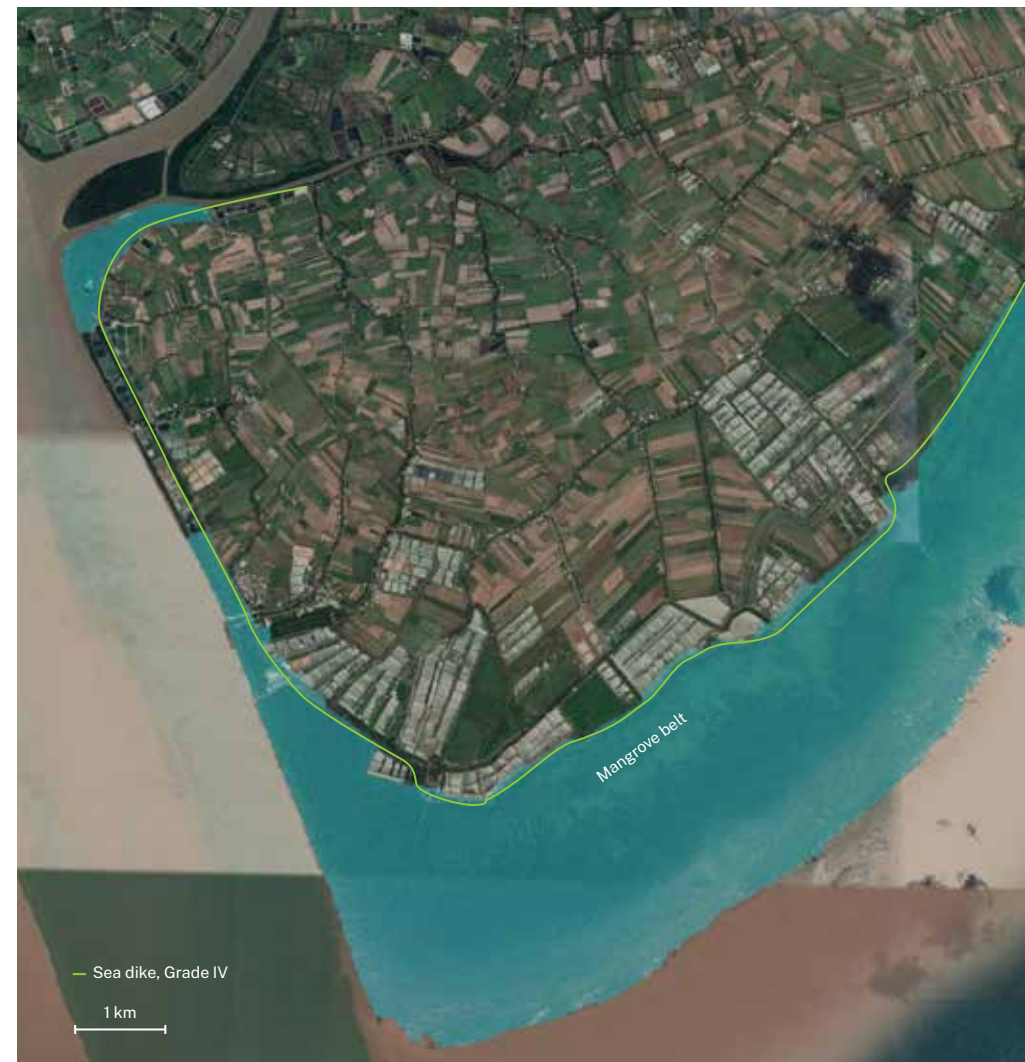
50% >> Half of Vietnam's mangroves have been lost in the last 30 years.

FIGURE 9.4 >> Many mangrove belts along the coast are too narrow to serve as an effective coastal protection system

Mangrove belts along the coast of Tien Giang (left) and Soc Trang (right) Provinces in the Mekong Delta.



Source: Google Earth



endangered species, and aims to increase forest cover to 45 percent, restore 15 percent of degraded ecosystems by 2020, and protect 25 percent of natural ecosystems with international and national importance by 2030.

National jurisdiction over mangroves rests on MARD, whose Directorate of Forestry is responsible for developing forest policy and providing oversight and guidance for its implementation. MONRE is responsible for land administration and related policies. At provincial, district and commune level, DARDs and DONREs are responsible for administering forest protection and development and land. In some coastal provinces, the Forest Protection Department is a key provincial-level actor. For example, in Ben Tre Province, the department has established a forest management board to coordinate and implement the regulation, monitoring and development of coastal mangroves across its three coastal districts (Wyatt et al. 2012).

Promising restoration and reforestation efforts are underway.

Pilot restoration programs show that the benefits can significantly outweigh the costs. Reforestation activities have been implemented since 1975, particularly in the Mekong Delta. Initiated by nongovernmental organizations (NGOs) with support from international development organizations, success rates were initially low. More recent projects, however, have had more success. For example, between 1994 and 2010, the Vietnam Red Cross' Mangrove Reforestation and Disaster Preparedness Programme afforested 8,961 hectares of mangrove, which

helped reduce damage from typhoons, avoiding \$80,000–\$295,000 in dike damage and almost \$15 million in shrimp production losses in Giao An commune, Nam Dinh Province alone. In Thai Do commune, Thai Binh Province, avoided losses in shrimp farms and paddy fields were almost \$5 million (IFRC 2011). These values greatly exceed the \$7.5 million cost of restoring the mangrove belt.

The government's Restoration and Development of the Coastal Mangrove Forests Programme (2008–2015) has reversed the decline in coastal mangrove coverage. In 2015, the government approved the Project for the Protection and Development of Coastal Forests to Cope with Climate Change in the 2015–2020 Period in all 28 coastal provinces.² Involving the community in restoration efforts — particularly at the implementation stage — and increased knowledge of the environmental setting have both helped improve the success rate of restoration programs (Nguyen et al. 2016; Cuong et al. 2015; Balke and Friess 2016).

Restoration efforts suffer from funding constraints.

Despite these successes and an increased awareness of the importance of mangrove forests, the systematic undervaluation of these ecosystems and the need to share limited conservation funding between various goals has led to persistent constraints on local budget and capacity (Veetil et al. 2019). But innovative schemes have emerged — such as community mangrove co-management models and payments for ecosystems services (PES) — that promote mangrove conservation and restoration while supporting local socioeconomic development (box 9.1).

BOX 9.1 >>

Case study: Mangroves ecosystem services in Can Gio District

The extremely biodiverse mangrove forests that cover over 40 percent of Can Gio (figure B9.1.1) are among the most pristine in Southeast Asia (Kuenzer and Tuan 2013). Covering 71,964 hectares, Can Gio Mangrove Biosphere Reserve is home to over 67,000 people, who manage, control and protect the forest area in which they live. As well as providing work for 50 percent of

the population, the reserve's 38,293 hectares of mangrove forest provide timber, food, firewood, charcoal, seedlings and medicine. Indirect benefits include protection from storms and erosion, carbon sequestration and wastewater filtration for about 1,740 hectares of intensive shrimp farming. Its overall ecosystem services are valued at \$442–503 million (Table B9.1.1).

Like the Mekong River Delta, Can Gio District is threatened by sea level rise and the lack of sediment supply from regulatory measures upstream. Other threats — including shoreline erosion, illegal clam-digging, and pollution from garbage dumps — also jeopardize the delivery of the mangroves' important services for the community.

TABLE B9.1.1 >> Annual estimated values of the mangrove forest in Can Gio Mangrove Biosphere Reserve

Service	Value (\$, millions)
Fishing (<i>inside mangrove</i>)	14.8
Fishing (<i>marine fish catch related to mangrove area</i>)	81.3
Timber	12.7
Tourism (<i>based on average travel costs to reach the reserve</i>)	176.1
Shoreline protection and dike maintenance (<i>avoided damage replacement costs</i>)	149.2
Carbon sequestration	8.3–68.9

Sources: Kuenzer and Tuan 2013 and Kuenzer et al. 2013, JAXA EORG 2018

Note: See Kuenzer and Tuan (2013) for a detailed assessment of the ecosystem services provided by the Can Gio Reserve.

Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE B9.1.1 >> Mangrove cover in Can Gio District



However, for the benefits from the widespread use of such innovative tools to be felt in communities across the country, these schemes need legal and regulatory support.

9.3 >>

Coral reefs

Ecosystem services and protection.

Healthy coral reefs are among the world's most biologically diverse and economically valuable ecosystems. As well as being hotspots of biodiversity, they provide food, protect coastlines from storms and erosion, offer habitat, spawning and nursery grounds for important fish species, and provide jobs and income from fishing, recreation and tourism (Beck et al. 2018; Ferrario et al. 2014; Brander and Beukering, 2013; Spalding et al. 2017). The wide range of reef diversity in Vietnamese waters supports over 350 species of hard corals (Burke et al. 2002; Chou et al. 2002). Primarily in shallow coastal waters, they cover some 1,100 square kilometers.

An analysis of the flood risk reduction service provided by coral reefs found that Vietnam's reefs avert \$42 million in flood damages each year (Beck et al. 2018). Healthy reefs can protect coasts from typhoons and strong wave

conditions (Storlazzi et al. 2019), protecting \$2.3 billion worth of built capital from flooding with a 100-year return period (Beck et al. 2018). Functioning much like low-crested breakwaters, coral reefs also protect coasts from erosion and flooding, primarily by dissipating wave energy, breaking waves at the seaward edge and through bottom friction.

Degradation is substantial.

Over the last three decades, sedimentation, changes in sea water acidity and temperature, overfishing, coastal development, pollution, typhoons, and other factors have considerably degraded Vietnam's coral reefs. However, the lack of regular monitoring makes it difficult to track these damages. By the early 2000s, 96 percent of Vietnam's coral reefs were estimated to be under threat from human activities (Burke et al. 2002). The most significant threat was from destructive fishing (harming 85 percent of coral reefs), followed by overfishing (60 percent), and sediment from upland sources (50 percent) and coastal development (40 percent). These pressures have only increased in the last 20 years.

While a unified legal framework is lacking, some local authorities are taking action.

Although the government of Vietnam has no specific policy or legal framework for coral reef management, it has developed a legislative framework that targets the sustainable use and conservation of Vietnam's biodiversity, natural resource management and

\$42M >> The cost in flood damages that are averted by coral reefs each year

environmental protection (MONRE 2014). Key policy and legal documents on biodiversity conservation and marine ecosystems that refer to coral reefs include: the Law on Fisheries (2003), the Biodiversity Law (2008), the Environmental Protection Law (amended in 2014), the National Action Plan on Biodiversity (2007) and the National Strategy on Biodiversity Conservation towards 2020 and Vision to 2030.

Jurisdiction over coral reefs is integrated within state biodiversity conservation functions for marine resources. The Vietnam Environment Administration³ (under MONRE) established the Biodiversity Conservation Agency to implement state management functions for the conservation and sustainable development of biodiversity resources. The Directorate of Fisheries⁴ (under MARD) manages fisheries resources and marine and inland water protected area systems. Some coastal provinces and cities have issued reef-related regulations to control exploitation, pollution, and destruction.

Several communities have established marine protected areas (MPAs) to protect coral ecology. But there has been no evaluation of the MPA network to assess how they are meeting standards. Doing so could help guide future expansion of the network (Hien et al. 2014). The government aims to implement zoning practices and create natural reserves and classified sites to develop sustainable tourism in Con Dao, Cat Ba and Ha Long Bay National Parks, the three MPAs with coral reefs. It is also in the process of increasing the number of MPAs. Implementing these plans will be an important step for coral reef preservation.

Action is needed to protect the contribution of coral reefs to resilience and coastal development.

Despite its policy framework for the conservation and sustainable use of marine biodiversity at national and provincial levels, the government is not putting enough effort into managing marine and overall biodiversity resources. The system of state management agencies responsible for marine resources and biodiversity remains fragmented and weak. Several issues constrain the effective implementation of legislation and must be addressed to ensure that coral reefs are protected and well maintained and keep contributing to Vietnam's coastal resilience. There are shortcomings in several areas, including institutional organization and cooperation, monitoring, technical capacity, community involvement, enforcement of conservation plans, and budgets.

Part 3 offers concrete recommendations to address these challenges, particularly through better data and monitoring (Chapter 11) and strengthened institutional and regulatory frameworks for managing protective ecosystems (Chapter 14).

Endnotes

1. Resolution 09/NQ-CP.
2. Decision No. 120/QĐ-TTg (January 22, 2015).
3. Decision No. 132/2008/QĐ-TTg (September 30, 2008) defines the administration's functions, tasks, powers and organizational structure.
4. Decision No. 05/2010/QĐ-TTg (January 25, 2010) stipulates regulations on the functions, responsibilities, authorities and organizational structure of the Directorate of Fisheries under MARD.

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Disaster preparedness is advanced, though capacity constraints persist

With its long experience with natural disasters, Vietnam has an advanced emergency preparedness and response system. Over the past decade, the government has made tremendous progress towards reducing losses from natural disasters through an early warning and evacuation system, multipurpose shelters, and contingency budgets to respond to crises. It has also created a sophisticated institutional structure for emergency response and a well-established network of partners that help during response and relief operations. But there is still scope — and need — for further improvements, especially as risks evolve and intensify. Experience shows that early warning systems are not effective, and social protection systems do not offer enough coverage and support for vulnerable population groups. Funding is a major constraint to improving and modernizing existing systems. Implementing a modern and diversified risk financing strategy could help the government address budget misallocations and shortfalls, and strengthen national disaster preparedness.

10.1 >>

Early warning systems

A nationwide early warning system covers hazards such as typhoons, floods, and rain.

Since 2010, the government has invested significant funds in developing early warning systems, particularly for typhoons. The Central Steering Committee for Natural Disaster Prevention and Control¹ is the highest directing and commanding organization for natural disaster prevention and control in Vietnam. Information flows from here to the VNDMA and Vietnam Meteorological and

Hydrological Administration (VNMHA), to stakeholders and decision makers at all levels, and finally, to the public.

Several agencies provide hydromet forecast and services. Operating under the MONRE, the VNMHA maintains more than 90 percent of Vietnam's weather, climate and hydrological observation networks, and issues nationwide forecasts and warnings. The National Center for Hydro-Meteorology and Forecasting delivers nationwide forecasts and the Regional and Provincial Hydro Meteorological Services delivers the local ones. The Institute of Transport, Science and Technology—under the Ministry of Transport (MoT)—is responsible for aviation weather, maintaining meteorological stations

at all Vietnam's airports. The MONRE's Institute of Meteorology, Hydrology and Environment is responsible for climate prediction and provides climate and agro meteorological outlooks and crop yield forecasts for the agricultural sector.

The VNMHA has proactively established bilateral cooperation agreements with international and national hydromet organizations in the region—including national hydromet services in Cambodia and Lao People's Democratic Republic to share data, strengthen forecasting capability and train staff. Vietnam's National Hydro-Meteorological Service participated in Mekong River Commission's Flood Management and Mitigation Programme's regional flood forecast and is a regional forecast support center for the World Meteorological Organization's Severe Weather Forecasting Demonstration Project.

Early warning information does not always reach end users and is often too technical.

The authorities disseminate early warning information by television, radio, internet and through the public loud-speaker system that exists in all Vietnamese communes. Improved cell phone and internet coverage have enabled warnings via SMS text messaging, although high costs limit their use. For the most vulnerable households, face-to-face communication is still most effective, with warnings delivered by local Committees for Disaster Prevention and Control officials and volunteers. For offshore communication, well-equipped fishing boats

are warned of impending storms through high-frequency radio or radio telephone. However, coverage gaps remain.

The VNMHA's early warning information is also highly technical and not user-friendly, limiting its usefulness for government decision makers at all levels and making it difficult for end users to understand. The current warning bulletin for commanding committees at every level is a text message describing the coordinates of a storm's location and direction and water levels of hydrological gauging stations. As local communities often cannot adequately interpret and act on this information, they tend to take actions only based on past experiences (JICA 2018).

Hydromet services do not meet the end users' needs.

The VNMHA's hydromet monitoring, forecasting and warning services do not adequately support the needs of users who are impacted by climate hazards. The VNMHA has improved its capacity and reliability for forecasting disasters and has extended its hydromet services commercially to the energy, agriculture and transport sectors. But its hydromet services—particularly environmental monitoring services, short, medium and



For the most vulnerable households, face-to-face communication is still most effective.

long-term forecasts, and user specificity within those forecasts — have yet to meet these sectors' needs. A recent World Bank-funded project supported the hydromet sector to translate technical forecast information into practical last-mile early warning information. After a successful pilot in 100 communes, the VNMHA is expanding the service to all communes across Vietnam.

Although the VNMHA operates a significant number of weather stations, especially in the mountain areas, there are few rainfall stations. Provinces have therefore started to develop their own rainfall observation systems to provide accurate and prompt warning services. Private initiatives have also emerged — for example, WATEC has installed 360 weather stations in the country, particularly in areas where VNDMA monitoring stations are lacking.

Funding is a major challenge for improving and modernizing the early warning system.

The VNMHA's total expenditure more than tripled from around US\$18 million in 2014 to \$61 million in 2018, and it expects to receive another \$68 million to continue modernizing and upgrading the system until 2024. But despite these increases, the VNMHA has faced budget constraints for operations and maintenance. On average, it spends about 56 percent on staff costs. Around 95–99 percent of this is for hydromet operational activities, leaving little for research and training. Total cost recovery for the hydromet sector was only \$3 million — less than 10 percent of its total budget allocation in 2013.

BOX 10.1 >>

Tsunamis are a rare but real possibility with potentially devastating consequences

Vietnam has experienced five tsunamis in the past 150 years: two near the Bing Tuan coast (1877 and 1882), one near the North Central coast (1899, with a recorded wave height of 3 meters), one off the South Central coast (1923) and most recently, in northern Vietnam (1987, with a recorded wave height of 3 meters) (figure B10.1.1).² However, the past is not a reliable guide for the future when it comes to rare events like tsunamis, and the probability of submarine earthquakes triggering tsunamis is notoriously difficult to estimate.

Other countries in the region face significant seismic risks. Tsunamis originating in the subduction zone close to the Philippines can cross the South China Sea and hit the Vietnamese coast. Simulations show that submarine earthquakes with a magnitude larger than 7 at the Central Asia shelf fault line or larger than 8 at the Manila Trench could lead to tsunamis along Vietnam's coastline (Kantarzhi and Hai 2018). A global probabilistic tsunami hazard assessment has also shown

FIGURE B10.1.1 >> Located near a seismically active region, the risk of tsunamis is real in Vietnam



Source: Based on data from NOAA 2020 (historic earthquakes data)² and US Geological Society 2019 (fault lines).³ *Disclaimer:* The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

that the tsunami wave run-up height in Vietnam is 1 to 3 meters for a 1-in-500 year tsunami and 3 to 10 meters in a 1-in-2,500 year tsunami (Davies et al. 2018).

The Vietnam Earthquake Information and Tsunami Warning Center (EITWC)⁴ is responsible for issuing tsunami warnings and

cooperating with regional and global tsunami warning systems. Vietnam is also a member of regional initiatives such as the Pacific Tsunami Warning System and the South China Sea Tsunami Advisory Center, which aims to provide 24-hour warning services to member countries. However, given the relatively rare occurrences of tsunamis in Vietnam, the EITWC's equipment

and capability for forecasting and detecting tsunamis is limited. Further exploring and updating rapid information-sharing agreements with neighboring countries can help protect against tsunami risk. Risk-informed coastal planning — through sea dikes, setback lines and sand dunes — will also help mitigate tsunami risk.

10.2 >>

Emergency preparedness and response follow advanced systems

A wealth of disaster risk management experience.

Vietnam has a well-established legal and regulatory disaster risk management framework, built through concerted efforts by government, international partners, NGOs and the Vietnamese people. The government has made tremendous progress towards reducing losses to natural disasters by leveraging central and local contingency funds. It has developed laws, strategies, and plans to assess its disaster risk management and response, improving disaster preparedness, response and recovery. It has also prioritized partnerships with neighboring nations to strategize emergency recovery and assistance. Since 2017, the government requires all regulatory authorities to actively prepare an emergency response and search and rescue plan.⁵ All communes, districts and provinces, and relevant sector ministries have prepared these and review them every year.

A special focus on community-based disaster risk management.

The government and communities have worked together to build understanding, preparedness, and response capacity through CBDRM. NGOs introduced the CBDRM concept in 2000, and it quickly gained ground.⁶ Program

1002⁷ aimed to implement it in 6,000 communes across 63 provinces vulnerable to disasters between 2009 and 2020. By the end of 2015, CBDRM was being practiced in almost one-third (1,763) of the targeted communes (JICA 2018).

The Ministry of Education provides disaster education and training, including swimming instruction programs, at all levels, from schoolchildren to core local government staff. As a result, Vietnam has a well-functioning evacuation system for fast-onset events such as typhoons and floods, with provinces using safe multifunction community facilities—schools, hospitals and other buildings—or purpose-built shelters to provide refuge for residents. Budget constraints, however, have delayed CBDRM activities, and as they depend on annual budget and donor aid, they are usually implemented on a short-term basis (JICA 2018).

Local government plays a central role in emergency response management.

Vietnam has a graded emergency response structure with functional divisions. It relies on the Four On-the-Spot Motto, an approach that ensures on-the-spot leadership, forces, materials and logistics⁸ and emphasizes local government's role in emergency management. National coordination and guidance for emergency response rests on the National Committee for Search and Rescue, which comprises all relevant ministries and mass organizations. At provincial level and below, the Provincial Committees

for Disaster Prevention and Control and Search and Rescue have helped increase the efficiency and timeliness of response activities.

Participation in emergency relief and response is widespread, but gaps remain in response actions.

The country has a well-established network of mass organizations, NGOs and international partners that help with emergency response and relief operations. This includes the Vietnam Fatherland Front, the Viet Nam Red Cross, the Vietnam Women's Union and Youth Union volunteers. The increasing frequency and intensity of disasters has drawn more organizations—from religious entities to private companies and local NGOs—and individuals to become involved in disaster response, distributing donations and relief.

Vietnam still faces challenges in providing effective and robust response actions. Some communes prepare their annual emergency preparedness plans in close consultation with representatives of vulnerable groups. But most lack the funding for such consultations, and, as a result, their plans tend to exclude the voices of the most vulnerable. There is a lack of capacity and tools for assessing damage and estimating financial recovery needs at all levels. The shortage of funding for simulations or rehearsals at all levels also hinders the effectiveness and readiness of these plans. With a strong focus on short-term emergency management, gaps remain in assisting people's long-term recovery in resilience building.

10.3 >>

Social protection systems support vulnerable groups, but coverage can be limited

As a country highly exposed to natural hazards, Vietnam needs an effective emergency assistance system for people affected by disasters. One of the three components of its social protection system, emergency assistance consists of ad hoc, short-term cash and in-kind support for those hit by crisis (UNPD 2016). The government has begun to strengthen its policy framework to regulate the mobilization of post-natural disaster support resources. Recognizing the challenges in its social assistance system, it commissioned the Master Plan for Social Assistance Reform and Development (2017–2025)⁹ and Vision to 2030 to provide a blueprint for the next 15 years.

Post-disaster social assistance promotes resilience.

Relief payments to vulnerable rural households make up the bulk of post-disaster expenditure, with different levels of support for loss of a household member, injury, death or missing persons during disasters, housing damage, and rebuilding and repairs (table 10.1). Central and local contingency budgets are the primary source of funding, so these payments are from short-term recovery funds, which need to be financed within the budget year.

The government has started to develop some aspects of a welfare state, with disaster relief payments to rural

households for loss or damage to crops, livestock, forestry, aquaculture and other forms of rural enterprise and some protection for laborers who lose their jobs due to disaster or force majeure.¹¹ To help restore agriculture production, it provides seeds, animals, aquaculture inputs, or part of initial production costs. Funding comes from central and local contingency budgets, state in-kind reserves and other sources. Post-disaster assistance is available for businesses including state-owned enterprises, with tax

breaks for physical damage arising from disasters (World Bank DRFI Program 2020).

