Climate Risks in the Mekong Delta

Ca Mau and Kien Giang Provinces of Viet Nam

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This report is a companion to Institute of Meteorology, Hydrology and Environment (IMHEN), Ca Mau People's Committee, and Kien Giang People's Committee (2011) *Climate Change Impact and Adaptation Study in the Mekong Delta – Part A Final Report: Climate Risk in the Mekong Region: Ca Mau and Kien Giang Provinces, Viet Nam*. Ha Noi, Viet Nam: IMHEN.

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Foreword

The Asian Development Bank (ADB), in line with its long-term strategic framework Strategy 2020 and white paper entitled "Addressing Climate Change in Asia and the Pacific: Priorities for Action" approved by its Board of Directors in April 2011, is investing in efforts to educate its developing member countries on climate change as a development challenge, while further enhancing its own ability to predict and plan for climate-related impacts on ADB's investments. This climate risk report developed for two Vietnamese provinces in the Mekong Delta demonstrates an approach for integrating climate risk considerations into sector and project planning. The approach involves combining data on communities and economic assets with temporal data on climate projections to depict climate risk at a resolution relevant to "street-level bureaucrats" and local policy makers.

The Mekong Delta region in Viet Nam has been identified as being particularly vulnerable to the impacts of sea level rise, extreme climate events, and climate variability. Despite a long history of disaster mitigation, planning, preparedness, and response, current regional and local level development plans in the Mekong Delta region include scant reference to climate change adaptation measures. Therefore, robust climate change impact assessments and effective climate change adaptation measures are required to enhance climate resilience of the region.

In 2008, the Prime Minister of Viet Nam announced the launch of the National Target Program on Climate Change (NTP-CC). The NTP-CC requires all ministries, provinces, and cities to develop climate change action plans. In 2010, ADB initiated a technical assistance program in Viet Nam (TA 7377: Climate Change Adaptation in the Mekong Delta), with financial support from the Australian Agency for International Development and ADB's Climate Change Fund, to strengthen the data sets and analytical basis for developing climate change action plans at the provincial level.

The technical assistance focused on assessing the potential impacts of climate change on three target sectors (agriculture, energy, and transport) in Ca Mau and Kieng Giang provinces. It was implemented in close collaboration with the Ministry of Natural Resources and Environment, which at the central level is responsible for all climate change–related scientific analysis and serves as the focal point for the NTP-CC, providing guidance on development of action plans.

In order to prepare this climate risk report, the study team reviewed and compiled the latest available climate projections for Viet Nam from a variety of sources. A comprehensive vulnerability analysis was conducted through a bottom–up evaluation of key socioeconomic trends, poverty indicators, and sector development plans for the agriculture, energy, and transport sectors. Subsequently, potential impacts on people, places, and key assets over the 2030 and 2050 time slices were described. Finally, the study points to broad categories of adaptation options that may be suitable for Ca Mau and Kieng Giang provinces.

This report has been produced by ADB's Southeast Asia Department and is part of ADB's overall effort to provide technical resources to assist both its operational staff and developing member country partners in managing climate risks confronting their investment projects. These resources encompass guidance materials, technical notes, and case studies on integrating climate change adaptation actions and climate-proofing vulnerable investments in critical development sectors.

James Nugent
Director General
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The technical assistance program was designed by Yongping Zhai (Director, Energy Division, South Asia Department) and Ancha Srinivasan (Principal Climate Change Specialist, Environmental and Natural Resources Division, Southeast Asia Department [SERD]), and implemented by Pradeep Tharakan (Climate Change Specialist, Energy Division, SERD), Ross Butler (Senior Social Development Specialist (Safeguards) Portfolio, Results, Safeguards and Social Sector Unit, Central and West Asia Department), and Lauren Sorkin (Country Specialist, Viet Nam Resident Mission). The report also benefited from valuable comments and suggestions from Cary Yeager (Climate Change Specialist, Environment and Natural Resources, East Asia Department). Production assistance was provided by Christine Samaniego (Senior Operations Assistant), Janice Alalay (Operations Assistant), and Wema Pacano (Operations Assistant) from the Energy Division, SERD; Jose Herman Ramos (Senior Logistics Management Assistant (Cartography), Logistics Management Unit; and Maria Cristina Pascual (Consultant). Support from ADB's Department of External Relations for the editing, proofreading, and layout of this report is gratefully acknowledged.