Local needs inform central planning.

MOLISA coordinates and oversees emergency support at a national level. Social assistance budgets are developed through a bottom-up process, starting at commune level, where budget requirements are estimated and sent up until

TABLE 10.1 >> Post-disaster household assistance measures

Area	Legal and regulatory framework	Level of support	Eligibility
Standard subsidy	• Decree 136/2013	• \$12/person	• Norm for social assistance calculation for various support programs
Emergency support	• Decree 136/2013 [Article 12 on Food Support] • [Article 13 on seriously injured support] • [Article 14 on burial cost support]	• 15kg rice/person/month, up to 3 months each support	• Households facing food shortages, as assessed by local community heads
		• 10 times standard subsidy (in cash) per person	• Those seriously injured from disaster
		• 20 times standard subsidy (in cash) per person	• Those who die or are found missing from disaster in location of their residence
		• 30 times standard subsidy (in cash) per person	• Those who die or are found missing from disaster outside location of their residence
Recovery support	• Decree 136/2013	• Up to \$894 per household	• Low-income and vulnerable households that have houses collapsed, swept away or completely burned due to disasters and left without shelter
		• Up to \$894 per household	• Households that must be evacuated due to exposure to landslide, flood, or disaster
		• Up to \$671 per household for repair	• Low-income and vulnerable households whose houses are heavily damaged
Regular support	• Decree 136/2013 • Circular 29/2014 • Decree 28/2012	• Expenses for both custodian and children under custody • Follow cost norms set out in relevant regulations	• Children who lose both parents due to disaster
	• Decree 136/2013	• Job creation/access or production development support	• Households that lost major materials and means of production due to disasters

Source: World Bank DRFI Program 2020. Note: Amounts in Vietnamese Dong have been converted to dollars using 2017 official exchange rate.¹⁰

they reach the Ministry of Finance (MoF). Finally, they go to the National Assembly for approval. The MoF coordinates the national budget and ensures financial resources are available. The central government emergency assistance budget is often supplemented by local government and private donations. Anecdotal evidence suggests that provinces sometimes pay out considerably more in compensation for private losses than is legally mandated. One of the advantages of a predominantly rural society is a strong local-level culture of community cooperation, social governance and safety nets, ensuring local decision making by communal consensus and emergency responses that prioritize vulnerable groups.

Despite significant progress, social assistance support for vulnerable groups is not enough.

The government has developed its social assistance system, particularly the emergency component. But it has struggled to keep pace with the speed of development following economic reforms and still faces many challenges. Despite increasingly supporting reforms to strengthen social protection, shortcomings remain in both coverage and adequacy of support.

World Bank estimates suggest that 17.5 percent of Vietnam's population is covered by social safety nets.¹² This is focused on low-income households; there is 63 percent coverage among the poorest 20 percent of the population. This implies that coverage in coastal regions – which have low poverty rates but high levels of risk exposure – is relatively low. And even where households are covered,

budget constraints mean that the level of assistance is often insufficient. It is estimated that safety net payments only amount to 3 percent of beneficiary households' regular needs.

Neither coverage, cash transfer value nor quality of social care are enough for a country at Vietnam's stage of development. Vietnam still has some way to go to have universal and effective social safety nets, welfare systems and insurance services that will give its poorest and most vulnerable groups the opportunity to rebuild their livelihoods and escape the cyclical, inter-related trappings of recurrent disasters, poverty, food insecurity and debt.

10.4 >>

Disaster insurance, risk financing and sharing

Vietnam has several sources of immediate post-disaster financing sources, which fall under three main categories: government funding, including contingency funding and reserve funds; in-country voluntary donations, including private sector participation; and international assistance (table 10.2). The state budget is the main source of disaster risk financing. The State Budget

17.5% >> The percentage of Vietnam's population covered by social safety nets

Law¹³ regulates budget-related resources for disaster prevention and control, including contingency budget, budget (re)allocation, recurrent and capital expenditure, targeted supplementary budget and temporary budget advancement (World Bank DRFI Program 2020).

The central contingency state budget covered about one-fifth of total reported disaster costs.

The contingency budget is provisioned for all types of risk, including natural disasters (World Bank DRFI Program

2020). Although there is no separate budget line for disaster response, all levels of government have to allocate 2–4 percent of their annual capital and recurrent expenditure budget to a contingency budget for “preventing, combating, and overcoming natural disasters and in important tasks of national defense and security”. This is for immediate post-disaster emergency relief and early recovery only and specifically excludes medium and long-term reconstruction expenditure. The national government makes central contingency budget spending decisions; PPCs decide on local contingency budget spending.

TABLE 10.2 >> Disaster financing instruments available to the government of Vietnam

Disaster risk	Source of funds (type of DRFI instrument)	Availability
High (such as major floods, major typhoons)	Donor assistance	• Funds are unpredictable and unreliable.
	Disaster risk insurance	• At least 1,000 organizations/entities in Vietnam have purchased insurance policies for public assets. • Pilot Agricultural Insurance Program: cumulative revenue from premiums paid amounted over \$17.6 million at the end of 2014. ¹⁴
Medium (such as regional floods)	Contingency budget	• This represents 2–4 percent of total yearly planned expenditure. • It is partly used to finance cash transfers and relief efforts in the aftermath of natural disasters. • In 2016–2018, 2 percent (around \$3.67 billion) was budgeted for contingency spending, of which \$557 million was spent.
	Financial Reserve Fund (FRF)	• In 2017, \$5.6 million (0.09 percent of state budget expenditure) was allocated to the FRF. In 2016, \$4.47 million (0.01 percent of state budget expenditure) was allocated. ¹⁵
	Natural Disaster Prevention and Control Fund (NDPCF)	• In 2017, this fund — set up in 56 provinces — had a cumulative value of \$42.5 million, of which 42 percent was spent. ¹⁶
	Fund for Inland Road Maintenance	• In 2015, total fund value was \$285 million, of which \$21 million was spent. This fund terminated in February 2020.
	State budget allocation for capital investment in the aftermath of a natural disaster	• Funds allocated to the annual budget plan are used to construct, rehabilitate and upgrade natural disaster mitigation projects, and to finance recurrent and operational costs. Budget allocation details were not available.
Low (such as annual localized floods, landslides)	State Reserve Fund ¹⁷	• Information on the size and in-kind value of the State Reserve Fund is not available to the public. In 2013, it supported disaster victims with 67,223 tons of rice.

Source: World Bank DRFI Program 2020.

But despite covering almost 50 percent of total reported disaster costs between 2009 and 2018 on average, the central contingency budget only extended support for 10 percent of total reported damages (figure 10.1). Current regulations and practices suggest that budgeting focuses more on response to recurrent events than on planning and preparedness for less frequent and high-impact events. Budget reallocations and external debts are the main sources of finance for more severe events (World Bank DRFI Program 2020).

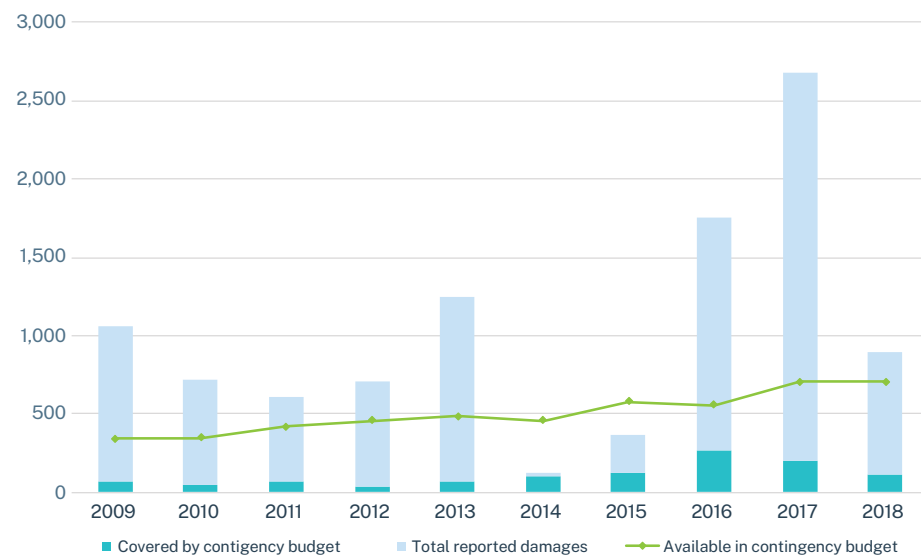
If the contingency budget cannot finance post-disaster emergency and recovery, central and provincial governments may draw on FRF funding or surplus revenue, but FRF funds have balance limits that may not exceed 25 percent of annual budget expenditure estimates at central or provincial level. The current status of the FRF is not well known, but these reserves have been limited in the last decade. As such, they are not guaranteed, especially in the event of a major disaster. Districts and communes do not have reserve funds for natural disasters.

There are other sources of finance, but these are limited.

The State Reserve Fund provides in-kind post-disaster emergency relief payments, including food and equipment. By law, national in-kind reserves must be covered by insurance. The fund's reserves and operations are financed by the state budget, leaving it vulnerable to fluctuations in government revenue.

FIGURE 10.1 >>

The contingency budget only covers a small part of total reported natural disasters damages



Source: World Bank DRFI Program 2020.

At provincial level, all Vietnamese citizens and businesses contribute to the Natural Disaster Prevention and Control Funds (DPCFs)¹⁸ which provide support for disaster risk management activities. However, there are several inefficiencies in their operations, and over past five years, DPCFs have only allocated 39 percent (\$41 million) of total revenue (\$105.5 million) to disaster prevention activities, implying that the remaining \$64.5 million remain frozen in the different funds (World Bank DRFI Program 2020).

Various NGOs also channel emergency relief and private voluntary donations to victims of natural disasters, and

different decrees¹⁹ regulate the mobilization, receipt, distribution, and use of voluntary contributions for recovery from disaster (World Bank DRFI Program 2020). However, there is no data on their overall volume. International and local NGOs and aid donors support immediate post-disaster emergency relief activities, including providing food and emergency goods. In 2000, 2002 and 2003, donors provided 20 percent of Vietnam's total averaged natural disaster expenditure (World Bank 2010).

The Fund for Inland Road Maintenance²⁰ used the state budget and revenues from tolls and fees to finance the reconstruction of roads damaged by natural disasters. Non-structural prevention work was financed out of recurrent expenditure and structural reconstruction from planned capital expenditure or other sources. However, as government capital expenditure is rigidly planned three years ahead with little flexibility, in practice, it could take several years before government post-disaster reconstruction funding becomes available, causing serious disruptions to the local economy and people's livelihoods. Provincial and central governments can reprioritize some of their capital investment budgets, reallocating a small fraction of their planned capital expenditure to reconstruct key lifeline infrastructure such as hospitals or main bridges. The government can also access post-disaster reconstruction loans from international financial institutions such as the World Bank or Asian Development Bank.

The use of market-based risk financing instruments is limited.

Although some laws stipulate the use of insurance to protect against potential disaster risks, the use of market-based risk financing instruments is limited in Vietnam. The Law on Management, Use and Investment of State Capital²¹ requires enterprises that manage, use or have state capital investments to insure state assets against potential risks. The Law on Public Assets Management and Use²² also requires insurance for financial risk management of public assets that are highly exposed to natural disasters. However, it does not define which assets need to be insured, risk tolerance, premium financing, procurement methods, or a roadmap for implementation (World Bank DRFI Program 2020).

In an effort to improve rural livelihoods and promote agriculture production and resilience, the government implemented an agriculture insurance pilot from 2011–2013.²³ Designed to target the poor, this program — covering rice, domestic animal and aquaculture insurance — helped farmers recover financial losses from natural disasters and epidemics, stabilize rural social security and promote agriculture production. But the pilot in 20 provinces paid out \$31.4 million in compensation, having accrued just \$17.6 million in insurance revenue. Participating insurance companies suffered more than \$13.4 million in financial losses,¹⁴ and the range of insurance products available for poor rural or urban communities remains limited.

Several disaster risk financing instruments are available in Vietnam. But with no strategic and systematic approach across government levels, coordination between these instruments has been inefficient and there is some overlap

between them. This is particularly so with contingency budgets and the DPCFs, both on sources of financing and beneficiary targeting. There is no instrument or mechanism — such as contingent credit, disaster insurance or catastrophe bonds — for protecting the central budget against extreme events (World Bank DRFI Program 2020).

Vietnam's risk financing strategies need to be modernized.

In the last decade, the government has actively explored financial and insurance solutions to manage natural disaster risks. In 2017, it developed an action plan in partnership with the World Bank's DRFI Program for

strengthening the country's risk financing strategy to mobilize adequate funding for rapid recovery and reconstruction and safeguard resilient socioeconomic development in the face of climate change and natural hazards (box 10.2). The main objective is to develop a strategic and flexible financial mechanism that allows for increased and more rapid access to funds for post-disaster recovery and reconstruction. Besides meeting short-term post-disaster relief needs, such a strategy would give Vietnam a longer-term recovery and reconstruction vision.

Overall, to ensure that its disaster preparedness and contingency financing capacity is equipped for the challenges of future decades, the government will need to

BOX 10.2 >>

World Bank DRFI initiatives in Vietnam

In 2010, the World Bank carried out a study to build institutional capacity on catastrophe risk financing and identify financial affordable and effective options for risk sharing and transfer in Vietnam, including sovereign risk financing and private insurance instruments (World Bank 2010). The study highlighted that data availability and accuracy was a key issue in developing risk transfer products. It also noted that sovereign parametric disaster insurance could be further explored to protect against the fiscal impact of major events occurring every 10 years or less.

Since 2017, the World Bank has provided technical assistance on sovereign disaster risk financing and insurance solutions for the MoF on several issues, including:

- Implementing the APEC 2017 Action Plan on Disaster Risk Finance and Insurance Policy
- Financial risk management of public assets by developing risk assessments of public assets and a draft decision by the prime minister to promulgate the list of public assets
- State budget protection through an in-depth review of the legal, regulatory and

institutional framework that governs DRFI in Vietnam and the proposal for financial solutions and support to increase the financial resilience of Da Nang City by developing its framework or strategy for disaster risk financing and integrating this into the city budget and financial planning

- A property catastrophe risk insurance market, by developing a catastrophe risk insurance database
- A national disaster risk assessment, with catastrophe risk model training.

modernize and implement these risk financing strategies. Part 3 offers concrete actions to help achieve this objective in Chapter 15 (Recommendation 5).

Endnotes

1. No. 367/2015/QĐ-TTg.
2. Information retrieved from NOAA's NCEI/WDS Global Historical Tsunami Database, <https://tinyurl.com/yawmjzk7>
3. Information retrieved from <https://tinyurl.com/ycx8bvn> on March 28, 2020.
4. Established by Decision No. 1798/QĐ-KHCNVN (September 4, 2007).
5. Decree No. 30/2017/ND-CP.
6. Framework on Community Based Disaster Risk Management in Vietnam, Joint Advocacy Network Initiative in Vietnam, <https://tinyurl.com/y9rh4t37>
7. Decision No. 1002/2009/QĐ-TTg (July 13, 2009).
8. The Four On-The-Spot Motto is included in several legal documents. According to the National Strategy on Natural Disaster Prevention and Mitigation until 2020, this is to “assist people to actively prevent, respond in a timely manner to, and promptly and efficiently recover from natural disasters”. JANI has developed, published and disseminated a comprehensive booklet on the issue, in close collaboration with the CCFSC. However, implementation of the motto is limited due to a lack of resources.
9. Decision No. 488/QĐ-TTg 14/4/2017.
10. Exchange rates are from World Bank Open Data, <https://data.worldbank.org/country/vietnam>
11. Decree 02/2017/ND-CP regulates post-disaster support to the agriculture sector. The relevant laws are DPCL 2013, SBL 2015, Veterinary Law 2015, Aquaculture Law 2003, Forest Protection and Development Law 2004, and Vegetation Protection and Quarantine Law 2013.
12. Information retrieved from <http://datatopics.worldbank.org/aspire/>
13. No. 83/2015/QH13.
14. Information retrieved from Insurance Supervisory Authority under the MoF.
15. Based on data from MoF.
16. Based on data from Central Steering Committee for Natural Disaster Prevention and Control.
17. Formerly known as National Reserve Fund, established and governed under the National Reserves Law No.22/2012/QH13.
18. Established under DPCL 2013 and Decree No. 94/2014/ND-CP.
19. Decree No. 30-2012/ND-CP and Decree No. 64/2008/ND-CP.
20. Decree No. 18/2012/ND-CP, Decree No. 56/2014/ND-CP and Decree No. 28/2016/ND-CP.
21. Law No. 69/2014/QH13.
22. Law No. 15/2017/QH14, revised and enacted in June 2017.
23. Article 1, Prime Minister's Decision No. 315/QĐ-TTg (March 1, 2011).

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PART 3 >>

A WAY FORWARD

TAKING ACTIONS TO SAFEGUARD
THE OPPORTUNITIES OF
RESILIENT COASTAL DEVELOPMENT



Parts 1 and 2 of this report showed that Vietnam's coastal regions are exposed to significant and growing natural risks. While the country has made much progress in managing these risks, major challenges and gaps remain. How can Vietnam ensure that its coastal regions fulfill their potential as engines of resilient socioeconomic growth and prosperity? Part 3 focuses on the way forward, summarizing the building blocks of a comprehensive strategy that will strengthen resilience in coastal areas. It outlines five areas of strategic interventions: strengthening data and decision-making tools, ensuring risk-informed coastal planning, strengthening the resilience of infrastructure systems, taking advantage of nature-based solutions, and improving preparedness and response capacity. For each area, there are concrete recommended actions that can be undertaken today to safeguard the opportunities of coastal development. These show that systematic risk assessments — as presented in Part 1 — can help to prioritize actions in areas where risks are most severe. The recommendations presented here reflect the complex challenges of resilient coastal development, making the most of limited resources while striking a balance between risk and opportunity.

HA LONG BAY >> [Google Images](#)



Vietnam's government and communities have long-standing experience with threats from natural hazards and have taken a wide range of measures to manage these risks. From its impressive sea dike system and protective ecosystems, to advanced institutional structures for risk management and disaster response, the country has created a good foundation for resilient coastal development. Yet there are weaknesses that expose coastal communities to substantial risk. These include a lack of detailed hazard and asset data and consistently enforced spatial planning, vulnerable infrastructure systems, degraded ecosystems, and gaps in disaster preparedness. And taking action is urgent: Unless these shortcomings are addressed, coastal risks will be exacerbated in coming decades by the rapid pace of urbanization and climate change. Delaying action by 10 years could expose an additional \$4.3 billion of economic growth to natural shocks.

This final part of the report recommends five areas of strategic actions that will help Vietnam strengthen its foundations for resilient coastal development:

Recommendation 1 includes actions to improve data and information systems, which would enable risk-informed decision making. To manage risk effectively, decision makers need robust and up-to-date information. Ongoing






socioeconomic and climate changes in the coastal zone warrant a continuous and systematic system of collecting, sharing, using and updating detailed hazard and risk information and the government must commit to doing this. Establishing systematic, detailed hazard and risk analytical information—for example, through flood maps—at national and subnational scales is essential for making evidence-based decisions on coastal area development planning and design. Improved modeling techniques and new scientific insights also justify a dynamic approach to this information.

Recommendation 2 highlights the importance of taking decisive action on coastal planning and management. Given the rapid economic and urban growth in the zone, avoiding growth patterns that lock in unsafe development is crucial. Protecting flood zones to develop economic activities such as tourism very close to the coastline might be an attractive short-term proposition. But allowing urban growth in high-risk areas will increase the burden of maintaining the level of safety for these exposed locations in the long run. Although it can be challenging in the short term, zoning—which encourages development in areas that are safe due to natural variability and intensifying hazards—is more sustainable and cost-effective in the long term. There is also a risk of lock-in when designing long-lasting infrastructure assets, such as energy plants

\$4.3 billion » The amount of economic growth at risk if action is delayed by 10 years.

TABLE P3.1 >>

Recommended actions to strengthen the resilience of Vietnam's coastal provinces

Recommendation	Action	Lead role
 1. Strengthen data and decision-making tools	1.1. Ensure availability of complete and robust hazard data and analysis tools	MARD, MONRE and relevant central ministries and provincial governments
	1.2. Establish systematically updated asset management systems for gray and green infrastructure	
 2. Enforce risk-informed coastal planning	2.1. Ensure systematic planning to protect high-risk and high-growth areas	MONRE, MARD, Ministry of Planning and Investment (MPI), and provincial authorities
	2.2. Implement ICZM to balance risks and opportunities	
 3. Strengthen the resilience of infrastructure systems	3.1. Strengthen the resilience of critical assets and services	MARD in close coordination with Ministry of Construction (MOC), MoT, and Ministry of Industry and Trade (MOIT)
	3.2. Ensure systematic infrastructure maintenance, especially in high-risk areas	
	3.3. Upgrade dikes, starting with the most exposed and under-protected regions	
	3.4. Update and enforce safety standards and technical guidelines for infrastructure systems	
 4. Take advantage of nature-based solutions	4.1. Ensure management and protection of the sandy coastline	MONRE and MARD
	4.2. Develop a plan for restoring and protecting mangroves and coral reefs	
 5. Improve preparedness, response, and recovery capacity	5.1. Improve early warning systems and communication channels	MONRE
	5.2. Strengthen emergency planning and civil protection capacity	MARD
	5.3. Establish a national financial protection strategy	MoF

or transport routes. Indeed, retrofitting tends to be more expensive than incorporating risk-informed designs during early planning.

Recommendation 3 outlines concrete actions to strengthen asset resilience. Transport, energy, water, disaster protection, health and school infrastructure systems are crucial lifelines for supporting livelihoods and prosperity in coastal areas. So, ensuring that they can deliver their essential services is crucial for continued growth. Decision makers must therefore strengthen critical assets by integrating risk information into the planning, design and maintenance stages of all infrastructure investments. Vietnam's dike system protects many people and economic assets along the coast and several coastal regions are already high-risk hotspots where many people face the threat of disasters. Dike upgrades should focus on the highest-risk areas (especially population centers), be accompanied by systematic maintenance and follow safety standards that are better aligned with hazard levels and population and asset patterns. Even short-term infrastructure investments should be aligned with a long-term integrated development strategy, an approach that the government has successfully piloted in the Mekong Delta.

Recommendation 4 emphasizes the need for enhanced action on restoring, managing, and protecting natural coastal defense systems. From sand dunes to coral reefs and mangrove forests, natural systems are often highly

effective at safeguarding coastal livelihoods. Protecting them can help reduce flood risk and eliminate or reduce the costs of building gray infrastructures, such as sea dikes. If managed sustainably, they can also provide tangible economic value—for example, by supporting tourism. However, overexploitation and a preference for gray infrastructure has led to significant degradation over the past decades.

Recommendation 5 calls for action on enhanced residual risk management. While risk-informed development strategies are key to avoiding future disasters, they cannot fully eliminate risk. In a changing climate, coastal Vietnam must be prepared for more intense storms, heavier rainfalls and higher coastal floods. The government needs to prepare for future shocks and effective emergency response and recovery—for example, by predefining evacuation routes and logistics, ensuring adequate shelters and clearly defining roles and responsibilities for national and local authorities. Pre-positioning relief assets can ensure that crisis response does not rely on vulnerable transport infrastructure and a comprehensive risk financing strategy can make recovery funds quickly available where they are most needed.

Together, these actions can address gaps in the current approach and form a consistent and effective coastal resilience strategy that contributes to a long-term vision of a resilient, prosperous future for Vietnam's coastal communities.

11 Recommendation 1: Strengthen data and decision-making tools



Despite ongoing data gathering and modeling efforts, existing data and decision-making tools are often insufficient for enabling effective risk management (Chapter 6). While the government recognizes the importance of robust risk data, there are major challenges to achieving a unified and well-maintained hazard and risk information system. Although different sectors record and update hazard and risk information, this is neither systematic nor coordinated. Instead, it is scattered across line ministries and different administrative government levels. The lack of information sharing between government entities and stakeholders also limits coordination on the frequency, method, and scope of data gathering. Inadequate IT infrastructure and the lack of regulation and financial resources for data management and systems operations also contributes to the fragmentation or inefficiency of hazard and risk data collection and sharing.

Addressing this information challenge will be a critical foundation for effective coastal risk management in Vietnam. With comprehensive data on natural risks, decision makers will be better placed to integrate risk management measures into all planning decisions, and prioritize cost-effective resilience building measures. Indeed, the World Bank's *Lifelines* report has shown that having suitable risk data can reduce the cost of resilience building measures in the infrastructure sector by as much as 85 percent (Hallegatte et al. 2019).

85% >>

Risk data can reduce the cost of infrastructure resilience by as much as 85 percent.

In Vietnam, the MARD is well positioned to tackle this challenge by establishing a comprehensive national disaster risk information system at the VNDMA. The latter should have overarching responsibility for developing and managing the system in collaboration with the MONRE and other relevant ministries. As a central repository of natural hazard data for Vietnam, this national system should be synchronized with existing national and provincial databases, such as public asset inventories. To ensure wide uptake, the information systems should be accessible to all stakeholders and include certain data for public use.

Several ongoing activities can facilitate the implementation of this recommendation. The VNDMA is already developing a proposal for establishing an

TABLE 11.1 >>

Recommended actions to strengthen the resilience of Vietnam’s coastal provinces



Action	Lead role
1.1. Ensure availability of complete and robust hazard data and analysis tools	MARD, MONRE and relevant central ministries and provincial governments
1.2. Establish systematically updated asset management systems for gray and green infrastructure	

emergency operations center to be hosted in a new building. The national data risk information system and its IT infrastructure should be installed and operated as part of this new center. By ensuring regulations for data management, system operations, and financial support, the VNDMA could be equipped with the authority to efficiently operate and maintain such a risk information system. Implementing these measures is likely to take several years, and swift action is required to take the first steps towards the long-term objective of a fully operational national disaster risk information system. Two short-term priority actions can help the government take these first steps (table 11.1).

Action 1.1 >>

Ensure availability of complete and robust hazard data and analysis tools

Natural hazard models and data play a crucial role in informing risk management and coastal development decisions. Given Vietnam’s significant exposure to natural hazards and long history of disaster risk management, different agencies and institutions have produced a range

of models and datasets. However, they are inconsistent, incomplete, difficult to access, and fragmented (Chapter 6). Important hazard data — such as flood maps — are drawn from global models, which do not accurately reflect local conditions, making them inadequate for planning purposes.

Having up-to-date, consistent, and robust hazard information is crucial for making risk-informed decisions across all sectors. To achieve this objective, the government should build on ongoing efforts to unify and expand existing hazard datasets. The following guiding principles are key to ensuring that hazard data is reliable and can be widely used:

1. **Ensure that robust, consistent, and disaggregated hazard data is available for all of Vietnam:** As Vietnam is exposed to a range of natural hazards, it needs detailed national hazard maps that cover coastal and riverine flood risks, coastal erosion, typhoons, saline intrusion, and droughts. Flood modeling will require a country-specific digital elevation model that accurately captures Vietnam’s topography. Global flood models do not possess the accuracy to depict topographic details with enough resolution; as such, they are not suitable for informing investment and planning decisions.

Global hazard maps also fail to account for Vietnam's extensive protective infrastructure system. Developing Vietnam-specific hazard maps will ensure that they are generated with consistent methods and assumptions, thus avoiding the current challenge of a patchwork of partial maps with limited comparability. Developing different climate change scenarios will enable the assessment of potential impacts on the probability of extreme events occurring in the future.

- 2. Ensure that data enables decision making under uncertainty:** All hazard predictions and climate change scenarios have an inherent element of uncertainty. Climate models rely on a range of simplifying assumptions, and future hazards often depend on external factors that cannot be easily predicted—for example, reservoir construction in upstream countries of the Mekong could significantly alter future hydrologic patterns and flood probabilities in Vietnam. To ensure that such uncertainties are acknowledged, decision makers must have access to hazard data that cover a range of possible scenarios, enabling them to stress-test their investment and planning options and select solutions that are robust to an uncertain future. New methods of decision making under uncertainty—such as robust decision making, decision trees, or adaptive pathways—should be used to select solutions that deliver acceptable outcomes in the largest range of possible futures, instead of optimizing for a particular future scenario (Lempert and Groves 2010; Ray and Brown 2015). The World Bank has supported countries with the application of such tools for investment designs.

- 3. Ensure regular updates and maintenance of data systems:** A unified platform of high-quality hazard data requires clearly defined responsibilities and funding for system maintenance. This includes quality assurance of new datasets, harmonization of new data collection and modeling efforts, and technical maintenance to ensure a functioning data repository. Moreover, information and data must be regularly updated, especially on fast-moving hazards. Saline intrusion and coastal erosion, for example, are both relatively fast-moving, and affected areas can change from year to year. Hydrological modeling may also need updating as new flood protection systems are built. In practice, a large number of actors generate natural hazard data, including ministries, academia, and the private sector. So, updating datasets requires continuous and close coordination with partners to ensure that updates are consistent, not duplicated, and made available or referenced through a central system. This implies that managing a data system also requires a standard setting function. Regions currently use different methodologies to monitor coastal erosion; harmonizing their approach will ensure comparability.

- 4. Ensure datasets are accessible to all relevant stakeholders:** High-quality hazard datasets can only serve their purpose if they are accessible to the wide set of users who need them, from central government agencies to local authorities, private sector investors, firms, and households. Making natural hazard information publicly available is the only way to incorporate risk-informed planning and decision

making in all sectors of coastal development. While asset maps and vulnerability data can be sensitive information, natural hazard data are not. An open data approach can address the challenge of fragmented information held by a wide range of agencies without access for decision makers.

The good news is that none of this work needs to start from scratch. Vietnam and its government have the experience and capacity to develop a high-quality hazard information system. They can build on existing data initiatives and platforms to systematically collect and standardize hazard data for coastal areas and all provinces. In the past decade, there have been efforts to collect and share hazard data at national and regional levels, such as the Mekong River Commission's regional data and information services portal. Seeking synergies with and drawing lessons learned from such regional data collection initiatives and platforms will be essential. Indeed, seeking these synergies and enhancing interagency data sharing standards will allow disaster risk information to be integrated at the heart of decision making across all sectors, forming the basis for risk-informed coastal development in Vietnam.

Action 1.2 >>

Establish systematically updated asset management systems for gray and green infrastructure

Natural hazard data is crucial for understanding which natural shocks need to be expected where. But what assets

are they putting at risk? To answer this question, decision makers need reliable information about the assets on which coastal development depends. They need to understand the location and vulnerability of natural and artificial assets to estimate the level of exposure and risk and hence prioritize risk reduction measures.

As with hazard data, having up-to-date, consistent and robust information about the state of assets is essential. This study's nationwide assessment and hotspot analyses highlight a lack of coherent datasets for natural and artificial coastal zone assets—including dunes, coastal reefs, mangroves, and dikes—as well as lifeline infrastructure systems, buildings, and schools. Systematic asset surveys and comprehensive monitoring to track changes are indispensable.

Rapid coastal urbanization and economic development are increasing the pressure on gray infrastructure and ecosystems. As these assets are critical for supporting continued coastal development, central and local government authorities need to develop asset management systems that can monitor the state and vulnerability of essential systems. This will enable actions to strengthen the resilience of these assets, so they continue to support resilient development along the coast.

Developing such multi-sectoral asset data and management systems will require strong interagency collaboration. MARD, the MONRE, the Ministry of Construction and other relevant ministries will have a key role in coordinating and facilitating the setup and

management of such asset systems. Local community participation in monitoring (eco)systems can also help raise awareness on the importance of preserving them. More specifically, setting up complete and regularly updated asset management systems will require several concrete actions:

1. Establish a management system detailing the location, type and vulnerability of critical assets:

Coastal zones are host to a wide range of critical public assets that are essential for supporting the livelihoods and welfare of communities. These include public service facilities such as schools, shelters, and health care facilities and critical lifeline infrastructure systems such as electricity plants, substations, transmission and distribution grid, roads, bridges, ports, and water treatment plants. Undertaking a complete georeferenced mapping of these assets can help government authorities identify assets that are at risk from natural shocks — and by extension, assess the risk of populations losing access to critical services during an emergency. Assessing the vulnerability of assets — for example, typhoon resistance of schools or road flood resilience standards — will also enable authorities to prioritize upgrading needs. As coastal development and infrastructure investments progress at a rapid rate, regularly updating such asset management systems and ensuring their continued accuracy will be critical.

2. Monitor urban expansion in coastal zones to track people's exposure to natural hazards: A large fraction

of Vietnam's coastal communities is already exposed to significant natural hazards. As urban growth continues to be spurred by economic opportunities in the coastal zones, the exposure of people will continue to rise. However, rapid urbanization makes it difficult for authorities to guide new developments into safe zones, especially when they are informal or have no systematic planning oversight. To manage risks to communities, the authorities will need to ensure risk-informed urban planning by tracking the expansion of built-up areas and ensuring they do not spread to high-risk zones. The European Space Agency's World Settlements Footprint Evolution is one example of annually updated satellite imagery that is designed to provide high-resolution tracking of built-up areas. With such tools, authorities can monitor the ongoing risk to coastal communities, prevent new settlement in risky zones, and guide coastal development into safe places. Such monitoring can also be highly cost-effective, as relocating at-risk settlements is far costlier than planning with foresight.

3. Establish a central dike management database:

Vietnam's government has long invested in its sea and river dike system to protect communities from floods. The VNDMA has already established a central dike management database, though it only covers major Grade I–III and special designation dikes, which represent about 16 percent of the 2,659 kilometers of sea dikes. Smaller Grade IV and V dikes — the other 84 percent of the system — are managed by provincial authorities rather than under central oversight. And

because provinces lack the capacity and resources to maintain advanced technical inventories, their dike databases are incomplete, not regularly updated, inconsistent, unsynchronized and not linked to the central system. A central database should be established that details the location, safety grade, and maintenance status of each dike. As well as enhancing dike assessment, inspection and maintenance, such a robust system would help prioritize upgrades and extensions, and assess the evolving flood risks in the areas they protect.

4. Ensure systematic mapping and monitoring of coastal ecosystems, such as mangrove forests, coral reefs, dunes, beaches and foreshores:

Although these natural systems play a critical role in delivering cost-effective protection to many coastal communities, there is no systematic inventory to monitor their location and status. National and local governments alike need to enhance their capacity to systematically plan, implement, and monitor coastal ecosystem conservation programs. As part of this effort, a community-based monitoring system could strengthen the role of communities and local stakeholders in coastal ecosystem management. Systematic mapping and monitoring of these natural

systems will help raise awareness of their crucial contribution to economic activities, such as tourism, as well as coastal risk reduction.

Developing a national coastal asset management system could be a game changer for facilitating resilient coastal development in Vietnam. And the above-described efforts would not need to start from scratch: many are already under way, but require better coordination. For example, various ministries and local authorities already hold information public asset and dike location and type; it just needs to be collected and curated in a central system. Similarly, while some authorities are already mapping and monitoring natural assets, they do it on a case-by-case basis, so the information has not been consistently integrated into national resilience strategies.

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Taking action: Next steps towards strengthening data and decision-making tools

Due to its mandate, the VNDMA is well positioned to coordinate data collection efforts and establish an asset management system, in collaboration with the relevant departments of MONRE, Ministry of Construction and provincial governmental bodies. Concrete next steps can be taken at two levels.

At national level, consolidating and gathering existing datasets can help take stock of existing information. Nationwide hazard maps should be produced based on Vietnam-specific digital elevation and hydrology models, to end the country's reliance on coarse global datasets. Developing a central data management platform and engaging with relevant data producers, holders, and users will be essential to lay an institutional basis for this effort.

At local level, the VNDMA should start with refined location-specific hazard and assets mapping exercises in three or four provinces, as a pilot that can be expanded later. The Red River Delta and central coastal regions offer good

pilot locations due to their high concentration of people, economic activity, and natural risks. Hai Phong, Thai Binh, Nam Dinh, and Ninh Dinh Provinces would be particularly well suited.

International best practice

Various international best data-gathering and management practices can serve as examples for developing this pilot in Vietnam. The Netherlands' Veiligheid Nederland in Kaart Program has developed tailored flood mapping methods for polders or embanked areas that take flood defense vulnerability into account. Its nationwide flood maps inform decisions around new flood protection levels and long-term risk management investments.

Examples from the EU can also offer best practice for asset datasets and management systems. For instance, the EU Flood Directive requires member states to update risk maps for flood-prone areas on a six-year cycle and make these data accessible to the public. The risk maps must identify consequences of floods to population, environment, economy and cultural

heritage and require an updated baseline of asset information in flood-prone areas. These maps serve as input for preparing and updating flood risk management plans to arrive at specific investment plans.

Five-year action plan

- Establish a government policy for sharing and managing hazard and risk data
- Develop an integrated central platform for hazard and risk data
- Select three or four provinces for piloting location-specific hazard and risk assessments

Lead role: MARD, in close coordination with the MONRE and relevant central ministries and provincial governments

Cost estimate: \$8–10 million upfront investment, plus ongoing operating costs

Financing options: Government budget, technical assistance, and investment lending by multilateral development banks

Recommendation 2: Enforce risk-informed coastal planning



At the meeting between land and sea, coastal zones are subject to continuous dynamic change. This report shows that most of Vietnam's inhabited coastal stretches are undergoing significant variation, as a result of either erosion or sediment build-up (Chapter 3). It also shows that coastal urbanization and infrastructure construction are occurring at a significantly faster rate than these natural changes. Satellite data reveals that new settlements are systematically being built in areas of high risk, but these risks often only become apparent years later — for example, when erosion reaches buildings, or a typhoon reinforces erosion and flooding. In such sensitive zones, urban growth and development investment planning requires careful risk assessments.

Current practices along Vietnam's coast show that urban and coastal planning is not keeping up with the rapid rate of change. With hazard data not readily available, urban planning and coastal development strategies do not consider threats from natural hazards. As a result, new coastal developments or low-income settlements are built within dynamic beach zones, with the consequent risks to people and economic activities. The hotspot analysis shows that tourism developments along the Phan Thiet coast have been damaged by beach erosion, as there was no buffer zone for the coast's natural retreat (Appendix A). New developments are systematically expanding into risky zones, with next to no buffer for sea level rise or erosion from storm events. Without action, direct and indirect economic losses will rapidly grow.

Part 2 of this report also shows that, although coastal zoning and planning strategies are in place, they are rarely

enforced. Among several key obstacles to the systemic implementation of integrated coastal planning, it identifies the lack of hazard data or capacity to carry out detailed risk assessments, which prevents authorities from putting risk-informed coastal management into practice at local and regional levels. For example, the most recent SEDPs for the hotspots studied in this report fail to address the challenges of adapting to climate change. ICZM policy frameworks and regulations lack systematic enforcement in all the hotspot locations.

To ensure that future coastal development can offer safe and sustainable livelihoods, authorities must systematically adopt and enforce risk-informed planning strategies. To implement such strategies, they will need rigorous planning frameworks that require public and private actors to integrate risk information at the heart of

TABLE 12.1 >>

Recommended actions to ensure risk-informed coastal planning

Action	Lead Role
2.1. Ensure systematic planning to manage risks in high-risk and high-growth areas	MONRE, MARD, MPI and provincial authorities
2.2. Implement ICZM to balance risks and opportunities	

their planning and investment decisions. Especially in high-growth areas, decisive action is required to ensure that new developments are guided into safe and sustainable zones. This principle should apply to all sectors—from tourism to agriculture and urban planning. If put into action systematically, ICZM can be a critical tool to ensure that Vietnam's coastline realizes its socioeconomic development potential, while also safeguarding it from natural risks. To take steps towards this long-term objective, this report recommends the government take two concrete priority actions (table 12.1).

Action 2.1 >>**Ensure systematic planning to protect high-risk and high-growth areas**

This study has shown that natural risks are not evenly distributed along Vietnam's coastline. Provinces in the Red River and Mekong Deltas stand out as areas that are at high risk from natural hazards, particularly flooding and storms. Both regions have a dense concentration of people, assets, livelihoods, and economic activities. Secondary coastal cities such as Hai Phong in the Red River Delta are

also the focus of ambitious coastal development plans, with regional strategies setting targets for expanding industry and trade. Such strategies require investments in infrastructure and production assets, and spatial planning that accounts for changing land use patterns. Careful risk assessments are needed to ensure that investment and spatial planning decisions are not jeopardized by current and future natural hazards. Natural risks—and strategies for managing them—should be at the heart of coastal development strategies.

Risk informed spatial planning is also crucial in the central coastal regions' high-growth provinces. The analysis for this report shows that urban and economic growth has been rapid in these regions, while the capacity to enforce systematic risk-informed spatial planning has remained low. In fast-growing areas like these, today's planning decisions will determine the risk management options and costs for decades to come. Long-lived infrastructure assets or new urban settlements can lock in decisions for generations. Once flood plains are settled on and built up, it is very costly or impossible to relocate settlements to safe areas. And as sea levels rise and the at-risk population grows, decision makers are likely to be forced to invest in

ever-more expensive flood protection infrastructure. Spatial planning decisions must therefore make the best use of natural hazard information and consider the long-term consequences of spatial lock-in. Without systematic, risk-informed, long-term planning, investing in a flood-prone area may appear like a good idea in the short term; but it can have devastating implications for long-term development.

To guide coastal development along a sustainable and resilient trajectory, provincial governments need planning frameworks that can help them answer several crucial questions: Which areas are safe for development? Which areas may face heightened risks in the future, especially due to climate change? Which already developed areas are not sufficiently protected? How close to the coastline should development be permitted? Which natural systems need to be preserved to ensure their coastal protection function?

Several essential tools can guide public and private sector decision makers. These include risk information and data, systematic requirements for risk assessments, and well-enforced guidelines and regulatory frameworks for safe spatial planning. Using these tools will help guide economic and urban growth and associated land use transformations along the coast without excessive exposure to natural risks. To achieve systematic risk-informed planning, the following actions will be indispensable:

- 1. Ensure that new coastal developments are systematically screened for natural risks:** To ensure that any new development and investment in coastal zones does not increase the risk of disaster, regulators

and authorities should require systematic risk assessments. Such risk assessments must consider present and near future risks and how the investment may attract follow-up investments that are vulnerable to long-term risks such as sea level rise. All regional SEDPs must take disaster risks into account and incorporate measures to reduce risks. Assessment tools and adequate budgets need to be made available to local authorities who are at the frontline of implementing these plans. Regulatory requirements must also be established that mandate private sector investors to conduct thorough risk assessments on whether their new developments are in line with resilient SEDPs. Especially large infrastructure investments that have long lifetimes or are located in sensitive seafront zones should be subject to systematic screening.

- 2. Develop and enforce risk-informed spatial planning frameworks at all levels of administration:** The complex interactions and trade-offs between risks and opportunities in coastal zones require robust yet practical spatial planning approaches, based on the best available risk information (Recommendation 1). They also need to balance seafront livelihoods—for example, in local fishery communities—with risk reduction. To strike this balance, local spatial planning approaches should be developed in close consultation with all stakeholders and sectors. Applying an iterative risk assessment and consultation process can develop a robust and flexible spatial planning strategy that helps support resilient land use changes while protecting livelihoods. These strategies are particularly important



BOX 12.1 >> HOTSPOT FOCUS

An opportunity for public-private partnerships to combat erosion in Phan Thiet

Phan Thiet is a coastal city on the beautiful curved coastline facing Phan Thiet Bay. With its numerous seafront resorts, the district recorded 4 million visitors in 2017. But serious coastal erosion affects communities and threatens tourism here. Several beachfront resorts have seen their beaches disappear and buildings collapse into the sea. Tourist numbers fell by 20 percent in 2018 and investment decreased as a result of erosion.

Yet, significant budget constraints have meant that neither the central nor provincial governments could undertake adequate measures to mitigate beach erosion in Phan Thiet. With the government unable to act, erosion seriously and rapidly damaged properties and businesses, so resort owners took matters in their own hands, building revetments and groins within their own properties to minimize

the impact of beach erosion. This fragmented and uncoordinated design and intervention has made them short-term patches rather than integrated, long-term solutions. But, while they have mostly been unsuccessful in the long term — and in several cases, have reinforced adverse effects on adjacent areas — these measures clearly indicate the private sector's willingness to help mitigate erosion.

The hotspot study for Phan Thiet proposes an integrated solution that prioritizes large-scale beach nourishment and a shelterbelt, and requires the removal of existing detrimental structures, managed coastal retreat in selected locations to allow natural beach dynamics, and strict enforcement to land use planning regulations. Such large-scale and combined structural and nature-based solutions would better manage

coastal erosion, while protecting and enhancing the area's touristic value.

The Phan Thiet situation highlights the need for strategic guidance from provincial government, and the opportunity to harness the private sector's willingness to finance erosion protection measures. The shared interest of resort owners is a promising starting point for a public-private partnership to combat erosion. It will require long-term commitment and collaboration between public and private partners to identify common interests and then finance, implement, and maintain measures such as beach nourishment and a shelterbelt. This could serve as an innovative blueprint for other erosion hotspots and demonstrate how to mobilize the private sector, especially when public resources are limited.

PHAN THIET >> Beach resort owners have taken fragmented and uncoordinated measures to counter the effects of erosion on their own properties

Google Earth

in secondary cities, where urban planning frameworks are not keeping up with the urban growth rate. Ensuring that local authorities have the capacity to guide this growth in a planned and risk-informed way will be crucial for avoiding uncontrolled coastal development, which is bound to increase disaster risks and economic losses. If they are well designed and enforced, strategic long-term spatial planning frameworks have the potential to contribute to the long-term resilience of coastal communities.

Action 2.1 aims to ensure that all new coastal developments — from beachfront hotels to roads, industrial parks, and new urban settlements — are designed and built in a way that fully accounts for natural hazards and the potential risks they may create in the future. The main challenge in implementing this action will lie in enforcing these standards and requirements in every planning and investment decision. Although widespread implementation of this action may take many years, the consequences of non-risk-informed development can be detrimental. Every bad decision taken today can create disaster risks in the future and increase the cost of risk mitigation. As such, no time should be lost in putting these principles into practice.

Action 2.2 >>

Implement ICZM to balance risks and opportunities

While ensuring the resilience of new developments is essential, spatial planning in sensitive coastal zones is

not limited to new developments in urban or economically active areas. As a comprehensive spatial planning strategy, ICZM must balance environmental, social, economic, cultural and recreational objectives within the limits of natural dynamics. In practice, an ICZM approach aligns all activities: information gathering, planning, decision making, investment, and monitoring and evaluation. The approach has proven effective in integrating a diverse set of objectives and stakeholders, especially in countries with sensitive coastal zones such as the Netherlands, New Zealand or Small Island Developing States.

Reflecting the trade-offs along its extensive and diverse coastline, the government of Vietnam has recognized the importance of balancing the risks and opportunities of coastal development. With the objective of bringing together stakeholders and adopting a sustainable development pathway for coastal regions, it has taken various measures to adopt the principles of ICZM (Chapter 7). This includes a range of policies and laws that frame coastal zone management and formalize the necessary institutional structures.

While these are promising steps, they have not yet proven to be effective in delivering systematic ICZM implementation. Significant challenges remain, as the policy framework has limited scope and lacks consistent enforcement. Institutional challenges also arise from the lack of clearly defined roles and responsibilities for key stakeholders, the functions and authority of the MONRE's VASI, and mechanisms to coordinate decisions across sectors and government levels. Operationally, limited

awareness, low commitment from policy and decision makers, limited cooperation and information sharing, and insufficient human and financial resources also obstruct ICZM initiatives.