Finally, this work would not have been possible without the collaborative spirit and technical support provided by the officials of the Centre for Environmental Research (CENRE) under the Viet Nam Institute of Meteorology, Hydrology and Environment (IMHEN), and government officials from the Ca Mau and Kien Giang Provincial governments.

Abbreviations

ADB	–	Asian Development Bank
AusAID	–	Australian Agency for International Development
CENRE	–	Center for Environmental Research
CVRA	–	comparative vulnerability risk assessment
DARD	–	Department of Agriculture and Rural Development
DONRE	–	Department of Natural Resources and Environment
DOT	–	Department of Transportation
EVN	–	Viet Nam Electricity
GDP	–	gross domestic product
GIS	–	geographical information system
IMHEN	–	Institute of Meteorology, Hydrology and Environment
IPCC	–	Intergovernmental Panel on Climate Change
IQQM	–	Integrated Quality and Quantity Model
MRC	–	Mekong River Commission
PVN	–	PetroVietNam
SKM	–	Sinclair Knight Merz
SLR	–	sea level rise
SRES	–	Special Report on Emissions Scenarios
TA	–	technical assistance

Currency, Weights, and Measures

$	–	US dollars
D	–	Vietnamese dong
kV	–	kilovolt
°C	–	celsius (centigrade)
km/h	–	kilometer per hour
ha	–	hectare
m	–	meter
ppt	–	parts per thousand

Key Terms

Adaptation	–	Actions taken in response to actual or projected climate change and impacts that lead to a reduction in risks or a realization of benefits. A distinction can be made between a planned or anticipatory approach to adaptation (i.e., risk treatments) and an approach that relies on unplanned or reactive adjustments.
Adaptive capacity	–	The capacity of an organization or system to moderate the risks of climate change or to realize benefits, through changes in its characteristics or behavior. Adaptive capacity can be an inherent property or it could have been developed as a result of previous policy, planning or design decisions of the organization.
Climate change	–	Climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (United Nations Framework Convention on Climate Change).
Climate scenario	–	A coherent, plausible but often simplified description of a possible future climate (simply, average weather). A climate scenario should not be viewed as a prediction of the future climate. Rather, it provides a means of understanding the potential impacts of climate change, and identifying the potential risks and opportunities created by an uncertain future climate.
Climatic vulnerability	–	Climatic vulnerability is defined by the Intergovernmental Panel on Climate Change as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."
Exposure	–	Defines the likelihood of a community being affected by a hazard. This is determined by geographic information system modeling and mapping of the predicted extent of hazards.
Hazard	–	A physically defined source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these.
Mitigation	–	A human intervention to actively reduce the production of greenhouse gas emissions (reducing energy consumption in transport, construction, at home, at work, etc.), or to remove greenhouse gases from the atmosphere (sequestration).
Resilience	–	A measure of the current ability of a community to resist, absorb, and recover from the effects of hazards, by quickly preserving or restoring its essential basic structures, functions, and identity.
Risk	–	Risk is defined in general terms as the product of the frequency (or likelihood) of a particular event and the consequence of that event, be it in terms of lives lost, financial cost, and/or environmental impact.
Sensitivity	–	Refers to the degree to which a system is affected, either adversely or beneficially, by climate related variables including means, extremes, and variability.
Vulnerability	–	Vulnerability is a function of risk and response capacity. It is a combination of the physical parameter of the hazards and its consequences such as personal injuries, degradation of buildings and infrastructure, and functional perturbations. It may vary depending on non-physical factors such as emergency preparation, education, and recovery capacity.