Nevertheless, the initial policy and regulatory foundations are in place, giving Vietnam an opportunity to step up to a high standard of ICZM that is compatible with the immense potential of resilient sustainable development in its coastal zones. ICZM can quickly make tangible contributions from the start of its implementation. But a series of complementary concrete actions will also be required to achieve the long-term objective of sustainable, risk-informed coastal development planning:

- 1. Strengthen the legislative and policy frameworks that facilitate ICZM:** To fully formalize and institutionalize the practice of ICZM, the government must create a consistent legal basis for its implementation. In particular, it requires explicit stipulation in an amendment to the Law on Natural Disaster Prevention and Control and the Marine Law. In line with regional SEDPs, ICZM requires five-year action plans and strategies that are integrated into relevant policy and legislation. Including ICZM in such development plans will allow the progress of implementation to be formally assessed. If there are shortcomings, obstacles can be identified and addressed through an iterative process of strengthening the regulatory framework.
- 2. Strengthen the existing institutional ICZM structure:** By definition, coastal zone management

is a multisectoral task, requiring the collaboration and coordination of a wide range of stakeholders. Successfully organizing this task requires strong institutional structures with clearly defined roles, responsibilities, and communication channels. Within central government, the role of convening cross-sectoral advisory groups to distribute relevant knowledge to local stakeholders and drive ICZM implementation falls to VASI. Other line ministries have crucial roles to play, from infrastructure, urban planning, ecosystem management and agriculture to fisheries. With guidance from the national level, provincial and local governments play a crucial role in defining priorities, and monitoring and enforcing implementation on the ground.

- 3. Strengthen local capacity and resources:** Successful implementation of ICZM strategies depends entirely on the local authorities in charge of implementation on the ground. Coordinating the complex demands of ICZM in practice requires technical and administrative capacity, clear guidance from central authorities, and adequate resources. Local governments would benefit, for example, from clear technical guidelines on implementing coastal setback lines, functional zoning, information management systems, and mainstreaming ICZM into socioeconomic and sectoral development planning. Implementing protocols for conducting or commissioning environmental impact assessments will be crucial for evaluating the sustainability of planning options. A robust monitoring system will also be essential to track progress over time and identify

challenges in current trends. This will require close coordination with the central platform for hazard and asset data. All these measures will require a capacity-building program for practitioners, as well as a budget plan for priority expenses.

Overall, ICZM offers a model for managing social, economic, and environmental objectives within one unified framework. Doing so allows decision makers to directly consider the potential trade-offs between these objectives

and take a balanced approach to managing coastal risks and opportunities. The government has already recognized the importance of such an approach and adopted initial policy measures and technical guidelines for this purpose. However, much remains to be done, and there is an opportunity for it to step this effort up to the next level by expanding an integrated approach to all sectors and regions. Enforcing regulations (for example, for setback lines) will be a key challenge, and will require a concerted effort between all government levels and stakeholders.

Taking action: Next steps towards systematic risk-informed coastal planning

The hotspot analyses carried out for this study (Appendix A) show how local risk assessments can help design a risk reduction strategy and determine concrete investment needs. To further advance the integrated coastal development planning agenda, the government should scale up such risk-informed strategic planning exercises in coastal regions. This is especially so in high-risk and high-growth areas like the Red River Delta and new large coastal developments such as Hai Phong City, Tuy An and Phan Thiet. It can build on experiences from previous pilots in Nam Dinh, Thua Thien-Hue and Ba Ria-Vung Tau as part of the Vietnam-Netherlands ICZM project.

It will be particularly important to adopt a multi-sector approach that reflects the priorities and needs of various stakeholder groups. It needs to pay particular attention to identifying and protecting sensitive ecological zones such as coastal dune systems, which are coming under pressure from rapid development and losing their ability to offer crucial protective functions (Recommendation 4).

National best practice

The government's strategic Mekong Delta Plan,

developed with donor support, has provided a long-term integrated vision for the region. It balances economic development objectives with recognition that the natural environment brings both risks and limitations. While coastal characteristics are different, the Mekong Delta Plan can inspire integrated approaches in other areas, such as the Red River Delta. Ho Chi Minh City's strategy formulation is another example of good practice, with detailed city planning exercises based on detailed flood risk information.

International best practice

To guide its efforts in implementing advanced coastal planning approaches, the government can refer to successful practices in the Netherlands, the United Kingdom, Australia, and other countries. They all integrate coastal risk mitigation strategies with regional and local strategic planning to balance coastal risks and opportunities.

The hotspot analyses in this report follow this approach and can serve as Vietnam-specific examples of such planning exercises. What all these examples have in common is that ICZM

is creating win-win strategies that safeguard socioeconomic development opportunities, protect sensitive ecosystems that contribute to risk mitigation, and strengthen regional authorities' technical and administrative capacity.

Five-year action plan

- Formulate and refine nationwide ICZM guidance to support coastal planning efforts
- Ensure technical and administrative capacity to integrate natural risk information in coastal planning processes
- Select two to three provinces for piloting integrated development plans in line with ICZM, with a focus on high-risk and high-growth areas

Lead role: MONRE, in close coordination with MARD, MPI, and provincial authorities

Cost estimate: \$10 million for pilot schemes in the Red River Delta and two or three pilot cities

Financing options: Government budget, technical assistance, and investment lending by multilateral development banks

Recommendation 3: Strengthen the resilience of infrastructure systems



From serving people's most basic needs to enabling ambitious goals of industrial development and trade, water, sanitation, energy, and transport services are critical for supporting well-being and development in coastal Vietnam. These lifeline infrastructure systems are essential for ensuring a decent quality of life in coastal communities (Hallegatte et al. 2019), as public services such as health care and education are heavily dependent on their smooth functioning.

These systems are also a central factor in driving business productivity in all sectors, enabling firms to provide the goods, services, and jobs that are the foundation of the country's diverse and prosperous coastal economy. Protective infrastructure—sea and river dikes in particular—forms a central element of Vietnam's coastal protection system, which is vital for community resilience.

However, to support coastal communities, infrastructure systems must provide reliable services that are resilient to shocks. The pressure on infrastructure systems is intensifying, not least as demand for infrastructure services increases due to rapid demographic and economic growth. Climate change and natural shocks are also testing the resilience of infrastructure systems, as floods, droughts, and storms damage assets and compromise their reliable functioning. Private and public buildings—including homes, schools and hospitals—are experiencing the destructive force of storms, floods and other natural shocks. This vulnerability was exposed in 2017, when Typhoon Damrey resulted in the staggering damage and destruction of 300,000 housing units, more than 500 kilometers of roads, 1,600 electricity poles and 460 kilometers of riverbank and irrigation channels.

While Vietnam has taken steps to improve infrastructure resilience in the coastal zone, major shortcomings persist and put future development at risk. As Chapter 8 shows, the vulnerability of infrastructure systems can be linked to several challenges faced by authorities at central and local levels. Insufficient focus and resources for systematic maintenance mean that assets are often not fully functional and have reduced lifetimes. Inadequate technical standards and building codes mean that assets often cannot resist the level of demand and intensity of natural shocks that they are regularly exposed to. Aggravating this challenge, safety standards are often not consistently enforced. For instance, only 35 percent of Vietnam's sea dikes meet their prescribed safety standards, leaving vast areas and population groups under-protected.

TABLE 13.1 >>

Recommended actions to strengthen the resilience of Vietnam's infrastructure systems



Action	Lead role
3.1. Strengthen the resilience of critical assets and services	MARD in close coordination with MoT and MOIT
3.2. Ensure systematic infrastructure maintenance, especially in high-risk areas	
3.3. Upgrade dikes, starting with the most exposed and under-protected regions	
3.4. Update and enforce safety standards and technical guidelines for infrastructure systems	

To keep up with coastal development, while also enhancing the level of protection and ensuring reliable service delivery, the government of Vietnam will need to strengthen the resilience of infrastructure systems and services. The World Bank's *Lifelines* report shows that increasing infrastructure resilience will require measures in five areas (Hallegatte et al. 2019):

1. The basics of general infrastructure design, operations, and maintenance
2. Building an integrated institutional approach to infrastructure resilience
3. Creating the regulations and incentives that require resilience to be integrated into infrastructure investments and planning
4. Investing in the data, information, and analytical tools needed to make risk-informed decisions

5. Ensuring that the necessary financing is made available

With high access rates to infrastructure services and a long track record of managing natural risks, Vietnam's government and infrastructure agencies have already made much progress in several of these areas. But the pressures of economic growth and climate change mean that more remains to be done. Increasing infrastructure and asset resilience in vulnerable coastal zones will require the responsible infrastructure ministries to make a concerted effort. While MARD leads the efforts to build the protection system and provides guidance on infrastructure resilience, the MoT, MOIT, and Ministry of Construction are responsible for resilient transport systems, energy infrastructure, and housing respectively. The VNDMA can play an important coordinating role in aligning these activities and ensuring consistency. Table 13.1. outlines concrete priority actions that will help the government take the first steps towards this long-term objective.

Action 3.1 >>

Strengthen the resilience of critical infrastructure assets and services

In prosperous, dynamic economies, infrastructure systems are central to the smooth functioning of everyday life and most economic activities. Chapter 5 shows that large shares of Vietnam's infrastructure systems are exposed to significant natural hazards, jeopardizing the provision of essential services in coastal communities. What actions can be taken to reduce and manage the natural risks to infrastructure systems?

FIGURE 13.1 >>

Infrastructure resilience should be considered at three complementary levels

Source: Hallegatte et al. 2019.



The World Bank's *Lifelines* report offers concrete and detailed recommendations for strengthening infrastructure resilience (Hallegatte et al. 2019), emphasizing that infrastructure resilience requires planning, investments, and policy actions at three levels: assets, services, and users (figure 13.1).

Infrastructure assets: In the narrowest sense, resilient infrastructure refers to assets such as roads, bridges, cellphone towers, electric substations, and power lines that can withstand external shocks, especially natural hazards. To strengthen them, Vietnam's authorities will need to conduct detailed asset vulnerability assessments in risk zones, as identified in Chapter 5. By upgrading roads and substations to protect them against floods, authorities do not only protect the functionality of these assets; they also reduce lifecycle costs by cutting repair and maintenance. Indeed, more resilient infrastructure assets tend to be more reliable even in the absence of natural shocks (Rentschler et al. 2019a).

Infrastructure services: Infrastructure systems are interconnected networks, and the resilience of individual assets is a poor proxy for the resilience of services provided at the network level. For instance, Vietnam's coastal North-South Highway is a critical road segment for supporting economic activity in coastal Vietnam. Disruptions along this route can have costly consequences for users across the entire network. Few alternative transport routes can accommodate the same traffic volume, so damage to this highway travels along supply chains (Colon et al. 2019; Pant et al. 2019). The government must therefore take a

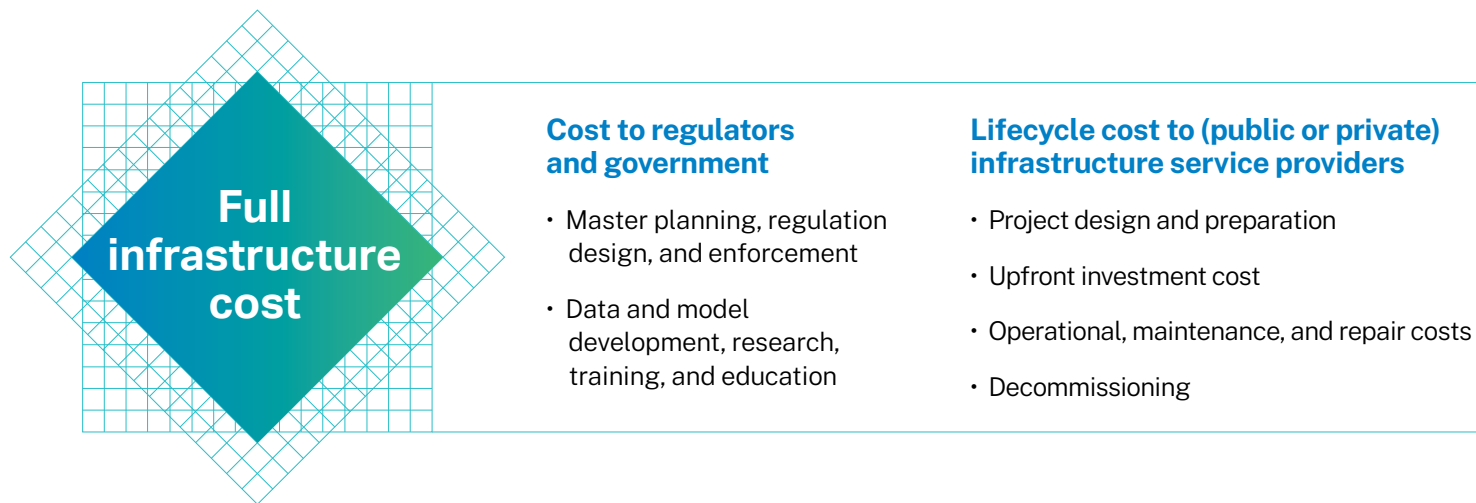


FIGURE 13.2 >>

For high-quality infrastructure, the government must provide for multiple funding needs

Source: Hallegatte et al. 2019.

systemic approach to infrastructure resilience by ensuring that systems have enough redundancy to deliver services, even if individual assets fail. Taking this approach can be an effective way to manage the costs of resilience investments. By identifying critical network segments, the government can strengthen the reliability of essential infrastructure services without having to invest in upgrading every single asset.

Infrastructure users: Because not all disruptions can be avoided, it is important to ensure that key users — such as large firms that provide jobs, essential goods and services and public service providers—can continue to operate. The consequences of infrastructure disruptions can be catastrophic or benign, depending on whether users—including people and supply chains—can cope with them. An important first step is identifying critical users, such as health care facilities, who must have access to back-

up capacity such as electricity generators or water tanks that can help bridge time in the case of disruptions, avoiding more serious consequences. Similarly, all infrastructure users can take actions to better manage service disruptions, and the government plays a key role in facilitating this effort. Overall, strengthening the resilience of infrastructure users reduces the total impact of natural hazards on people, and even contributes to managing disruptions caused by non-natural factors, such as technical failure.

To implement resilience-enhancing measures at these three levels, the government should review funding allocations for the entire lifecycle of infrastructure projects (figure 13.2). Too often, even with large-scale infrastructure investments, the focus lies on the up-front capital requirements of the construction phase. Even investments worth hundreds of millions of dollars can

omit the early phase funding needed for risk assessments, developing necessary data, risk-informed project design, and ensuring alignment with resilient spatial master plans. Similarly, once infrastructure assets are built, operators often lack the funds they need for maintenance and repairs. Strengthening infrastructure resilience means recognizing the full lifecycle costs of infrastructure systems, and allocating capacity and resources to meet these needs.

The good news is that there is a strong business case for strengthening the resilience of infrastructure systems. Because they are fundamental to economic activity and people's welfare, disruptions have huge societal costs. Infrastructure disruptions cost businesses in Vietnam an average of \$280 million a year (Rentschler et al. 2019a). Considering these costs, investing in infrastructure resilience would have a benefit-cost ratio of around 4 to 1: that is, every \$1 invested in resilience would yield \$4 in societal benefits (Hallegatte et al. 2019). The extra cost of ensuring that infrastructure investments meet high resilience standards is relatively low, at only 3 percent of overall infrastructure investment volumes (Rozenberg and Fay 2019).

Recommendations 1 and 2 can make an important contribution to increasing infrastructure system resilience

by ensuring the availability of relevant risk data and developing risk-informed spatial plans. The following concrete actions will help strengthen the resilience of critical infrastructure systems in coastal regions:

1. Align infrastructure developments with risk-informed spatial master plans: Chapter 2 shows that built-up space in coastal Vietnam is expanding. New urban and economic coastal zones are being developed, closely accompanied by investments in new infrastructure systems, including roads, electricity, water supply, or drainage systems. Risk-informed spatial planning (Recommendation 2) is crucial to ensure that such developments occur in safe areas. Infrastructure systems can play a key role in guiding such developments. For example, a new road is bound to attract settlements and businesses along its path, thus determining future risk exposure. Risk-informed spatial planning will not only reduce assets' exposure to natural hazards; it will also reduce risks to all the activities that the assets attract in the longer term. By mandating in-depth risk, environmental and social impact assessments, the government can ensure that new infrastructure investments are fully aligned with its objectives of resilient socioeconomic development.

2. Strengthen infrastructure segments identified as critical and high risk: Several segments of Vietnam's road network—such as the North-South coastal transport corridor—are in high-risk locations and crucial for economic activity, because few alternative

 On average, every \$1 invested in infrastructure resilience yields \$4 in societal benefits.

routes exist (Chapter 5). Any upgrades to the resilience of the road network should therefore start with those critical links which, while not necessarily in areas with the highest economic activity, provide essential connectivity between economic hubs. Pant et al. (2019) can act as a guide for prioritizing actions and serve as a blueprint for more localized criticality analyses. The power sector analysis in Chapter 5 also identified segments of the electric transmission and distribution grid that could be particularly vulnerable to natural shocks—for example, due to storm exposure. Nicolas et al. (2019) also offer a detailed account of measures that can be taken to improve resilience in power grids, especially by increasing redundancy capacity, smart network designs, and decentralized grids.

- 3. Ensure that critical infrastructure user (particularly health care providers) can continue operations, even when disrupted by natural shocks like typhoons:** Health care facilities play a crucial role in supporting relief and recovery efforts, especially during emergency situations. In high-risk coastal areas, the government should assist health care providers by establishing adequate back-up capacity to help bridge infrastructure disruptions. Even if relatively short-lived, this bridging capacity can buy time for providers

to address the disruption. Placing back-up generators, water storage and treatment capacity in strategic locations will help ensure access to services in disaster situations. Risk assessments of infrastructure systems (Chapter 5) and critical public services (Chapter 4) can help guide such decisions.

- 4. Incentivize firms to develop business continuity plans for managing disasters and infrastructure disruptions:** Businesses play a crucial role in providing essential goods, services, and jobs to coastal communities. Their contribution to recovery from natural disasters can be essential. Businesses need to operate even when access to production inputs or infrastructure services is disrupted. In Japan, the government has supported firms to develop business continuity plans by establishing dedicated regulation and subsidy schemes. These measures have proven to be highly effective at increasing the resilience of firms and have helped them continue operations even when infrastructure disruptions occur. Examples from industrial parks in Japan also show that firms that jointly invest in back-up capacity to reduce up-front investment needs facilitate their own business operations and also those of their suppliers and clients (Hallegatte et al. 2019).

+3% >>

Making infrastructure investments resilient will only add 3% to overall infrastructure investment volumes.



Action 3.2 >>

Ensure systematic infrastructure maintenance

Evidence shows that common management and maintenance principles can significantly increase infrastructure resilience (Hallegatte et al. 2019). Countries with stronger operations and maintenance frameworks tend to have power systems that are not only more resilient to natural shocks, but also offer more reliable service when there are no shocks (Rentschler et al. 2019b). Indeed, regular asset maintenance can significantly slow their

deterioration and extend their lifetimes, avoiding costly repairs. But infrastructure investment projects often focus on construction and do not make adequate provision for operations and maintenance. As a result, even large investments lack adequate planning and financing for long-term maintenance.

The quality and reliability of Vietnam's infrastructure services are relatively high compared to other countries in the region. But there is no centrally coordinated and systematic strategy setting out funding provisions for maintenance. The local authorities responsible for maintaining the dike system suffer a chronic shortfall in

maintenance budgets, while maintenance of the power system is managed through a fragmented system of local utilities, with limited central oversight of maintenance expenses and needs (Chapter 8).

Addressing these shortcomings could significantly improve service quality and reduce repair costs. The following concrete actions can help the government seize this opportunity.

- 1. Prioritize funding for lifeline infrastructure asset maintenance, particularly in high-risk areas:** Central government will have to identify high-priority areas for maintenance activities, and successively expand this scope across regions and sectors. In urban areas, drainage systems play a crucial role in flood management; a function they can only fulfill when drains are regularly cleaned. Similarly, vegetation management is critical for strengthening the resilience of the power system (Rentschler et al. 2019b), so regular maintenance of electrical transmission and distribution lines is essential. Chapter 5 estimates that 8,498 kilometers of Vietnam's electric grid are in forested areas. Annual vegetation control measures cost about \$500–2,000 per kilometer, so a maintenance budget of \$4–17 million per year is required for adequate vegetation control in the national electric grid. Adequate maintenance of Vietnam's extensive dike system would require around \$60–90 million per year. Tracking national spending on resilience-enhancing infrastructure maintenance across all these sectors could help identify priority

areas that have underfunded maintenance programs and are high-risk zones. Dedicated maintenance budgets should also be accompanied by a clear definition of roles and responsibilities across all levels of government.

- 2. Develop a long-term funding strategy to improve infrastructure system maintenance:** Past lapses in adequate maintenance budget provision can be explained by a lack of attention to the importance of maintenance and by overall financing constraints. Considering the rapid pace of coastal zone development and the intensifying impacts of climate change, infrastructure maintenance will require a long-term funding strategy. Besides analyzing existing and required upgrades, such a process should estimate maintenance costs—including potential increases due to climate and socioeconomic change—and identify funding mechanisms. For instance, incorporating maintenance requirements as a key component of a comprehensive risk financing strategy can ensure the long-term availability of funding, while highlighting the important contribution of maintenance efforts to coastal resilience (Recommendation 5).

Action 3.3 >>

Upgrade dikes, starting with the most exposed and under-protected areas

Vietnam's extensive sea and river dike system has long been at the heart of the government's coastal resilience

strategy. Built over several decades, today the dike system is an impressive feat of engineering that offers flood protection to millions of people in coastal communities. The dike system will play a central role in safeguarding livelihoods over coming years, especially where large and growing populations are concentrated in high-risk areas with limited natural defense systems. Despite its immense dimensions, the dike system has significant limitations. The government-prescribed safety standards are outdated and offer inadequate protection in many areas with rapidly growing populations and economies. The dikes often do not even meet the prescribed standards, as funding constraints have limited local authorities' ability to upgrade them. About two-thirds of the sea dike system does not comply with established design standards, with the largest deficiencies found in the Red River Delta. Inadequate dike maintenance (often due to funding constraints) has also led to premature deterioration in many areas, shortening dike lifetime and structural robustness. As coastal zones continue to develop and the impacts of climate change intensify, the system's shortcomings are bound to increase further.

The multisectoral risk assessment in Part 1 shows that the dike system has significant protection gaps. People, economic sectors, and public assets in Red River and Mekong Deltas are more exposed to the threats of riverine and coastal floods than anywhere else along the coast. In these regions, 8,000 square kilometers of agricultural land, 85 percent of aquaculture ponds, more than 2 million workers and \$2 billion of agricultural production are directly exposed to coastal flooding with a 50-year return

period. In central Vietnam's coastal regions, communities are mainly exposed to riverine floods but are not protected by an extensive river dike system. While the risk is less concentrated in these regions, pockets of high risk remain near industrial or urban centers. The following concrete actions will be necessary to get the system up to standard for the growing challenges over the coming decades.

- 1. Prioritize coastal protection investments, with a focus on the Red River Delta:** With the dike system falling massively short of the government-prescribed safety standards, an estimated 11.8 million people in coastal communities are exposed to the risk of intense coastal flooding, many of them in the densely populated Red River Delta. To mitigate these risks, the government must ensure that dike systems meet prescribed safety standards. Where they do not, investments in upgrades will be necessary, alongside a review of the safety standards themselves (Action 3.4). The costs of these upgrades will be substantial, with more than \$1 billion needed in the Red River Delta Region alone. Existing and future exposure levels may justify further investment.
- 2. Increase protection levels in built-up areas in the central regions:** While the North and South Central Regions are less densely populated than, for instance, the Red River Delta, they are experiencing rapid growth with fast infrastructure development, urban expansion, and the rise of industry and tourism. As this growth continues, it increasingly puts people and assets at risk from both river and coastal flood

hazards. The hotspot analyses of Quang Ngai, Quynh Luu and Phan Thiet show that local improvements of protection infrastructures could reduce these risks in a cost-effective manner (Box 13.1). Alternative or complementary measures can be deployed to further mitigate risks but are highly dependent on local circumstances. For example, river widening or sand nourishment should be carefully considered on a case-by-case basis, as they can mitigate risks while maintaining flexibility in the future by avoiding gray construction. Reservoirs, dredging, and widening bridge openings should also be considered as part of the toolbox.