Introduction

Management of the potential impacts of climate change on coastal areas is a major environmental challenge for Viet Nam. The main influence on climate change is global warming and the associated sea level rise due to greenhouse gas emissions from human activities. Rising sea levels will directly affect coastal areas, potentially inundating land or increasing the intrusion of saline water into rivers and canals, leading to a gradual loss of protective mangrove forests, and increasing the costs of maintaining coastal infrastructure, such as renovation of sea dikes, port facilities, and coastal urban areas. The Mekong Delta is almost entirely less than 5 meters above sea level, making it one of the three most vulnerable deltas in the world to sea level rise.

Climate change is also projected to lead to strong fluctuations in rainfall and an increase in the frequency and impact of extreme weather events such as floods and droughts. In the Mekong Delta, increases in the extent and duration of flooding, changes in wet season and dry season precipitation, inundation from sea level rise, and changes to salinity intrusion could be significant threats to the region's agricultural and fisheries productivity, as well as remaining natural coastal ecosystems.

This study has been undertaken in order to provide provincial and district policy makers with an understanding of the key areas of vulnerability and hotspots with regard to climate change in the period up to 2050. The study identifies potential future climate conditions in the Mekong Delta region and assesses the effects of future climate scenarios on natural, social, and economic systems in the region.

This report presents an assessment of the potential impacts of climate change on the socioeconomic, agriculture, livelihoods, urban settlements, transportation, energy, and industry sectors in Ca Mau and Kien Giang provinces. The spatial extent of exposure to climate change hazards is mapped, the most vulnerable districts in each sector are identified, and the key climate change risks faced by each district are outlined. In this context, the study primarily targets provincial and district level decision makers in Ca Mau and Kien Giang, as well as major development partners. It provides practical measures that provincial and district administrations can take to inform and strengthen their programs.

Purpose and Scope of the Study

The Asian Development Bank (ADB) engaged Sinclair Knight Merz (SKM), in association with the Center for Environmental Research (CENRE) under the Viet Nam Institute of Meteorology, Hydrology and Environment (IMHEN), Acclimatise, and the University of Newcastle, Australia to undertake Part A of the project "Climate Change Impact and Adaptation Study in the Mekong Delta" funded by the Australian Agency for International Development (AusAID).

This report is one of two products that represent the culmination of Part A of the Climate Change Impact and Adaptation Study in the Mekong Delta. It provides a brief overview of the results of the modeling and vulnerability assessment as well as presents detailed maps of the projected impacts of climate change and of present and projected vulnerability at the district level. The consultant's report "Climate Change Vulnerability and Risk Assessment Study for Ca Mau and Kien Giang Provinces, Viet Nam" provides more detailed descriptions of projected future climate conditions in the Mekong Delta region; descriptions of the target sectors in each province; an assessment of the effects of future climate scenarios on natural, social, and economic systems in the Mekong Delta region; and a baseline analysis of existing climate change capacity within the Government of Viet Nam.

Part B of the Climate Change Impact and Adaptation Study focused on the identification of appropriate climate change adaptation measures for target provinces and targeted regional sectors, and the development of pilot projects for up-scaling and replication of technical assistance outcomes and support to collaborative mechanisms for information sharing and coordinated action on climate change.

Target Provinces

The study focuses on the two most southern provinces of Viet Nam: Ca Mau and Kien Giang. The economies of both provinces are primarily based on agriculture, aquaculture, fishing, and primary industries. Twenty-four districts from the two provinces were considered in the scope of this assessment.