While structural measures can effectively mitigate risks, they are costly, invasive, and often irreversible measures that affect the natural coastline. So, it is important to carefully choose the location of dike upgrades. Overprotecting undeveloped, high-risk areas should be avoided. While it may be possible to protect such areas against current risks, their protection needs are likely to increase over the coming decades. Building dikes is also likely to encourage development in newly protected areas, and once flood risks or sea level rise intensify, they may become increasingly unaffordable to protect. In such a scenario, dikes could increase risks by encouraging development in high-risk zones that cannot be effectively protected in the long term. It should also be recognized that the dike system can never offer complete protection, and that its protective contribution should not be overstated compared to the other recommendations put forward in this report.

Action 3.4 >>

Update and enforce safety standards and technical guidelines for infrastructure systems

Which protection level should a dike in a certain location provide? What construction materials, design, and techniques should be used to achieve these protection levels? What flood or storm protection features should be incorporated into road and power grid designs? Consistent and evidence-backed answers to such questions are essential for guiding infrastructure system investors and operators and ensuring high resilience standards. Government-prescribed safety standards and technical guidelines can offer the framework necessary to increase the resilience of infrastructure systems, if standards and guidelines are realistic, adaptable, and enforced.

The strengths and shortcomings of Vietnam's extensive dike system highlight the importance of such a framework. The government has introduced and updated comprehensive regulations and technical design standards, applying a single safety system to all the country's sea dikes. These standards also allow a location-specific approach—for instance, by mandating higher safety requirements in areas with large populations or important economic assets.

However, the safety standard system has its shortcomings. There are inconsistencies in the way safety requirements are applied across sectors, and design standards do not usually

BOX 13.1 >> HOTSPOT FOCUS

Tien Lang's dike system provides limited protection against flooding

Tien Lang, a coastal polder in the Red River Delta that is home to 155,000 people, highlights the challenges in Vietnam's dike system. National Road No.10 and Provincial Road 354 are main transport corridors in this district, connecting Tien Lang to nearby provinces and other districts in Hai Phong. Although activities on the polder are mainly rural, it is transitioning towards more industrial activities, projected along the main transport corridor. Economic risk is predicted to increase about tenfold, predominantly due to the projected socioeconomic development, between now and 2070.

Tien Lang is protected by 21 kilometers of sea dike and 57 kilometers of river dike (figure B13.1). The Grade IV coastal dike should protect the polder against coastal flooding with return periods up to 30 years. While it has been partly improved, the southern part — made of not yet solidified earth with a grass surface — is in poor condition. The weakest sections are where the river meets the sea and where the mangrove area has retreated. Plans to improve some sections of the sea dike have been approved, but no funding has been arranged yet. Other hotspots, Quang Ngai and Quynh Luu, face the same issues.

Another challenge on the polder is that the protection level offered by the river dikes varies.

FIGURE B13.1 >> Tien Lang is protected by 21 kilometers of sea and 57 kilometers of river dike



Disclaimer: The boundaries, colors, denominations, and other information shown on this map do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

The Grade II sections protect against 100-year river floods, whereas the Grade IV sections protect against 30-year river flood levels. In this small, low-lying polder, such differences should be harmonized to arrive at a comprehensive protection system. River dike protection is also very low here, considering the number

of people and economic activities at risk. It is not surprising, therefore, that Tien Lang's cost-benefit analysis clearly indicates a strong economic rationale for investing in the river dike system to buy down this risk. Other hotspots such as Quynh Luu tell an identical story, with a much higher safety standard economically justified.

consider the implications of socioeconomic or climatic change. As a result, areas that experience a significant increase in risk do not have a corresponding increase in safety requirements. This is particularly problematic for large infrastructure investments with long lifetimes, of say, 50 years. Safety standards that were adequate 30 years ago could be wholly insufficient after several decades of rapid urban and economic growth. So, regularly reviewing and updating safety standards is crucial to ensure their continued relevance. Similarly, the large protection gaps in the sea dike system illustrate that standards alone are not enough; they must also be systematically enforced and matched by the financing necessary to meet the costs of construction and maintenance.

Vietnam's framework of sea dike safety standards and technical guidelines considers the risk of natural hazards and determines safety levels against potential storm surge levels and the risk that a levee breach may pose to communities. In contrast, building codes and technical guidelines for other infrastructure types—such as power, transport, or buildings—are far less advanced in terms of integrating resilience requirements. More specifically, resilience-enhancing measures are not systematically reflected in the design, risk assessment, construction, operations, and maintenance guidelines for infrastructure systems. As a result, new infrastructure developments are locking in long-term weaknesses.

Fortunately, the actions needed to address these shortcomings are well understood and do not require large resources. Essentially, this action is about creating,

reviewing, and updating the technical rule book that can guide large infrastructure developments and operations in a way that equips them for the risks and requirements of the future. The risk assessments conducted for this report can act as a starting point for assessing the hazards faced by infrastructure systems, and formulating safety standards that correspond to these risks. However, each infrastructure type is different in terms of the usage, responsibilities, and exposure, hence requiring dedicated technical guidelines. To this end, the government can take several priority actions.

1. Review, and where necessary, update safety standards and building codes for lifeline infrastructure systems and buildings:

Given the critical contribution of lifeline infrastructure systems and public facilities such as schools and hospitals, creating an authoritative technical design guideline can set standards for the resilience of coastal communities. Systematically mandating and implementing resilient design elements into infrastructure development can mainstream resilience to natural hazards into the coastal development process. When natural shocks strike, systematically reviewing, updating and enforcing standards can reduce losses and damage to new infrastructure and buildings. It can also help identify existing assets and infrastructure systems that do not meet resilience standards and need retrofitting or upgrading. The scope of such technical guidelines should cover the whole design and planning process for new assets—from location choice to construction requirements, and operational and maintenance needs. Generally, safety standards should

reflect both the hazard level and the population at risk. As socioeconomic and demographic factors are never constant, it is important to make provision to review and update standards in the future. Finally, safety standards should not be wish lists of desired safety levels; rather, they should consider practical implementation constraints such as the availability of funding, materials, or maintenance capacity.

- 2. Review, and where necessary, update safety standards for river and sea dikes:** The safety standard framework for Vietnam's sea dike system is more aligned with natural hazards than other infrastructure system frameworks. Nevertheless, it leaves significant gaps in terms of both coverage and enforcement. By better aligning safety standards with observed socioeconomic and demographic trends, Vietnam's dike system can be adapted to evolving levels of risk from climate change and rapid coastal development. This is particularly important for ensuring a more consistent flood safety approach for low-lying areas in the Red River Delta that heavily rely on a combination of river and coastal protection. Vietnam's dike safety standards illustrate that even a well-defined system can struggle to fully implement mandated requirements. For example, safety

standards mandated by central government are unlikely to be implemented if they are not matched with an adequate budget for upgrades and maintenance (Action 3.2 and 3.3). So, the review of safety standards should cover institutional oversight and budget allocation mechanisms as well as technical requirements.

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Taking action: Next steps towards strengthening the resilience of infrastructure systems

Short-term pilot projects for different infrastructure systems can help prioritize existing maintenance funds. These pilots can be national or regional, depending on each infrastructure system's maintenance authority and funding level. Selecting high-risk areas with low maintenance funding for the pilots will maximize results. The coastal provinces of the Red River Delta, a high-risk region with responsibility for maintaining most of the sea dike system, are good candidates. The hazard and risk information collected under Recommendation 1 will be essential input, so linking the pilots would be beneficial.

Detailed and comprehensive feasibility studies should be carried out in Hai Phong, Thai Binh and Nam Dinh Provinces, with a view to upgrading their coastal protection. These Red River Delta provinces have the largest number of people and economical activities at risk and their sections of the sea dike system show significant deficiencies. Investments in riverine and coastal protection should also be pursued at selective built-up areas along the central coast, such as Quang Ngai, Quynh Luu, Khanh Hoa and Phan Thiet. Other areas along the central coast with concentrated assets and population should formulate an investment plan.

International best practice and lessons learned

Vietnam can learn lessons from other countries where risk-based infrastructure system maintenance is well established. Large dike investment programs can provide useful lessons for improving the setup, prioritization, design, construction, and management of a large flood protection investment program. The Netherlands' 'Room for the River' and 'National Flood Safety' programs have similarities in both size and geography. An overarching lesson from these programs is that investing in flood protection pays off in many ways if win-win opportunities are actively pursued. As well as increasing flood safety, it can strengthen spatial quality around the river, improve navigation or make city waterfronts more attractive to boost economic growth.

Road maintenance programs in the United Kingdom and hydraulic structure maintenance in the Netherlands are other useful examples. The United States, United Kingdom and Netherlands have well-established building codes and safety standards for infrastructure and assets in coastal regions with (extra-) tropical winds and floods that can inspire pilots to review the adoption and enforcement of building codes and safety standards in Vietnam.

Five-year action plan

Undertake pilots in two or three provinces — selected along the length of the coast to ensure a variety of infrastructure and hazards — to provide a cross-sectoral view of differences in safety standards. The pilots should provide recommendations for finetuning, upgrading and enforcing regulations and guidelines. Prioritized areas and actions include:

- Integrating risk information into maintenance practices for electricity, transport, dike, and other infrastructure systems, with emphasis on highest-risk locations
- Strengthening the resilience of critical public assets, such as transport links and hospital access
- Targeting dike upgrades in high-risk areas
- Reviewing and aligning safety standards of all infrastructure assets, including dikes

Lead role: MARD in close coordination with MoT, MOIT, and selected provinces

Cost estimate: \$5 million (Actions 1 and 4), \$300–500 million (for initial investments, Actions 2 and 3)

Financing options: Government budget, as well as private and multilateral investment

Recommendation 4: Take advantage of nature-based solutions



Provinces along Vietnam's coastline have long relied on their extensive dike system as an integral part of their coastal protection strategy. While the system provides much-needed protection to many communities, this report also highlights the challenges associated with a strong reliance on gray infrastructure. High investment and maintenance costs exceed available budgets, while focusing on the dike system has compromised the preservation of important ecosystems that give communities both protective and economic services.

Vietnam's coastline has dunes, sandy beaches, foreshores, mangrove forests, and coral reefs. These ecosystems host an abundant biodiversity that is part of the country's rich natural heritage, and they are an important contributor to coastal livelihoods, supporting diverse economic activities such as fisheries and tourism. More importantly for the resilience of coastal communities, these ecosystems offer significant natural protection, dissipating wave energy, stopping storm surges from typhoons, and reducing erosion by stabilizing sediments.

However, rapid growth in Vietnam's coastal zones is compromising the state of these ecosystems. Rapid urbanization is encroaching on sensitive ecological zones, while unsustainable tourism development, land use intensification, sand extraction, and pollution further degrade them. The effect of these trends is clear. The degradation of natural systems is resulting in a loss of biodiversity, compromising ecosystems' ability to protect

communities from natural hazards and threatening coastal assets and economic activities. In Hoi An, Cat Hai, and Phan Thiet, for example, development has compromised the sensitive balance of natural sediment flows; the resulting erosion has heavily impacted tourism and housing along the coast.

As coastal development continues, these pressures on ecosystems are bound to increase. However, this trend can be reversed by acknowledging and protecting the important contribution of natural ecosystems, and actively integrating them into a coastal development and resilience strategy. The government of Vietnam has had some success in taking such action — for example, restoring mangroves — though not at the scale required. It must now take decisive action to use nature-based solutions to strengthen coastal resilience by prioritizing their preservation — and where possible, their restoration — in coming years. While this will require a concerted effort within and between responsible ministries,

TABLE 14.1 >>

Recommended actions to take advantage of nature-based solutions



Action	Lead role
4.1. Ensure management and protection of the sandy coastline	MONRE, in close coordination with MARD and provincial authorities
4.2. Develop a plan for restoring and protecting mangroves and coral reefs	

the good news is that institutional frameworks already exist, and roles are well defined. MONRE is well positioned to take the lead role, while closely coordinating with MARD and province-level authorities to ensure that nature-based solutions are well implemented and managed. Table 14.1 summarizes the recommended short-term priority actions that will help the government take the first steps towards this long-term objective.

Action 4.1 >>

Ensure management and protection of the sandy coastline

With its shallow foreshore, beaches and dunes, the central regions' healthy sandy coastline is a valuable resource for Vietnam's coastal communities, providing rich biodiversity, natural protection against hazards, and significant economic value for tourism and other sectors. To ensure that the CDS continues to provide these valuable contributions to resilient coastal development, managing and protecting it will be crucial, especially as urbanization and economic growth increase the pressure on ecosystems.

Chapter 9 shows that a range of harmful practices — such as sand extraction, shrimp farming and aquaculture — are commonplace and require urgent action to ensure to prevent further dune degradation. Beach and foreshore erosion caused by natural and human factors marginalize them further. In the worst cases, some dunes have completely disappeared, reducing communities' adaptive capacity to deal with disaster risk. In others, their slow but ongoing erosion threatens communities and results in large costs to protect assets and activities near the coast. These impacts will be further compounded by the projected effects of climate change, particularly sea level rise, which will add pressure on the coastal areas and the CDS.

The authorities in Vietnam have already begun to address the diverse and complex causes of dune degradation and better manage the country's sandy coastline. While further action is needed to ensure the CDS is sustainably used and managed, this does not have to start from scratch. Building on the government's ongoing efforts, the following priority actions can strengthen dune management and their contribution to resilient development.

BOX 14.1 >>

Integrating green and gray: nature-based solutions can offer cost-effective protection

A recent World Bank study reviews the evidence for combining gray and green infrastructure solutions — complementing gray infrastructure with nature-based solutions, such as mangroves, sand dunes, coral reefs, or wetlands — to boost climate resilience (Browder et al. 2019). This approach has several advantages:

- **Technical and environmental:** Green infrastructure is flexible, adaptive, and regenerative, so it can boost a system's resilience. It can also be multifunctional, generating environmental benefits by preserving and restoring ecosystems.
- **Social:** Green infrastructure can empower communities through participation in project operations, enhancing project sustainability as long-term viability is highly dependent on community support.
- **Economic:** Green infrastructure can be low-cost and cost-effective, helping enhance the economic efficiency of infrastructure

investments. It can generate both monetary and nonmarket benefits.

A climate resilience and sustainable livelihoods project in the Mekong Delta, implemented in partnership between the World Bank and the government of Vietnam, is already demonstrating the benefits of nature-based solutions (Browder et al. 2019). The project design explicitly integrates mangroves and sea dikes to protect coastal communities from flooding and erosion, while also supporting livelihoods.

By embedding nature-based solutions, the project design is flexible and can adapt to the delta's dynamic natural conditions. In Ca Mau Province for instance, the project is restoring and expanding mangroves, while also rehabilitating sea dikes. As well as protecting communities from flooding and erosion, this approach creates economic opportunities — for instance, by enabling mangrove shrimp systems that match natural soil and water conditions. Vietnam's mangrove forests are also proving to be valuable assets for the tourism sector.



- 1. Develop a knowledge base on coastal sediment budgets and trends:** As emphasized in Recommendation 1, data and information are crucial for enabling smart management of coastal assets. For sand dune systems, necessary knowledge base goes beyond simply knowing their location; it requires a thorough understanding of coastal dynamics. For example, there is little information available on cross-and longshore sediment transport along sandy coastlines. Creating a comprehensive account of sediment flows will enable an understanding of the natural factors that nourish and maintain sand dunes, which can be used to assess the potential impact of large infrastructure investments on sediment flows and coastal erosion. To create a knowledge base on the dynamics of sandy ecosystems, the government needs to implement regular monitoring programs, numerical modeling exercises, and analysis of historical observations. The government of the Netherlands used such exercises to identify the causes of erosion and was able to target measures to protect sediment budgets and coastline dynamics in the country's foreshore, beaches and dunes. The government of Vietnam can also generate such knowledge, building on the country's significant expertise in coastal hydrology to create the basis for effective dune management and protection.
- 2. Strengthen the regulatory and legal framework for managing coastal sand dunes:** In Vietnam, the CDS is not fully recognized for its critical contribution to coastal resilience and livelihoods, so

there is no dedicated policy or legal framework to comprehensively guide dune use, management, and conservation. A policy for coastal setback lines¹ goes some way in mandating seafront corridors to protect dynamic and sensitive ecosystems, including dunes, but enforcement has been limited and inconsistent. Without strong regulatory and legal frameworks to prescribe dune conservation, there is no basis on which the government and private actors can build conservation measures. Such frameworks will be crucial for bringing about a transition in the way coastal protection is understood, with dunes and other ecosystems forming an integral part of the coastal defense line, complementing sea dikes. Regulatory and legal frameworks should be accompanied by technical guidelines and zoning schemes that define areas with different protection and use requirements.

- 3. Implement dune conservation, restoration, and management with coordinated actions:** Every CDS faces a unique set of pressures and circumstances. Actions to protect and manage dunes must take these pressures into account, as different circumstances will require different approaches. Where dunes remain intact, protection and sustainable natural resource management will be essential. Authorities should begin by mandating systematic risk assessments to select priority areas for dune conservation restoration programs. Enforcing coastal setback lines will be an essential task for local authorities—especially in less developed areas—to ensure that new coastal developments are built in safe locations, without

compromising sensitive sandy ecosystems. Where dunes have already been compromised, the focus should be on restoring and preventing further damage while safeguarding local communities' long-term livelihoods.

Vietnam's coastal regions have traditionally used gray structures such as revetments and geotubes to address dune erosion problems. But this fragmented approach has had limited success, often with negative effects further down the coast. Green solutions such as beach or foreshore nourishments are rarely implemented, despite their proven cost-effectiveness and flexibility in the United States and the Netherlands. Such solutions should be explored and integrated in coastal protection strategies, as they mitigate coastal erosion and support tourism development.

Action 4.2 >>

Develop a plan for restoring and protecting mangroves and coral reefs

Restoring mangroves

In recent years, Vietnam has successfully reversed its historical trend of significant mangrove losses. The country has developed a comprehensive legal framework for mangrove protection and conservation and established several restoration programs. However, in many provinces, government and community mangrove forest management programs face a range of challenges, particularly funding and expertise to implement effective

mangrove management. As with CDS, the contribution of mangrove ecosystems to coastal resilience and livelihoods is systematically underestimated. As a result, fund allocations are often insufficient and need to be shared between various conservation objectives. In the coming decades, climate change-induced sea level rise and increasing coastal urbanization are bound to further aggravate the threat to Vietnam's mangrove forests.

The government has a promising opportunity to consolidate recent successes in mangrove restoration and expand the reach and effectiveness of its sustainable mangrove management programs. To this end, the following priority actions are essential.

1. **Strengthen the legal and regulatory framework for mangrove co-management:** Community mangrove co-management models have helped reduce potentially adverse side-effects of mangrove restoration on local populations and improved their sense of ownership and responsibility. Co-management schemes implement reforestation and conservation initiatives through an ownership contract between local government and communities, making the people who live near mangrove forests responsible as forest co-owners. By guarding the forests while using them for aquaculture, ecotourism, and other economic functions, local populations have a role to play in reforestation initiatives. This model has been successfully implemented in various districts in Red River and Mekong Delta Provinces over the last decades. However, to establish long-term and sustainable

co-management contracts, the government must first establish legal and regulatory frameworks that formalize such arrangements. Local authorities will then be able to formulate co-management rules that suit their local context (Nayna et al. 2018).

2. Further explore the use of PES models: While coastal ecosystems provide important environmental services for many stakeholders, the benefits for owners or managers of these habitats have been traditionally limited (Sommerville 2016). Payments for ecosystem services (PES) mechanisms can be an efficient way to generate revenue streams that would incentivize those with mangrove management or ownership rights to manage the land for these wider benefits to community livelihoods. For example, where shrimp farming is practiced within intact mangrove forests, a share of aquaculture profits could be used for mangrove conservation. Vietnam is a global leader in piloting PES in upland forests but has yet to apply these experiences in its coastal mangrove forests (Sommerville 2016). Mangrove PES constitutes a promising complement to government funding for conservation efforts, as it could generate significant, long-term monetary and non-monetary benefits in terms of carbon sequestration, storm and flood protection and aquaculture support.

3. Develop technical guidelines and action plans for provincial-level mangrove conservation programs: Overall, the government's efforts in mangrove restoration have resulted in impressive successes

in several coastal locations. These have yielded important lessons around choice of land, mangrove species, planting methods, and management approaches. Such lessons may be known to authorities in individual districts, but have not been systematically documented to guide mangrove programs in other parts of the country. Drawing on these lessons and international practices in similar environments, the government should develop technical guidelines to inform future conservation programs. These can help avoid repeating past mistakes and support the implementation of comprehensive action plans for mangrove for restoration and rehabilitation. Such action plans are particularly urgent in high-risk areas in the Red River and Mekong Deltas identified in Part 1.

Protecting coral reefs

Submerged in the sea, Vietnam's coral reefs are less visible, but their contribution to the economy and coastal protection is nevertheless substantial. Not only do they offer significant economic value through tourism, they can also significantly reduce the impact of storm surges. Vietnam's coral reefs face several environmental threats from overfishing, destructive fishing, tourism, coastal development, sedimentation, pollution, coral exploitation, and storms, particularly in areas of high population density. The impacts of climate change—especially increasing acidification and temperature of sea water—are also bound to increase pressure on them.

Through its mangrove conservation efforts, the government has already demonstrated its capacity to restore and

protect essential ecosystems. Building on this experience, it is well positioned to take the following effective actions to conserve reefs.

- 1. Conduct an inventory of lessons learned from coral reef restoration initiatives:** Around the world, coral reefs are under increasing pressure from the impacts of human activity and climate change. Efforts to protect coral reefs under these evolving pressures have yielded a range of important lessons—for example, around the choice of coral species and different management approaches—that the government should review and document to help guide such action in Vietnam. Coral reefs are perhaps the least well documented and monitored ecosystem in Vietnam’s natural coastal defense system. To address this shortcoming, the government should complement international lessons learned by developing a detailed national coral reef database that captures the location and state of all reef systems (Recommendation 1). This information can help guide effective decision making around coral resources and enable more focused prioritization of the limited human and financial resources for their conservation.
- 2. Establish a dedicated policy and legal framework to formalize coral reef conservation:** The inadequate management of coral reefs is not only down to the lack of detailed coral reef data. There is no dedicated

policy or legal framework and the institutional set-up for managing marine resources is fragmented. To ensure the effectiveness of coral conservation programs, central government will need to formalize such programs through dedicated policy decisions and legal mandates. This includes revising the Law on Coral Reef Protection, Conservation and Management and developing a common national strategy on coral reef management. Such frameworks can then serve as a basis for the detailed allocation of responsibilities and funding to coastal provinces, so they are empowered to develop, implement and scale up coral reef conservation and restoration plans.

Endnotes

1. Setback lines are regulated in the 2015 Law on Marine and Island Resources and Environment (No. 82/2015/QH13).
2. Retrieved from <https://www.wacaprogram.org/about-us>

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Taking action: Next steps towards an effective use of nature-based solutions

Pilot projects that conserve and restore ecosystems can constitute important steps towards a comprehensive approach to integrating nature-based solutions in the national coastal resilience strategy. In particular, protecting and restoring coastal dunes and sandy foreshores and beaches is an urgent challenge, as coastal erosion is threatening communities at alarming rates. But where should such pilots be conducted? From the hotspot analyses, Phan Thiet and Quynh Luu emerge as suitable candidates, as both districts would benefit from strategic beach and foreshore nourishments to combat erosion (Appendix A). Such pilots should include supporting districts to establish data and information systems on coastal sediment dynamics and enforce coastal setback lines. The experiences from the pilot districts will be an important guide for scaling up efforts to other provinces.

While several successful pilots to restore and conserve mangrove forests have already been conducted, a more systematic approach could help increase the effectiveness of further such efforts. In particular, technical guidelines and action plans for mangrove rehabilitation should be prepared based on lessons learned from past initiatives. Such action plans should rely on hazard and risk information to prioritize suitable areas for mangrove restoration, identifying win-win opportunities where mangrove rehabilitation can be effectively combined with

dike improvements, thus reducing investments in dike infrastructure. One of the analysis hotspots, Tien Lang district in the Red River Delta, can serve as an inspirational example where successful mangrove reforestation in front of the coastal sea dike has provided a large buffer for wave dissipation during typhoons, helping to protect the local community. Such successes should be scaled up in many more locations along the coast; Tuy Hoa in Phu Yen Province and Cam Xuyen in Ha Tinh Province are suitable for mangrove reforestation pilots.

International best practice and lessons learned

The situation on Vietnam's sandy coastline is part of a wider global picture in which many countries are struggling with coastal management and erosion. The government can draw on vast experience from France, the Netherlands (in particular, the Sand Engine near The Hague), Belgium, the United States and Australia, with their long traditions of managing, formulating policies on and implementing gray and green solutions for their sandy coastlines. It can also draw on the West Africa Coastal Management Program, a multi-country program managed by the World Bank and developed in partnership with the West African people that supports efforts to improve coastal management and reduce natural and human-induced risks in coastal communities. The program's goal is to boost "the transfer

of knowledge, foster political dialogue among countries, and mobilize public and private finance to tackle coastal erosion, flooding, pollution and climate change adaptation."

Five-year action plan

Systematically implement nature-based solutions in two selected provinces, which can be scaled up to other areas in subsequent stages. Prioritized areas and actions include:

- Piloting nature-based solutions to strengthen the coastline through strategic beach and foreshore nourishment to mitigate erosion and restore dunes and sandy coastlines (for example, in Phan Thiet and Quynh Luu), and rehabilitate mangrove forests (for example, in Tuy Hoa and Cam Xuyen).
- Complementing nature-based solutions by enforcing coastal setback lines and protection corridors.
- Preparing technical guidelines and action plans for systematic mangrove rehabilitation in the Red River and Mekong Deltas.

Lead role: MONRE, in close coordination with MARD and selected provinces

Cost estimate: \$70–100 million for two selected locations

Financing options: Government budget, private and multilateral investment

Recommendation 5: Improve preparedness, response, and recovery capacity



The recommendations in previous chapters advocate risk-informed development strategies that are key to reducing risk and avoiding future disasters.¹ However, disaster risks can never be fully eliminated: residual risk always remains, so systematic disaster preparedness is required. The question is not whether another major hurricane or flood will strike, but when. In a changing climate, the government of Vietnam must prepare for more intense storms, more active typhoon seasons, heavier rainfalls, and stronger coastal floods and droughts. Continued urbanization and population growth, particularly in coastal areas, will expose many more people to these impacts of climate change in the coming decades. While prevention and risk-informed development can minimize exposure and risk, coastal communities will remain exposed to residual risks; and this needs to be addressed.

With their long-standing experience of natural disasters, Vietnam's authorities have taken many measures to prepare for future shocks. The country has a functioning early warning system for typhoons, floods, rainfall, and droughts from central to community levels, though its effectiveness could be improved. Preparedness also concerns effective emergency response in the hours and days following a disaster. The authorities have a well-established framework for emergency preparedness, short-term response mechanisms and emergency relief, leveraging both central and local contingency funds. Community-

based DRM efforts have strengthened community-level awareness and response capacities, reflected in successful evacuation planning and execution before typhoon and flood events. Yet, more progress is needed. For instance, systematically pre-positioning relief assets can ensure that crisis response does not rely on vulnerable transport infrastructure, while having well-trained and efficiently deployed search and rescue teams is key to saving lives in the immediate aftermath of an adverse event.

But preparedness goes beyond the immediate emergency phase, when the focus is on saving lives and providing humanitarian relief. It also includes the recovery and reconstruction period. This is when basic services are restored, buildings and infrastructure are repaired, and livelihoods and economic activities are restored to their

48% >> Potential reduction in annual well-being losses from disasters thanks to building back better

TABLE 15.1 >>

Recommended actions to improve preparedness, response, and recovery capacity

Action	Lead role
5.1. Improve early warning systems and communication channels	MONRE
5.2. Strengthen emergency planning and civil protection capacity	MARD
5.3. Establish a national financial protection strategy	MoF

pre-disaster level or better. The government of Vietnam could significantly reduce the impact of future disasters on economic growth, livelihoods, and well-being by improving the effectiveness, speed, and quality of post-disaster recovery. A World Bank study estimates that implementing measures that ensure stronger, faster and more inclusive recovery from natural disasters could reduce Vietnam's annual well-being losses from disasters by 48 percent, from \$11 to \$5.6 billion a year, in PPP terms (Hallegatte et al. 2018).

In practice, it may take many years to implement large-scale investments in improved protection and land use changes to reduce exposure, not least due to limited funding. In the meanwhile, Vietnam's coastal communities will continue to rely on solid disaster preparedness and response capacity. A comprehensive contingency financing strategy and social protection system can help improve the capacity of Vietnam's coastal communities to cope with and recover from disasters without devastating long-term consequences. This includes effective mechanisms for the rapid mobilization of contingent financing in post-disaster

situations and channels for efficiently delivering these resources to those who need them most, such as frontline local authorities and vulnerable households. This chapter recommends concrete actions that the government can take to improve preparedness and disaster response capacity (table 15.1).

Action 5.1 >>**Improve early warning systems and communication channels**

Significant government investment has increased the VNMHA's capacity to forecast typhoons, rainfall and flood events. As well as providing traditional emergency response services to the public, it has extended hydromet monitoring, forecasting, and warning services to sectors such as energy, agriculture, and transport. Overall, Vietnam's hydromet capacity is a success story that has helped inform development planning and lessened disaster losses. The government can take several concrete actions to build on these successes, by addressing

weaknesses and preparing the system for the evolving needs of the future.

- 1. Explicitly address the needs of different user groups in a robust communication system that translates weather forecast data into actionable information:** Early warnings should always be paired with clear instructions on necessary preparedness or evacuation measures. Such measures can differ significantly for different affected groups, such as infrastructure operators, agricultural households, or fisheries. The practicality and usefulness of warning communications can be strengthened through mechanisms to assess users' needs and feedback on the quality of early warning information. A more demand-driven system will help users take more effective disaster prevention measures, reducing overall disaster losses. Particular attention is needed to ensure that warnings do not exclude vulnerable groups such as women, children, or minorities.
- 2. Develop a concept of operations (CONOPs) to guide the usage and management of an integrated hydromet system.** A well-developed CONOPs helps lower the risk of technical or financial failure by conceptualizing the fully integrated, end-to-end system's operations and guiding the implementation of equipment, hardware, software, and training packages. A comprehensive CONOPs is also needed to provide a framework modernization process and define the operation of future hydromet services. The CONOPs is not only important to facilitate systems engineering

for hydromet infrastructure; it should also establish a consensus among stakeholders around the system's methods and objectives. Developing a CONOPs is an important step towards ensuring that Vietnam's hydromet system is fit for purpose, by reflecting stakeholder needs, long-term financing needs, systematic review and modernization processes, and accounting for the evolving nature of risks.

- 3. Strengthen capacity to monitor and forecast slow-onset natural hazards, particularly droughts:** The severe drought and associated saline intrusion in 2016 in the Mekong Delta Region were a premonition of the future impacts of climate change. As precipitation patterns change, hydromet and early warning systems will need to adapt to better account for slow-onset disasters. This has implications for the VNMHA's technical requirements and necessitates a different approach to formulating and disseminating warnings. The hydromet systems CONOPs and the VNMHA's mandate and funding must recognize the need for medium and long-term forecasts. This should also be integrated in the information dissemination strategy with actionable warnings for different users.

Action 5.2 >>

Strengthen emergency planning and civil protection capacity

Vietnam has a wealth of experience in disaster response and a well-functioning emergency relief and recovery

system. But rapid growth along parts of the coast means that continuous attention is required to ensure the system covers new communities and accounts for the evolving nature of risk. Historically, emergency preparedness and response has focused on typhoons and flood events. But the impact of the 2016 drought highlights that slow-onset disasters require more attention in terms of preparedness and response. The following recommended priority actions will help strengthen Vietnam's emergency planning and civil protection capacity.

1. Ensure consistent emergency response capacity along the entire coast by establishing a National Emergency Command Center (NECC) at the VNDMA:

The NECC could provide the oversight and facilities required to enhance emergency preparedness and response at all levels. Systems and facilities are also required at subnational level, potentially through regional emergency command centers in Da Nang and Ho Chi Minh City, and enhanced communications for mobile command post units. The NECC and its regional centers would be well placed to plan the pre-positioning of emergency supplies in strategic locations to ensure that relief measures can be initiated rapidly, even when vital transport links are disrupted. The NECC would also be able to review and oversee provincial and district-level civil protection capacities, including emergency health services, firefighting, and search-and-rescue capacity. These are crucial for saving lives in the immediate aftermath of disasters, and yet funding gaps and capacity constraints are not systematically monitored and addressed.

2. Further strengthen the capacity for locally led and inclusive emergency response:

Local communities bear the brunt of disasters and are at the forefront of implementing relief and recovery measures. Empowering them to effectively fulfill this role, with support from regional and central governments, is essential for an effective disaster response. This should include improving emergency plan dissemination at community, village, and household levels, especially in disaster-prone communes. These plans can only be effective if they actively account for the needs of the most vulnerable, including women, children, and socially disadvantaged groups. Building capacity and delivering training to community-level administrative and technical staff and others will empower all stakeholders, especially at sub-national government levels and in vulnerable groups. Establishing clear coordination mechanisms for emergency response among local authorities, police and the military is also vital.

3. Develop emergency plans and resettlement or relocation strategies for slow-onset hazards:

Historically, disaster management plans have focused on rapid-onset disasters, such as flood and typhoons. The impacts of climate change make it necessary to develop more detailed emergency response and recovery strategies for slow-onset disasters, particularly droughts. Areas to focus on include protecting the livelihoods of agricultural households—for example, through social protection coverage—and ensuring a reliable safe drinking water supply in affected areas through pre-arranged freshwater supply contracts.

Action 5.3 >>

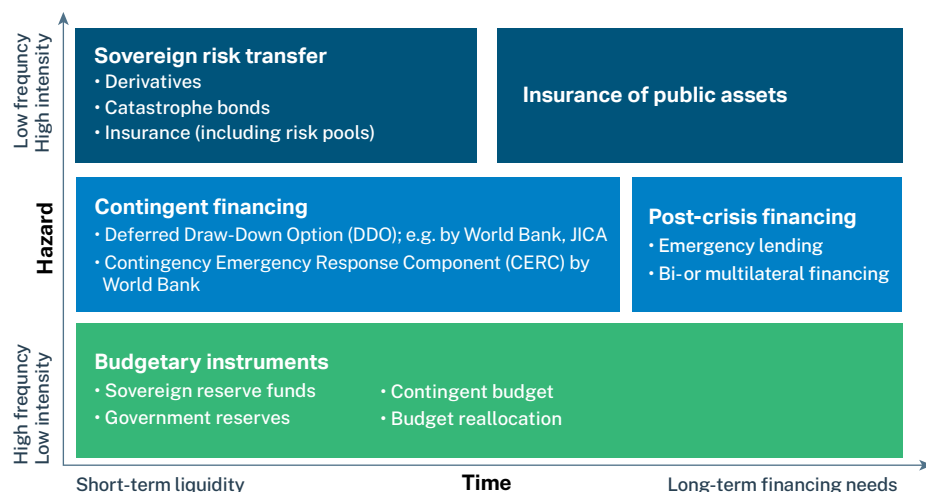
Establish a national financial protection strategy

The efficiency and scale at which a country mobilizes resources can determine the course of its recovery from disaster. Chapter 10 shows that Vietnam has budgetary arrangements that institutionalize the allocation of financial and in-kind resources to accelerate post-disaster response and recovery. Such financial preparedness is essential for ensuring that resources can be delivered to those who need them most. However, the assessment also showed that the size of Vietnam's emergency budget is inadequate considering the magnitude of annual disaster losses. By setting a fixed annual allocation, spending is also inefficient, as decision makers need to reserve funds for future disasters in the budget period.

FIGURE 15.1 >>

A layered risk financing strategy

Source: Adapted from World Bank 2017.



The challenges of disaster risk financing are common to many countries threatened by natural shocks and international lessons learned and best practice examples can help the government of Vietnam become a leader in risk financing (Hallegatte and Rentschler 2018). Risk financing addresses two key challenges that determine the effectiveness of post-disaster response: rapidly mobilizing funds to finance relief, recovery, and reconstruction efforts, and effectively channeling these funds to beneficiaries and those in charge of implementing efforts on the ground — in other words, last mile delivery.

Rapidly mobilizing finance to manage crises

The traditional approach to disaster risk financing—a combination of post-disaster budget reallocation and international assistance—is costly, slow, and unreliable (Cevik and Huang 2018). By preparing secure, fast and reliable access to contingency financing, the government of Vietnam could be better prepared to manage future crises. Several instruments can help governments manage the impact of natural disasters on public finance and social expenditures, and enhance public spending efficiency, but the three main ways to ensure liquidity are: maintaining sufficient reserve funds; arranging for contingent credit facilities; and using insurance schemes or transferring risks. These financial instruments are most effective when structured along ‘risk layers’, with different instruments covering different types of risks (figure 15.1). Reserve funds are used to manage low-cost, high-probability events, while contingent financing and sovereign risk transfer instruments are used for high-cost, low-probability events.

Budgetary instruments for small and frequent disasters:

In disaster-prone countries like Vietnam, national reserve funds can effectively provide immediate liquidity for financing post-disaster relief and recovery as well as essential in-kind post-disaster emergency relief, including food and equipment. However, reserve funds have limited capacities and cannot be designed to cope with rarer and more extreme events (Mahul and Ghesquiere 2010). Maintaining large cash reserves is costly and politically challenging, as they crowd out investments in other important sectors such as education and health care. This means that reserve funds are best suited for smaller and more frequent disasters.

Contingent financing for rapid resource mobilization:

Budgetary instruments should be complemented by pre-arranged contingent financing, which can be accessed rapidly in the event of a major crisis. Contingent credit lines can serve as an early financing tool before funds from other sources such as government reallocations, bilateral aid, or reconstruction loans become available. With such financial tools in place, the government of Vietnam could be better placed to respond to emergencies, without diverting resources from existing social and economic development programs. Moreover, these financial instruments provide a platform for developing integrated risk management strategies and investments that go beyond disaster response to enhance preparedness and resilience.

Multiple institutions offer contingent lines of credit for disasters. The World Bank's Catastrophe Deferred Drawdown Options (Cat-DDOs) provide immediate

liquidity following a disaster and help strengthen DRM capacity. Similarly, JICA's Stand-by Emergency Credit for Urgent Recovery (SECURE) provides immediate post-disaster financing. The World Bank's Contingency Emergency Response Component (CERC) is designed to support emergency response and preparedness by quickly mobilizing pre-approved funds in the face of a disaster, including disease outbreaks. It allows for the rapid reallocation of investment project funds towards urgent post-disaster recovery needs, following adequate ex-ante technical preparation and logistical planning for its disbursement and use. Such contingent credit tools can also help to involve the MoF more directly in the disaster risk management agenda.

Sovereign risk transfer using insurance and bond products:

National catastrophe risk insurance programs can act as a last line of defense against severe natural disasters. Experiences from other countries could help Vietnam develop similar risk transfer instruments. In 2017, the Philippines launched a catastrophe risk insurance program to protect national and local government agencies against financial losses from severe natural disasters. Under this program, the Government Service Insurance System (GSIS), a public insurance agency, provides \$206 million in aggregate coverage to protect the assets of the national government and 25 highly exposed provinces. The World Bank acts as intermediary for the transfer of GSIS's risk to a panel of international private reinsurance firms. The program complements other funding sources, such as the national and local disaster risk reduction management funds and contingent credit, that protect against less severe natural disasters.

Catastrophe bonds are another option the government of Vietnam could use to leverage its resources and transfer sovereign disaster risks to international capital markets. Experiences from other countries can guide the design and implementation of such measures. For example, the government of Mexico established a natural disaster fund, FONDEN, to support disaster relief and reconstruction. FONDEN leverages private sector financing by layering risk retention and risk transfer instruments. In 2006, it issued a \$160 million catastrophe bond to transfer Mexico's earthquake risk to the international capital markets. Though costly, financial schemes like this can disburse funds more rapidly than public budgets. And by predefining payout rules for allocating post-disaster support, formal insurance and financial products can improve transparency and predictability.

Vietnam faces a wide range of natural hazards, from small and frequent shocks to extreme rare events and slow-onset disasters such as droughts. So, none of these financing instruments are likely to be enough on its own. Rather, they would each form part of a comprehensive risk financing strategy. The choice of financial instruments must be guided by a careful evaluation of expected costs and benefits. More complex instruments designed to hedge against rare and extreme shocks can have high administrative costs (Hallegatte and Rentschler 2018), but financial instruments must not be compared solely by their financial cost and volume. Other important considerations include the speed of disbursement, and the transparency and predictability of resources. Rule-based instruments like index insurance products or risk

transfer mechanisms based on measurable indicators give governments, technical agencies, local authorities, firms, and households a predictable amount of support.

Effectively channeling funds to the 'last mile'

Even if post-disaster funds are successfully mobilized, their effective and timely delivery can remain a serious challenge. There can be multiple causes of delay in post-disaster support delivery, including a lack of clearly defined responsibilities and accountabilities, a need for data collection to support heavily affected households, and procurement issues—for example, in the case of debris removal or reconstruction. Establishing effective mechanisms for delivering post-disaster financing would allow the government of Vietnam to further strengthen the effectiveness of its post-disaster response capacity. It is particularly important that the national agencies, local authorities, and private-sector providers, who are in charge of restoring infrastructure services to businesses, ensure effective 'last mile' delivery of resources to those who need them. This will help restart production and protect jobs and households, smoothing the impact of the shock and help people recover. (Hallegatte and Rentschler 2018).

So, what could determine the effectiveness with which Vietnam's central government can deliver financial resources effectively? Financial services—especially savings instruments and access to borrowing—are a direct way to deposit cash support without major transaction costs and administrative challenges. However, the World Bank estimates that 60 percent of adults in Vietnam do not have access to formal financial services,

including savings accounts or affordable credit.² Social protection schemes can also be crucial for effectively transferring post-disaster support to those who need it most, including women and marginalized groups. And yet, only 17.5 percent of the population is covered by social protection schemes. This stands in contrast to social health insurance, which had 87 percent coverage in 2019, including the poorest and most vulnerable groups, whose premium contributions are covered through government subsidies (Teo et al. 2019).

Overall, the government of Vietnam has an opportunity to significantly strengthen and modernize its risk financing strategy. A comprehensive financial protection strategy would set guiding principles for the consistent, efficient and sustainable coordination of post-disaster response and recovery funding. Developing similar strategies at provincial and city levels would also strengthen sub-national disaster risk financing and deliver funds more quickly to where they are most needed. The following actions can help address challenges around adequate post-disaster resource mobilization and improve 'last mile' resource delivery.

1. Establish a comprehensive and layered risk financing strategy that enables rapid and cost-effective resource mobilization for disasters: By adopting a layered risk financing strategy, the government can get faster access to financial resources for disaster relief and recovery. A range of financial instruments are available and have a proven track record of effectively strengthening governments' financial resilience

in other countries. Multi-year reserves, contingent credit, sovereign insurance, and catastrophe bonds can be used to rapidly mobilize resources. An ongoing engagement between the government of Vietnam and the World Bank's DRFI is exploring these instruments in detail, including their cost viability and composition, and developing a path towards implementation. The risk financing strategy should go beyond financial instruments, but also strengthen institutional arrangements for disaster risk finance. For example, it could clearly delineate the roles and responsibilities of ministries and agencies involved, including the MoF to mobilize and manage funds, and MARD and MPI for planning and allocation. Successful implementation will be crucial for a financial resilience strategy that reflects Vietnam's long track record in DRM and increasing future risks.

2. Strengthen delivery mechanisms for post-disaster financial resources: In the aftermath of disasters, needs are urgent, and any delay in providing relief and facilitating recovery can have devastating long-term consequences. Thus, any risk financing strategy also needs to carefully prepare delivery mechanisms to ensure financial resources reach affected areas and groups. Improving financial inclusion by ensuring people have access to banking services, such as savings accounts and credit, will be an important measure for Vietnam's coastal communities, as it will allow the authorities to make rapid social protection payouts to disaster-affected groups. Formal financial services can also help households and firms manage

smaller shocks by drawing on savings or borrowing (World Bank 2013). Keeping track of the number and location of potentially vulnerable population groups is crucial, particularly in rapidly urbanizing areas. Maintaining social registries will allow the government to effectively target and scale up social assistance programs. Finally, it is not only households that receive post-disaster support. Local government and firms do, too. Fiscal transfer mechanisms between central and local government should therefore be reviewed to address administrative bottlenecks. Clearly defined roles and responsibilities must also be established to help local authorities effectively channel post-disaster support resources—for example, to pre-identified firms that can restore essential public services.

3. **Strengthen institutional coordination between social protection programs and integrated disaster response mechanisms:** As well as being an essential channel for delivering post-disaster support, social protection systems can systematically strengthen beneficiary resilience in the long term. Although Vietnam has made progress in developing its social protection system—particularly its emergency assistance system—it has limited coverage and support levels. Social protection schemes target the lowest-income households, which tend to be in the more remote mountainous regions. So, the level of support in coastal areas is generally low. To strengthen these support systems, central government must provide consistent guidance to define the levels of support available by income level, disaster type,

and magnitude of household damage. This includes defining clear eligibility criteria that prioritize the most heavily affected and vulnerable households. Existing social protection systems should also be updated to increase their flexibility, scalability, and linkage with contingency budgets and risk financing instruments. Large-scale disasters can push households that have not previously relied on social protection into poverty. Quickly expanding coverage to these households is crucial to avoid increased poverty rates. Implementing these measures will require closer coordination between MOLISA, MARD, and regional departments to streamline multiple social protection schemes.

Endnotes

1. This chapter is partly based on Hallegatte and Rentschler (2018).
2. Information retrieved from <https://ufa.worldbank.org/en/ufo>

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Taking action: Next steps towards strengthening preparedness and response capacity

The government of Vietnam can build on its extensive experience to equip its emergency response capacity for the needs of the coming decades. This will require upgrading the effectiveness of its early warning system (particularly its communication protocols), and upgrading local emergency response capacity and central emergency coordination and oversight. Developing a comprehensive risk financing strategy that can effectively mobilize and deliver financial resources to affected areas and groups is also needed. Together, these measures can go a long way to better prepare Vietnam's coastal communities for future disasters that cannot be avoided, boosting its ability to build back stronger, faster, and more inclusively.

International best practice and lessons learned

In recent decades, many countries have made progress in developing strategies and technical capacities to enhance residual disaster risk management. The World Bank offers detailed reviews of international experiences and best practice in this area (Hallegatte et al 2018;

Hallegatte and Rentschler 2018). The European system, Meteoalarm, is considered the golden standard on early warning, providing information on exceptional weather anywhere in Europe. The United States' early warning system provides end user-specific information for tropical events while its Drought Monitor is considered one of the world's most advanced, mapping drought conditions countrywide and providing short and long-term indicators for different sectors. Several middle-income countries — including Mexico and the Philippines — have successfully adopted risk financing strategies, while the Turkish Catastrophe Insurance Pool and Mongolian Livestock Insurance Pool are good examples of public-private partnerships that provide insurance coverage against natural disasters. Fiji maintains a strong disaster-responsive social protection system.

Five-year action plan

Strengthen central government's disaster response capacity through systematic emergency coordination and risk financing. Strengthen disaster response capacity in selected high-risk provinces in the Red

River and Mekong Deltas through enhanced community-led emergency response plans, civil protection, early warning, and social protection. Prioritized areas and actions include:

- Strengthening communication channels for actionable early warning to different end users
- Establishing the NECC, with close coordination and oversight functions at province level
- Developing and adopting a national financial protection strategy, building on ongoing engagement with the World Bank's DRFI

Lead roles: MONRE for improving early warning information services; MARD for establishing and operating national and regional emergency control centers; and MoF for developing a national financial protection strategy

Cost estimate: \$30 million (Action 1), \$10 million (Action 2), \$5 million (Action 3)

Financing options: Government budget, technical assistance, and lending investment

From recovery to resilient prosperity

16.1 >>

A sustainable stimulus package to recover from the COVID-19 pandemic

An unprecedented crisis.

The COVID-19 pandemic is a global health and economic emergency that has not left a single country unaffected. Through bold and timely actions, Vietnam is considered to have contained the spread of the virus more effectively than most countries. But the economic consequences of quarantine measures and the global economic crisis mean that the consequences of the pandemic are still severe. For example, the closing of borders meant that Vietnam's thriving international tourism sector came to a standstill. While the long-term impacts cannot yet be fully understood, it is clear that millions of jobs have been lost and that most of the population is experiencing hardships.

In preparing to recover from this crisis, governments around the world are planning targeted support measures and stimulus packages. While the priority is to alleviate immediate hardships, the scale of stimulus measures also offers an opportunity to build a more resilient and sustainable future (Hallegatte and Hammer 2020). So, how can economic stimulus packages help accelerate

the recovery, while also laying the foundation for long-term socioeconomic development? To rapidly build back a fairer and stronger economy, governments must not only consider short-term needs such as immediate job creation; long-term development requirements — such as investing in skills, resilience, and environmental sustainability — are equally important.

A sustainability checklist for screening recovery actions.

The World Bank has proposed a sustainability checklist to help identify and prioritize investments that offer effective short-term stimulus to emerge from the COVID-19 pandemic while also contributing to a sustainable, long-term recovery (Hammer and Hallegatte 2020, World Bank 2020). The checklist emphasizes that in the short term, three main considerations should guide the choice of stimulus measures:

- **Job creation**, to help replace lost jobs, while ensuring that any jobs created match existing skills and regional needs
- **Boosting economic activity**, to replace missing demand and have a strong economic multiplier effect, enabling and stimulating further investments and consumption

- **Timeliness and risk**, with rapidly implementable measures to start generating stimulus and employment benefits even in the very short term, while also ensuring that such benefits are robust to the risk of quarantine measures being reimposed.

So how can governments ensure their stimulus measures create a temporary economic boost while also contributing to long-term, sustainable and resilient development? The sustainability checklist further emphasizes the importance of selecting stimulus measures according to the following criteria (World Bank 2020):

- **Long-term growth potential**, to help strengthen human, natural, and physical capital — for example, by building people's skills or providing essential public infrastructure
- **Resilience to future shocks**, to build the capacity of communities to cope with and recover from shocks, including pandemics, natural disasters, and climate change
- **Decarbonization and sustainable growth**, prioritizing measures that foster green and sustainable solutions and avoiding investments in stranded assets, such as declining technologies or high-risk locations (Hammer and Hallegatte 2020)

By selecting interventions that meet the sustainable stimulus criteria for both short- and long-term benefits, governments can devise a fast, cost-effective, and climate-informed recovery strategy.

This report has spelled out the measures that the government of Vietnam can undertake to safeguard future coastal development against disaster risks. Several of these measures could also play an important role in stimulating the country's recovery from the economic repercussions of the COVID-19 crisis. To identify resilience-building measures that can double as economic stimulus measures, figure 16.1 presents a normative ranking of the priority actions presented in Part 3 of this report. All 13 actions are scored against the above sustainability checklist criteria, classifying them according to their short- and long-term contributions.

Two intervention areas stand out from this screening. Investments in infrastructure upgrades and maintenance (Actions 3.1 to 3.3) can boost short-term employment — for example, through public works programs — and target economic hubs that have been strongly affected by quarantine measures. Likewise, investing in nature-based solutions such as community-level initiatives to restore and protect the sandy coastline and mangroves forests (Actions 4.1 and 4.2) can boost local employment, while also contributing to coastal protection from natural hazards and to the recovery of a sustainable tourism sector.

It is important to note, however, that some interventions that score relatively low against short-term criteria — such as job creation — are vital for achieving longer-term resilience objectives. So, for risk-informed development in coastal zones, robust and up-to-date hazard data and decision-making tools (Actions 1.1 and 1.2) are indispensable. Likewise, to be able to quickly provide

social assistance and allocate resources in post-disaster situations or pandemics, a national financial protection strategy (Action 5.3) is key.

By integrating such long-term considerations, the government of Vietnam can ensure that measures to support the country's recovery from COVID-19 not only address immediate hardships, but also contribute to Vietnam's resilience and preparedness to future shocks.

16.2 >>

Resilience will support long-term prosperity and development

The evidence presented in this report leaves no doubt that Vietnam's coastal communities are exposed to severe natural hazards. Typhoons, storm surges, flooding, droughts, coastal erosion, and saline intrusion are already impacting

FIGURE 16.1 >>

Priority actions that make for a good stimulus

	Recommendations	SHORT-TERM IMPACT			LONG-TERM IMPACT			Total
		Job creation	Boost economic activity	Timeliness and risk	Long-term growth potential	Resilience to future shocks	Decarbonization	
	1.1. Data and decision-making tools	0.0	0.0	0.3	0.6	0.7	0.2	1.8
	1.2. Establish asset management systems	0.0	0.3	0.0	0.6	0.7	0.3	1.9
	2.1. Enforce risk-informed coastal planning	0.3	0.0	0.3	0.5	0.7	0.3	2.1
	2.2. Implement ICZM	0.3	0.0	0.0	0.5	0.7	0.2	1.6
	3.1. Strengthen infrastructure resilience	1.0	0.7	0.7	0.7	0.7	0.5	4.2
	3.2. Improve infrastructure maintenance	1.0	0.7	1.0	0.7	0.7	0.5	4.6
	3.3. Upgrade dikes	1.0	0.7	0.7	0.3	0.7	0.2	3.5
	3.4. Update and enforce safety standards	0.3	0.3	0.3	0.2	0.7	0.3	2.1
	4.1. Protect and manage coastal dunes	0.5	1.0	0.7	0.7	0.7	0.8	4.3
	4.2. Restore mangroves and coral reefs	1.0	1.0	1.0	0.7	0.7	0.8	5.2
	5.1. Improve early warning systems	0.8	0.0	0.3	0.3	0.7	0.0	2.0
	5.2. Strengthen emergency planning	0.3	0.0	0.0	0.3	0.7	0.0	1.2
	5.3. Develop risk financing strategy	0.0	0.0	0.3	0.5	0.7	0.0	1.5

Source: Scoring criteria are based on Hammer and Hallegatte 2020.

Note: Under the World Bank sustainability checklist, measures that perform well against a given criteria are assigned a score of 1, those performing poorly a score of -1, and those where performance is neutral or criteria are not relevant, a score of 0. For this exercise, all categories were given equal weights. However, this can be changed according to governments' prioritization of interests. All scores are normative and serve the purpose of illustration.

the lives of most of the people who live along Vietnam's coast. Key economic sectors, essential public services, and lifeline infrastructure systems are all exposed to these hazards, and the associated costs for households, firms and authorities are substantial. The country's geography — with over 3,000 kilometers of coastline that face the elements — means that natural risks are a reality for all.

Yet despite these risks, Vietnam's coastal regions have played host to thriving economic sectors, providing livelihoods to a growing and rapidly urbanizing population. Growth sectors include modern large-scale agriculture, aquaculture, booming tourism, manufacturing, service industries in growing coastal towns, and hubs for international trade. Indeed, coastal regions have the potential to be a powerful engine for Vietnam's continued socioeconomic development.

However, rapid urbanization and economic growth in coastal regions also mean that risks are bound to increase. Evidence in this report has shown that the coastline is becoming crowded. Almost 30 percent of the coastline is already built up with towns and settlements (Chapter 2). As safe zones have already been occupied, new coastal development is increasingly occurring in high-risk zones. This report estimates that high-growth zones are 22 percentage points more exposed to flood risks than other areas. Moreover, as economic growth continues, the value of economic activities and assets at risk is bound to increase.

And the natural hazards themselves are intensifying. First, there is the impact of local human interference. As

coastal development continues to compromise protective ecosystems such as dunes or mangroves, erosion, and flood risks are exacerbated. Inconsistent measures to mitigate beach erosion have intensified the risks (Chapter 12). Second, the effects of anthropogenic climate change are already changing conditions across the country. The frequency of intense droughts, floods, or typhoons is likely to further increase. Seasonal precipitation patterns are also becoming less reliable, thus posing risks to safe water supplies and agriculture. While the long-term trajectory of climate change and local implications are impossible to predict precisely, the evidence suggests that the country needs to prepare for significant adverse changes.

All these trends mean that the economic losses from natural shocks are bound to increase if no additional actions are taken to mitigate and manage risk. And taking action is urgent: The estimates in this report imply that delaying action by 10 years could expose an additional \$4.3 billion of economic growth to natural shocks by 2030.

A window of opportunity.

Not all disasters can be prevented, and natural shocks will continue to hit Vietnam's coastal regions. However, it is possible to make coastal development more resilient to shocks by making informed decisions about balancing development opportunities and disaster risks.

Over the past decades, the government of Vietnam has demonstrated that a pro-active risk management approach can save lives and reduce losses. It has made



impressive progress in reducing and managing natural risks at all levels of government. However, this work is far from complete. The policy stock take in this report (Part 2) has shown that current measures are falling short of the needs and failing to address serious risks to coastal communities. These vulnerabilities could be exacerbated in coming years, as the trends of coastal urbanization and climate change progress.

Vietnam is at a crossroads and its government has an opportunity to take decisive action to safeguard its future development in the face of disaster risks. Its experience with disaster risks, and its proven long-term and systemic planning approaches, are important elements for formulating and implementing a resilient development strategy. Vietnam's international partners, including the World Bank, are committed to continue their support to the government's important efforts in this area. Indeed, while the expertise gathered in other countries can help inform Vietnam's decisions, they too can learn from Vietnam's experience in taking action at the forefront of natural risks and climate change. These actions, if taken decisively, are an opportunity to strengthen the resilience of coastal communities and hence the prosperity of coming generations.

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Hotspot focus: Strategies for reducing disaster risk in six coastal districts in Vietnam

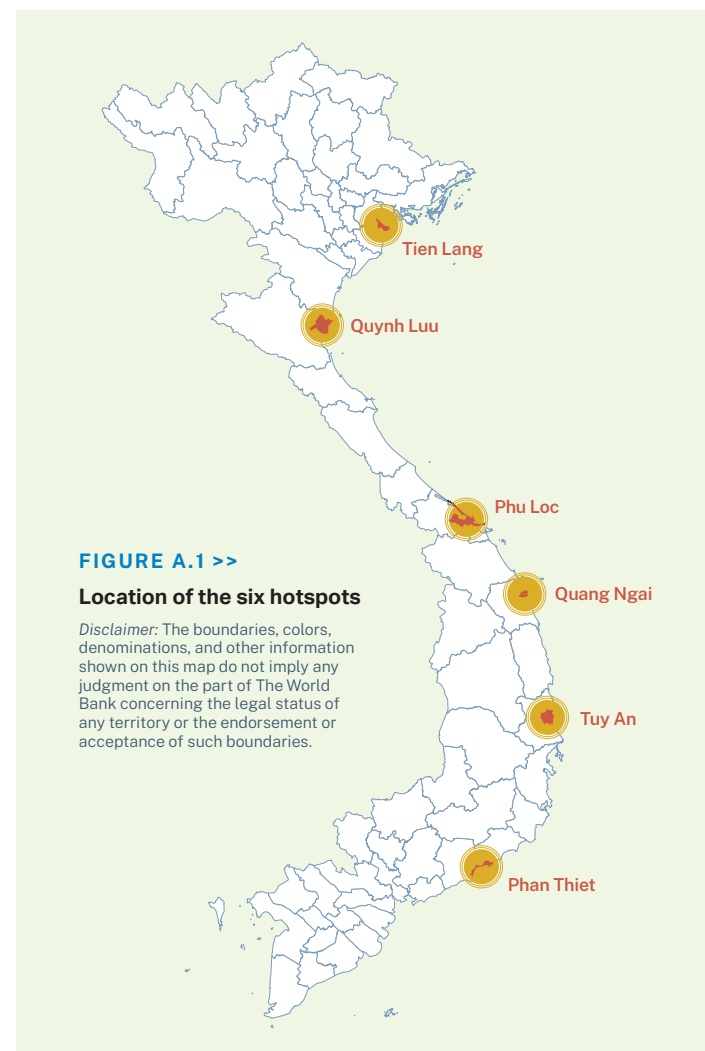
The study team carried out in-depth risk assessments for six coastal areas—known as hotspots—to help national and local stakeholders develop concrete and location-specific investment frameworks and to identify priorities for reducing disaster risks. The process involved continuous interaction with national, regional, and local stakeholders.

A.1 >>

Study area selection

The team worked with the national government to select the six areas or study hotspots (figure A.1). These districts represent the diversity of Vietnam's coastline, in terms of geography, natural hazards, and socioeconomic characteristics. From north to south, the hotspots are:

- **Tien Lang:** a polder at risk from pluvial, coastal flooding
- **Quynh Luu:** a flat rural area with pluvial and coastal flood risk
- **Phu Loc:** a key economic gateway under threat of flooding and beach erosion
- **Quang Ngai:** a coastal city with compounded flood and erosion risk
- **Tuy An:** a transforming rural coastal community at risk from flooding and erosion
- **Phan Thiet:** a tourist hub suffering from erosion



The selection was made using a semi-quantitative prioritization procedure based on urgency for improving resilience, distinguishing characteristics, geographical spread, and other factors. The six hotspot studies reflect and provide examples for the wide range of physical and socioeconomic characteristics found along the Vietnamese shoreline: beaches, dunes, lagoons, and estuaries; rural and urban aspects; agriculture, industry, tourism, trade, forestry, fishery, aquaculture, and services. One or more natural hazards — fluvial, pluvial and coastal flooding and erosion — are also at play in each location.

A.2 >>

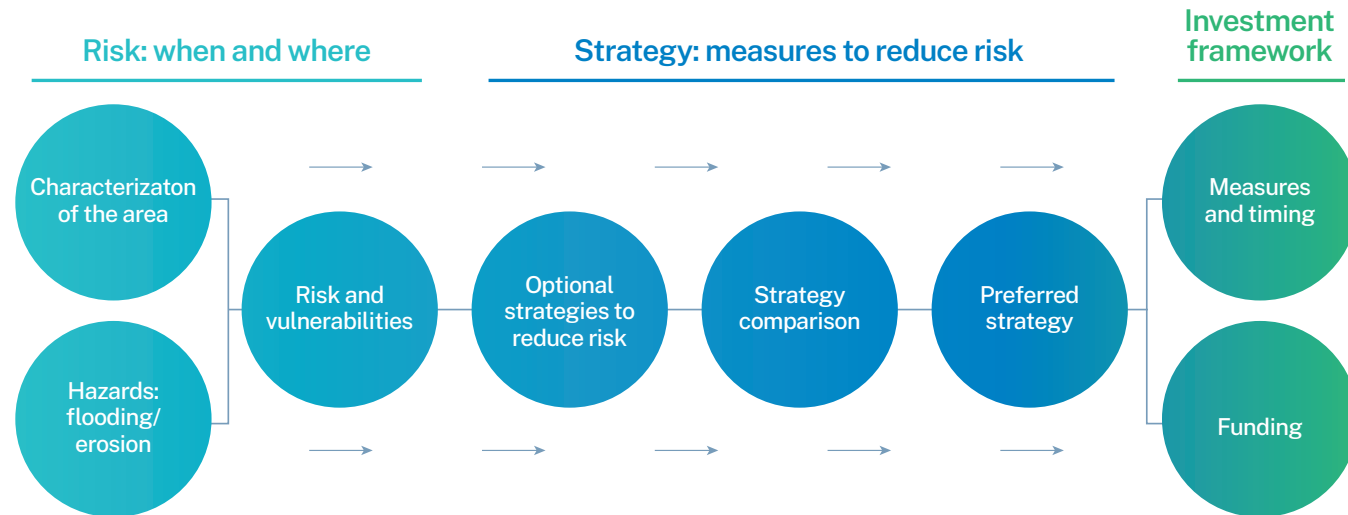
Developing the framework

Using a stepwise approach (figure A.2) and supported by local and national stakeholders involved in the workshops, the study team developed an investment framework with prioritized investments. This step-by-step planning, based on stakeholders' inputs and verified at consequent workshops, included:

- 1. Characterizing the areas:** Characterizing each area by assessing existing ecosystems and infrastructure, and current and future socioeconomic situations and land use. The districts' five-year SEDPs provided input for future or projected land use.
- 2. Hazards:** Undertaking detailed assessments of hazards and their consequences to identify vulnerable critical infrastructure in terms of economic damage and people affected.
- 3. Risks and vulnerabilities:** Using the results of these assessments for insight into the areas that would be at risk in the medium or long term, identifying areas where unacceptable risks rendered necessary measures and reviewing those that were already in place or planned — for example, in the SEDPs.
- 4. Optional strategies to reduce risk:** Using these inputs, developing several strategic options for managing flooding and erosion.
- 5. Strategy comparison:** Comparing stakeholder support, flexibility and effectiveness for each of these strategic options to increase coastal resilience.
- 6. Preferred strategy:** Defining a preferred coastal resilience strategy for each area using the strategy comparisons.
- 7. Measures and timing:** Using multi-criteria assessments and cost-benefit analysis to define prioritized investments, and no-regret measures, and recommend long-term directions that fit within the preferred strategy.
- 8. Funding:** Proposing opportunities for financing and funding the identified investments for each coastal area.

FIGURE A.2 >>

Developing a hotspot-specific investment framework



A.3 >>

Stakeholder consultations

The team organized a number of national and local workshops where a diverse set of participants exchanged information, generated ideas and validated results and conclusions. There have been at least two national and 18 local workshops — three in each hotspot.

An initial national inception workshop was followed by field visits and project introduction workshops at each hotspot. At the second round of hotspot-level workshops,

stakeholders identified and discussed local vulnerabilities, and in the final set, they focused on potential measures and/or plans to address these vulnerabilities. A second national workshop was held to discuss results and assessments.

Stakeholders were actively involved in these highly interactive working sessions chaired by the VNDMA. There were typically 15–25 participants, including representatives from the regional DARDs, and DONRES; district-level departments of water resources, economics and aquaculture; police and city military command; commune-level people's committees; as well as women's, farmers', and youth unions.

Hotspot 1 >>

Tien Lang: A polder facing pluvial and coastal flooding



Region:	Red River Delta
Geography:	Coastal polder
Population:	155,000
Economy:	Mainly agricultural, but transitioning towards more industrial activities
Threats:	Pluvial and coastal flooding

Proposed high-priority interventions:

- Upgrading weak spots in dike system (\$10 million; DARD to lead)
- Where possible, reallocating planned industrial zones to less flood-prone areas and allocating appropriate corridors for future upgrades to drainage and dike infrastructure in the land use plans (DONRE)
- Defining and implementing improvements to existing early warning system (DARD)

Proposed long-term interventions:

- Planning and upgrading dikes and drainage system
- Implementing a self-sustaining mechanism to finance these investments, their operation and maintenance

Geography

Tien Lang District in Hai Phong Province is at the downstream end of the Red River Delta in northern Vietnam. It is a coastal polder surrounded by several river branches, and has a 17-kilometer coastline on the Gulf of Tonkin. At the seaward side, a coastal flat has steadily grown as a result of abundant sediment supply from the river. Mainly covered with mangrove forests, these mudflats also host

aquaculture activities. The population is equally distributed across the polder's 23 rural communes and Tien Lang township. National Road 10 and Provincial Road 354 are the main transport corridors connecting Tien Lang to nearby provinces and other districts within Hai Phong.

Socioeconomic context

This is a rural district where rice production and other agriculture occupy 77 percent of total available land. The economy of Tien Lang has shown steady growth of over 9 percent each year, with total production valued at \$350 million in 2017. Poverty in the district was at 3.6 percent in 2017. The contribution of rice production to the economy has dropped over the years, in favor of industry and services sector growth. The district's SEDP aspires to continue with this shift, with a long-term economic production goal of 35 percent agriculture and 65 percent industry and services.

Major natural hazards

Tien Lang is in one of the most storm-prone areas in Vietnam, especially between July and September. The region is affected by three to five low tropical pressures each year, with one or two storms hitting the area directly, accompanied by strong winds, storm surge and heavy rains. In 2012, Storm No 8 brought heavy rain, causing around \$14 million worth of damage.

A dike system reduces flood risk from both rivers and the sea. Inland, the polder's complex network of canals, culverts and 85 pump stations (with a total hourly capacity of 110,000 cubed meters) provides agricultural irrigation, drains excess rainwater, and prevents saline intrusion.

People, economic activity, and assets at risk

The emerging short-term picture from the detailed risk assessment is that by 2030, the southeastern coastal communes that directly face the sea (Tay Hung, Dong Hung, Tien Hung and Vinh Quang) and the northwestern communes along the Thai Binh and Van Uc Rivers (Kien Thiet, Cap Tien, Tien Thanh, Khoi Nghia, Tien Tien and Quyet Tien) will face the highest natural risks. This is mainly due to weak spots in the existing dike system, which could be breached by extreme high water events in either the rivers or the sea. A 1-in-100-year event would directly expose about half of the district's population and cause direct damages of around \$40 million. About 70 percent of this would be to housing, 10 percent to industry and 5 percent to agricultural sectors, including rice and aquaculture.

In the long term, the economic risk increases about tenfold, mainly due to the expected 70 percent growth in the local economy. By 2070, the entire polder would be at some risk, although this would be highest in Tien Thanh and Quyet Tien Communes, due to planned industrial development. The risk would still originate from both fluvial and coastal flooding, while the economic risk from pluvial flooding is negligible. A 1-in-100-year event would affect about 70 percent of the district's population and cause direct damages worth \$300 million. This strong increase in risk is partly because the analysis uses the existing protection system and does not account for possible upgrades. However, the projected shift in economic activities on the polder would also see an increase in high-value assets and activities such as industry and tourism, which would contribute more significantly to overall long-term risk.

Options for mitigating disaster risks

Working with local and national stakeholders, the team developed a preferred long-term resilience strategy that combines risk informed spatial planning for new activities with upgrading dikes in the near future. Although upgrading those dike segments that do not meet current government requirements is important in the short term, projected risks warrant a higher level of protection, so the district should consider updating safety standards and upgrading the entire dike system accordingly in the long run. Better spatial planning, however, will help it manage the increased risks better, allowing it to postpone dike system upgrades.

Prioritized short-term interventions

The district needs to upgrade a 100-meter stretch of dike and 1,245 meters of revetment and rebuild the Lam Cao culvert on the right bank of the Huu Van Uc River. It also needs to repair 10 culverts: Minh Thi, Duong Ao cu, Tien Cuu, Ben Than, Khue, Da Do, Chinh Ly, Son Dong, Dong Con and Quay. This work should consider improving future system requirements — for example, building the required base for future upgrades.

Another priority is re-evaluating planned industrial zones and dike and drainage system upgrades in light of flood hazards. For example, the next SEDP should consider alternative locations for the industrial zones. Finally, the district's conventional loudspeaker system is outdated. Therefore a detailed evaluation of the early warning system is needed to define necessary improvements.

Hotspot 2 >>

Quynh Luu: A flat rural area with pluvial and coastal flood risk



Region:	North Central Coast
Geography:	Flat in the east, semi-mountainous in the west
Population:	250,000
Economy:	Rural, agriculture, fisheries
Threats:	Pluvial and coastal flooding, erosion

Proposed high-priority interventions:

- Upgrading the dikes along the Hau and Thai Rivers to reduce pluvial flood risk (\$76 million)
- Repairing and upgrading the coastal dike, dredging and beach nourishment in Thai River mouth to control coastal flood and erosion (\$16 million)
- Reconsidering land use planning for the next SEDP

Proposed long-term interventions:

- Improved planning in view of the coastal hazards
- Developing and implementing a self-sustaining mechanism to finance the capital and maintenance costs of any existing or new gray or green interventions

Geography

Quynh Luu district is one of Nghe An Province's four coastal districts. Its total surface is 463 square kilometers and it has a 19.5-kilometer coastline. The town and most of the communes are in the flat eastern area, which is also home to about 75 percent of the population.

Socioeconomic context

The key economic activities are rice and livestock farming,

and fisheries. The district has a fishing fleet of over 1,200 boats and exports about 40 percent of its aquatic products. In 2017, the district's total production value was \$199 million, up 14 percent from 2016. Between 2016 and 2020, the economy grew about 10 percent. The poverty rate is declining, and was about 2 percent in 2017. The district's economic focus, as set out in its SEDP, is slowly shifting away from rice, agriculture and fishery towards industry and services. However, the SEDP does not consider climate change, except for environmental protection.

Major natural hazards

Half of the district is regularly flooded by storm surge and excessive rainfall. Quynh Luu is affected by three to five storms a year between June to November. In the northeast, the dunes and coastal forest provide some protection, while a coastal dike system protects parts of the district from flooding events with up to a 30-year return period. River dikes are also in place, but have no safety standards. A 1-in-10-year flood would inundate 30–40 percent of the district. The coastline is relatively stable. Only one stretch west of the Thai River mouth faces severe erosion. Structural coastline retreat is expected in the long run due to sea level rise.

People, economic activity, and assets at risk

By 2030, about 65,000 people—24 percent of the population—are expected to be affected by flood hazards each year. Vast extents of mainly rural land will suffer economic damage, representing almost 73 percent of the estimated \$17 million annual total damage. Most of this will be in Quynh Thanh, Quynh Bang, and Cau Giat.

By 2070, climate change and economic development will increase the severity of damage in the district. Total annual economic damage is expected to increase to \$48 million, concentrated in rural areas, the coastal plains, and Cau Giat. In the long term, about 85,000 people—30 percent of the total population—are expected to be affected each year.

The risk of coastal erosion is lower, with damage estimated at \$1 million by 2030, 90 percent of which is expected to be on rural land. In the longer term, however, the whole coastline will be affected by erosion due to sea level rise. Although limited, the damage is estimated to increase more than tenfold to \$12 million by 2070. While this remains mostly rural (64 percent), urban areas (19 percent) and land used for tourism (14 percent) will also be affected.

Options for mitigating disaster risks

The preferred long-term strategy for this district uses improved dike protection along the Thai and Hau Rivers to protect adjacent areas from pluvial flooding and combines flood risks and district elevation differences to inform spatial planning. The strategy outlines the need

to develop a maintenance plan with sufficient budget to ensure better coastal management with flood and erosion control measures in the urbanized coastal area near the Thai River mouth.

Prioritized short-term interventions

Upgrading river dike systems to Grade IV, which would provide protection against floods with return periods up to 30 years, is a priority. This would include upgrading:

- Eight kilometers along the Thai River, running through Quynh Bang, Quynh Thanh, Quynh Van and Cau Giat
- 32 kilometers along the Hau River
- Two kilometers of the Long-Thuan-Tho dike near the Thai River mouth, running through Tho Dong, Tho Tien and Tho Thanh hamlets, including reforestation in front of the dike.

Deploying reefs balls in front of Sam Sam Beach, dredging the Thai River mouth, and nourishing the beach are priorities to control erosion. The district also needs to revisit its SEDP and review projected land use across the district, considering existing and future risks.

Hotspot 3 >>

Phu Loc: A key economic gateway under threat of flooding and beach erosion



Region:	North Central Coast
Geography:	Lagoons and low-lying land in the east, mountainous in the west
Population:	Over 140,530
Economy:	Mainly services (tourism) and industry, with some agriculture, forestry and fishery
Threats:	Flooding and beach erosion

Proposed short-term interventions:

- Implementing the Thuy Cam Reservoir and developing a second storage reservoir in the upstream area of the Rui River (\$21.5 million)
- Dredging the inlets of the Lang Co and Cau Hai Lagoons (\$2.9 million)
- Beach nourishment and reforestation in Loc Vinh (\$26.9 million)

Proposed long-term interventions:

- Widening the river and improving drainage to cope with increased flood risk
- Implementing setback areas to allow flooding and erosion through managed retreat
- Afforestation, dredging of inlets and beach nourishment

Geography

Located between the Central Region's two largest cities, Phu Loc lies 45 kilometers north of Hue City and 55 kilometers south of Da Nang City. The district has two coastal lagoons: Cau Hai in the north and Lang Co (Lap Anh) in the east. The Annamite mountain range shapes the

lagoons' catchments, directing runoff towards the coast and flooding low-lying areas.

Socioeconomic context

Phu Loc is an important economic gateway and national traffic routes, including National Highway 1A and the North-South Railway route, run through it. Its deep-water Chan May port is the region's biggest seaport and one of the East-West Economic Corridor's most important sea gateways. In 2018, the district's total production value was \$873 million, a 15.6 percent increase on 2017. This was made up of: 59 percent services, 34 percent industry and 7 percent agriculture, forestry and fisheries. Services are mainly related to tourism, which is growing strongly. The district's socioeconomic plan focuses on continued growth of the services and industry sectors at the expense of agriculture and forestry, with further urbanization and new industrial areas in the coastal zone.

Major natural hazards

Phu Loc has a rudimentary dike system around the northern end of the Cau Hai Lagoon, offering minimal protection. It protects agricultural areas from frequent, minor floods with return periods of less than 10 years. The district is prone to fluvial, pluvial, and coastal flooding. The lagoons' outlets tend to experience sediment built-up, reducing the outflow capacity of excess water to the sea. Inability to discharge these floodwaters results in localized flooding of the surrounding areas.

Most of the Phu Loc shoreline is also exposed to erosion. The beaches in Vinh Hai, Vinh My and Vinh Hien Communes

are the most affected; long-term structural erosion over the last 30 years has caused the shoreline to retreat by more than 100 meters. During typhoons, storm surge raises the water levels inside the lagoons, resulting in flooding, causing erosion up to 70 meters along the shore. Beaches recover naturally from these events, but economic developments can be damaged.

People, economic activity and assets at risk

Most of the flooded areas in Phu Loc District are rural and sparsely populated. Hence, exposed areas belong mainly to the low-risk category. By 2030, it is estimated that over 50 percent of economic damage will be to rural buildings, about 30 percent to urban buildings, 8 percent to industry, and about 4 percent to agriculture and aquaculture.

By 2070, the risk of flooding is expected to increase in Phu Loc District, especially in the urban communes of Loc Tien and Loc Thuy, both areas that are projected to grow. Although the exposed flooded area will remain relatively constant due to the district's geography, flood depths are expected to increase. Direct annual flood damage is expected to rise by a factor of five, from \$14.5 million in 2030 to \$73.2 million by 2070.

An estimated 300 hectares of land will be lost to erosion by 2030. Of this, 40 percent will probably be in currently unused areas, 32 percent in forested areas and 11 percent on agricultural land. By 2070, land loss is expected to reach 560 hectares. Of this, 110 hectares will be in urban areas, representing 80 percent of total damage from erosion.

Without action, erosion damage is expected to jump from \$1.1 million in 2030 to \$14.7 million by 2070, a more than tenfold increase.

Options for mitigating disaster risks

Working with local and national stakeholders, the team evaluated different options for mitigating disaster risks to develop a preferred long-term strategy for the district. To mitigate flooding, the Thuy Cam Reservoir should be implemented and a second storage reservoir in the upstream area of the Rui River should be developed. This river must be widened, diverting it to create flood plains. The lagoons' inlets should be dredged and those of the Cau Hai Lagoon should be stabilized with groins. To discharge runoff into surrounding water bodies, the drainage system should be enhanced and the national highway's drainage capacity should be increased. Finally, planting mangroves in the lagoons should improve their natural ecology.

To tackle coastal erosion, it is recommended to implement beach nourishment and reforestation, supplemented with an erosion management plan, a maintenance plan and improved land use planning. Strong stakeholder collaboration and engagement are also essential to ensure long-term flood and erosion protection.

Prioritized short-term interventions

Priority actions in the district include dredging the lagoon inlets, building an upstream storage to reduce the flood risk for the entire district and large-scale beach nourishment and reforestation along the coast of the Loc Vinh Commune.

Hotspot 4 >>

Quang Ngai City: A coastal city with compounded flood and erosion risk



Region:	Central Coast Region
Geography:	Rural coastal plain to the east of the city's urbanized center
Population:	255,000
Economy:	Commercial and construction services
Threats:	Flooding and erosion

Proposed high-priority interventions:

- Improving the Khe Hoa Bridge weir, building a new storage reservoir and river dredging (\$34 million)
- Beach nourishment and revetment in Tinh Ky Commune (\$6 million)
- Reconsidering land use planning, particularly for coastal urbanized zones, for the next SEDP

Proposed long-term interventions:

- Improved planning that considers coastal hazards
- Developing and implementing a self-sustaining mechanism to finance the capital and maintenance costs of any existing or new gray or green intervention

Geography

The study focused on the city's rural coastal communes. The urbanized center lies inland, several kilometers from the coast. The urban area is surrounded by a flat, low-lying plain, with mountains, hills and rivers to the west. The Tra Khuc River flows through the city to the sea, with the rural coastal communes located on both sides of the river.

The 18-kilometer coastline within the city boundaries is relatively straight, with a narrow strip of land separating lagoons from the sea.

Socioeconomic context

Quang Ngai City is the political, economic, cultural, scientific and technical center of Quang Ngai Province. Nearly half of its 255,000 inhabitants live in the urbanized city center. Commercial and construction services contribute over 85 percent of the city's annual production value. Although tourism is not currently a large contributor to the economy, there are plans to develop this sector. My Khe beach near Tinh Ky at the northern end of the city boundary is a popular tourist destination. District authorities have already transferred land near this key tourist attraction to investors, but there has not yet been much investment or infrastructure, other than a coastal road.

The city's economy shows steady growth, with a 13 percent increase in 2014–2015 to the production value of \$1.9 billion. With the economy growing, the poverty rate is declining — from 4.4 percent in 2014 to 3.6 percent in 2015 and 2.8 percent in 2016. Plans show a major shift from rural to urban land use in the city's coastal communes.

Major natural hazards

Regular floods and severe coastal erosion are serious threats to the population. Heavy rainfall, high river flows and storm surges cause floods, with Nghia Ha, Truong Quang Trong, Le Hong Phong, Tinh Thien, Tinh Hoa and Tran Hung Dao Communes all exposed to severe flooding. To reduce this hazard, an extensive 60-kilometer Grade IV river and

sea dike system has been built, designed to protect against flooding with up to 30-year return periods. However, gaps and a relatively low safety level mean that this system offers limited protection.

Although accretion dominates in most of the city's coastal area, the coast is eroding in three villages: Nghe An and Ky Xuyen in Tinh Ky Commune and Khe Tan in Tinh Khe Commune. A revetment protects Tinh Ky from structural erosion, but not storm waves. Khe Tan is exposed to the extreme dynamics of the Tra Khuc River outlet, which oscillates between erosion and accretion.

People, economic activity, and assets at risk

In the short term, all of Quang Ngai's coastal communes will be exposed to flooding, due to the district's low-lying geography and the low levels of protection offered by its dike system. But despite this high exposure, most of these areas fall into the low-risk category because projected flood depths and land use value are low. Flooding is mainly a result of high water levels in the Tra Khuc River and heavy rainfall that pools in the absence of a drainage system. The impact of coastal flooding is lower than fluvial and pluvial flooding.

Without action, the total annual damage from flooding is expected to rise significantly from \$3 million in 2030 to \$29 million in 2070. This is mainly due to the planned shift from rural to urban land use in the coastal communes, which Quang Ngai's development plans project to jump from negligible urban land use in 2030 to almost 19 percent

in 2070. By 2030, 74 percent of flood damage is expected to be in the rural sector; by 2070, 81 percent is expected to be in urban lands. The total annual damage from erosion is also expected to increase drastically, with estimates ranging from \$0.5–15 million by 2070.

Options for mitigating disaster risks

The developed preferred long-term strategy combines green and gray engineering solutions for flooding and erosion protection. Green solutions are preferred in most cases due to their flexibility, effectiveness, and indirect benefits to tourism. The strategy includes improving upstream floodwater storage, combined with widening and dredging the river to better protect downstream coastal areas. To combat coastal erosion in Tinh Ky Commune, the strategy recommends revetments, combined with beach nourishments. These measures will be supplemented with an erosion management plan, a maintenance plan and improved land use planning. Strong stakeholder collaboration and engagement are also essential to ensure long-term flood and erosion protection.

Prioritized short-term interventions

Priority actions include building an upstream reservoir, improving the Khe Hoa bridge weir and dredging the river. In Tinh Ky Commune, a 500-meter revetment and nourishing 500 meters of beach have been prioritized to counter erosion. Other priorities include re-evaluating projected land use (particularly planned urbanized zones) in light of the flood hazard in the coastal zone and considering alternative options in its next SEDP.

Hotspot 5 >>

Tuy An: A transforming rural coastal community with strong growth and a combined risk of flooding and erosion



Region:	South Central Coast
Geography:	Diverse terrain, includes hilly and mountainous areas with a coastal plain
Population:	125,656
Economy:	Mainly rural activities, transforming into agro-forestry-fishery products
Threats:	Regular flooding and storm erosion

Proposed high-priority interventions:

- Diverting the spillway and river with dredging and flood plain management (\$36 million)
- Repairing and upgrading the An Ninh Dong revetment (\$1 million)
- Large-scale beach nourishment and reforestation in the coastal area (\$37 million)

Proposed long-term interventions:

- Ensuring the coastal corridor works in tandem with gray and green measures to better protect the district against erosion
- Reconsidering projected new urban and industrial land use in light of the detailed risk assessment, shifting these activities to less flood-prone areas
- Implementing self-sustaining mechanisms to finance the capital and maintenance costs for flood protection and erosion control measures.

Geography

Tuy An is a coastal district in the north of Phu Yen province, with a 39-kilometer coastline. Its township Chi Thanh is 30

kilometers from Tuy Hoa city. Its diverse terrain includes hills, mountains and a coastal plain where the 17.5-square kilometer O Loan Lagoon borders the sea. Its main river, the Ky Lo River — the second-largest in Phu Yen — is known as La Hien River upstream and Cai River downstream. It has 407.6 square kilometres of natural land area, of which 45 percent is agricultural, 26.5 percent hilly and mountainous, and 12.6 percent forest. Over 90 percent of its 125,656 population lives in rural areas.

Socioeconomic context

Tuy An is focused on developing and diversifying its agro-forestry-fishery-based economy and shows strong economic growth. Its production structure is increasingly shifting to service and trade, while the proportion of agriculture, forestry and fisheries decreases. The new activities include construction material, textile and garment production, food and wood processing, and machinery and equipment repair and maintenance.

In 2017, the district's total production value reached \$227 million, up 13.6 percent from 2016. Although the poverty rate has declined alongside this growth, it remained around 10 percent in 2017. The district's SEDP foresees a further shift towards industry and tourism, with large urban developments projected in the coastal plain and upstream along the Ky Lo River and its tributaries.

Major natural hazards

The main hazard in Tuy An is flooding from heavy rainfall, high river flows and storm surges. Regular floods pose serious threats to the population, with Chi Thanh, An

Ninh Tay, An Cu, An Ninh Dong, and An Chan Communes all exposed to severe flood hazards, as observed in 2009, 2017, and 2018, affecting National Highway 1A and the railway at several sections, disrupting traffic.

Floods in Tuy An are caused by the lack of drainage capacity to the sea. As a result, the floodwaters accumulate in the estuaries and lagoon, ultimately backing up in the rivers. Tuy An's coastal system appears to be in a dynamic equilibrium without large structural erosion. However, its beaches are very narrow and the built-up zone is close to the shoreline, on the beaches or in the dunes, resulting in temporal erosion from storm events damaging properties, according to residents and local authorities. Sea level rise will result in a gradual retreat of the coastline.

People, economic activity, and assets at risk

The detailed risk assessment shows that the district is prone to fluvial and pluvial flooding. In the short term, direct damage from floods is expected to amount to \$4 million each year. Nearly half of this will be in the rural sector, 25 percent urban, 15 percent tourism-related, and 6 percent in agricultural sectors. Without action, this damage will more than triple by 2070 due to increased exposure in the coastal zone's projected tourist and urbanized areas. On average, 30,000 people (21 percent of the population) will be directly affected by floods in both the short and longer term.

By 2030, it is estimated that 70 percent of the land at risk of erosion in the coastal area will be unused, but 81 percent of projected damage will be in tourist areas. These are expected to grow along the eastern coastline, increasing

erosion damage by 2070. Urbanization will also increase exposure levels along the coast. Annual direct damage from erosion is expected to increase from \$3.5 million in 2030 to \$23 million in 2070. The number of people directly affected by erosion will remain relatively small, between 300 and 400.

Options for mitigating disaster risks

The developed preferred long-term strategy combines green and gray engineering solutions for flooding and erosion protection. Green solutions are preferred in most cases due to their flexibility, effectiveness in dealing with flooding, and indirect benefits to tourism and ecology. To protect flood-prone areas, the strategy favors flexible measures such as dredging and river widening. The district has established a coastal corridor—a strip along the coast in which buildings and assets are restricted to create a buffer zone against the impacts of hazards or future changes. If properly enforced, this coastal corridor will work in tandem with the gray and green measures to better protect against erosion.

Prioritized short-term interventions

To stabilize the shoreline and protect against storm erosion, the district will build a spillway, divert and dredge the river, upgrade the An Ninh Dong revetment near the mouth of the Ky Lo River, nourish the beach in An Hoa and An My Communes and undertake reforestation work in An Ninh Dong Commune. It will also re-evaluate projected land use—particularly in planned urbanized and industrial zones—in light of flood hazards, considering alternative locations for industrial and urbanized zones in its next SEDP.

Hotspot 6 >>

Phan Thiet: A tourist hub suffering from erosion



Region:	South Central Coast
Geography:	Relatively flat, with sandy beaches and dunes
Population:	207,200
Economy:	Tourism
Threats:	Erosion

Proposed high-priority interventions:

- Beach nourishment and planting a 60-hectare shelterbelt (\$31 million)
- Building an additional revetment (\$1.5 million)
- Beach nourishment (\$45 million)

Proposed long-term interventions:

- Upgrading and extending revetments in the urbanized area
- Land use planning controls and managed retreat, alongside planting coastal shelterbelts and beach nourishment

Geography

Phan Thiet City is the capital and administrative, economic and cultural centre of Binh Thuan Province. Located on the coast of Phan Thiet Bay, it stretches northeast and southwest over 49 kilometers. Two rivers—Ca Ty and Phu Hai—enter the sea in Phan Thiet and are bordered by narrow plains. Both river mouths have been extensively developed through heavy urbanization, prawn farming and port infrastructure, including a small-sized seaport and two fishery ports.

Socioeconomic context

This sea-facing city is a major tourist hub, with 4 million visitors per year. Tourism is mainly concentrated in the northern part of Phan Thiet, which has numerous water-side resorts. Agriculture and fishery are both in decline. The city's total production value reached \$1,558 million in 2017, up 7 percent from 2016. With this growth in the economy, poverty is declining. From 2016 to 2017, the poverty rate fell from 1.7 to 1.1 percent, though the percentage of near-poor households stayed more or less the same. The city's SEDP focuses on continuing the shift towards services and industry for significant economic growth and further decline in the number of poor households.

Major natural hazards

Phan Thiet faces serious erosion at various locations along the coast, affecting communities and threatening tourism. Northeast of Phan Thiet City, storm events can cause several tens of meters of erosion, directly affecting many tourist resorts in Ham Tien ward. As a result of erosion, tourist numbers fell by 20 percent in 2018 and investment by businesses also decreased. Many resort owners have built their own revetments and groins to stabilize the coast—mostly without much success or with negative effects on adjacent areas. The beaches in Tien Thanh and the residential zone of Doi Duong are other erosion hotspots, mainly caused by human activities such as jetty construction and land reclamation.

People, economic activity, and assets at risk

Most of the short-term economic damage is in the tourism sector, along a narrow strip of coastal land with many

valuable properties. Along this strip, 0.6 square kilometers of land will be at risk in 2030, specifically 30–50 meters of coastline scattered with beachfront hotels. While this only accounts for around 28 percent of the total land area that will be at risk in the district, it represents nearly 80 percent of the district's total estimated erosion damage—as tourism is the primary economic activity in Phan Thiet City. Although there has been no significant structural erosion in the city, its shoreline has suffered some temporary retreat from storms and poorly planned mitigation measures. The resulting total estimated damage value for a 1-in-100-year storm is \$156 million by 2030.

In the longer term, storm intensity and erosion are expected to increase due to climate change. There will be more pressure on resorts and human settlements, with the area at risk increasing by around 62 percent to 3.4 square kilometers by 2070. Public space at risk is expected to increase from less than 1 percent in 2030 to more than 25 percent in 2070. However, the low economic value of this land type means that economic damages are low, at less than 0.1 percent of total. Urban space at risk will also increase significantly, from 8 to 16 percent of total land use. In terms of value, urban land uses will account for nearly 20 percent of total damages by 2070. The total resulting direct and indirect erosion damage for a 1-in-100-year storm is estimated to increase to \$475 million by 2070. The population directly affected by coastal erosion

risk is expected to double, from approximately 900 in 2030 to 2,000 in 2070.

Options for mitigating disaster risks

The developed preferred long-term strategy includes gray measures—such as building revetments in urbanized areas—and green solutions—such as widescale beach nourishment and reforestation—in other parts of the coast. Green engineering solutions are preferred in most cases due to their flexibility, effectiveness, and indirect benefits to tourism. These measures will be tied to an erosion monitoring plan, a maintenance plan and improved land use planning. Strong private sector collaboration and engagement are also essential to ensure better long-term risk management of the erosion hazard along this stretch of coast.

Prioritized short-term interventions

To combat erosion, the district will build a revetment west of the Phu Hai harbor jetty and implement large-scale beach nourishment and reforestation just north and south of the city center in Ham Tien and Tien Thanh respectively.

To ensure the effective implementation of green interventions, resort owners and residents will need to be actively involved in monitoring erosion and maintenance, removing detrimental structures, cooperating in managed retreat where necessary, and strictly adhering to land use planning regulations.



RESILIENT SHORES

VIETNAM'S COASTAL DEVELOPMENT
BETWEEN OPPORTUNITY
AND DISASTER RISK

In a country that is among the most exposed to natural hazards, Vietnam's coastline often bears the brunt. Typhoons, storm surges, riverine flooding, coastal erosion, droughts, or saline intrusion are all-too-familiar threats to most people living along the coast. Yet despite these risks, coastal regions host thriving economic sectors, providing livelihoods for a growing and rapidly urbanizing population. The coastal regions could be a powerful engine for Vietnam's continued socioeconomic development, but rapid urbanization, economic growth, and climate change mean that disaster risks are bound to increase in the future.

Although the government of Vietnam has made impressive progress in reducing and managing natural risks, current trends show that the work is far from complete. To guide effective action, this report provides an in-depth and multi-sectoral analysis of natural risks in coastal Vietnam and reviews current efforts in risk management, proposing a concrete action plan to balance the risks and opportunities of coastal development. These actions, if taken decisively, are an opportunity to strengthen the resilience of coastal communities and hence the prosperity of coming generations.