Stakeholder consultations and field surveys were conducted in all districts, including:

- In Ca Mau province: Ca Mau City, Cai Nuoc, Dam Doi, Nam Can, Ngoc Hien, Phu Tan, Thoi Binh, Tran Van Thoi, and U Minh districts; and
- In Kien Giang province: Rach Gia City, Ha Tien, An Bien, An Minh, Chau Thanh, Giang Thanh, Giong Rieng, Go Quao, Hon Dat, Kien Luong, Tan Hiep, U Minh Thuong, Vinh Thuan, and the island districts of Kien Hai and Phu Quoc.

Target Sectors

The approach used in this study recognizes the need to identify not only where the most socially vulnerable are located, but also how much infrastructure and services are physically more exposed and vulnerable. The approach incorporates social dimensions such as population, poverty, and well-being, as well as the biophysical attributes of topography, natural resources, and physical infrastructure.

In this context, vulnerability incorporates a number of dimensions: social, demographic, geographic, environmental, economic, and cultural processes that influence how vulnerable a community or system is to the effects of climate change. In order to be able to evaluate and map vulnerability, the study used the approach of ranking the exposure and sensitivity for both natural and human systems across five key dimensions and sectors:

- Population
- Poverty
- Agriculture and Livelihoods
- Energy and Industry
- Urban Settlements and Transportation

The Approach

The primary purpose of this vulnerability assessment study is to identify and evaluate the net biophysical and social vulnerability of Ca Mau and Kien Giang provinces. In this context and for the purposes of this report, vulnerability is considered to be a function of:

- exposure to climatic conditions and sensitivity to the impacts of climate change;
- the frequency, magnitude, and extent of climate-related risks to the community, assessed in terms of the probability of occurrence (likelihood) and magnitude of hazards (consequence); and
- the ability or adaptive capacity to respond to climate-related risks (including adaptive measures, coping strategies, or actions taken in reaction to the impacts or to mitigate the risks).

Map of Study Area

The study developed a comparative vulnerability risk assessment (CVRA) conceptual framework that uses a geographical information system (GIS) to identify key geographic areas that are particularly vulnerable to the combined effects of climate change and sea level rise, and particularly the impacts of flooding, inundation, salinity, and storm surges on the target sectors. The CVRA incorporates a range of vulnerability indicators that cover the important aspects of the social, economic, and development systems that lead to climate change vulnerability. The indicators that were used for each sector incorporate measures of exposure (from modeling and GIS mapping), sensitivity (from district survey data), and adaptive capacity (observations and findings from the sector consultations). The method also incorporates weighting factors that are based on expert opinions that estimate the current status of existing protection measures and assess their suitability to provide protection from projected changes to the extent of climate change impacts.

The method uses the results from the exposure modeling together with the key observations and findings from the sector consultations and surveys to determine the relative levels of risk for a particular threat source—expressed as a function of "likelihood" and "consequence" to highlight the major risks at the district and provincial levels.

In order to determine the exposure to climate change hazards and their likelihood of occurrence, three different forms of modeling were carried out as part of the study: regional climate modeling, hydrological modeling, and coastal modeling. The baseline period used for the modeling is 1980–1999 (and the September 2000 flood event), with the periods 2030 and 2050 also modeled under selected greenhouse gas emissions scenarios.

Climate Change in the Mekong Delta

Climate change is a major environmental challenge for Viet Nam. The main indicator of climate change is global warming due to greenhouse gas emissions from human activities. Climate change also leads to a strong fluctuation in rainfall and an increase in extreme weather and climate conditions, such as floods and droughts. Rising sea levels will also directly affect coastal areas, potentially inundating land or increasing salinity, with the gradual loss of mangrove forests, and increasing the coastal infrastructure costs, such as for renovation of port facilities and coastal urban areas.

The Mekong Delta is almost entirely less than 5 meters above sea level, making it one of the three most vulnerable deltas in the world to sea level rise. With global climate change, the impact and frequency of extreme weather events are expected to intensify. Increased extent and duration of flooding, changes in wet and dry season precipitation, inundation from sea level rise, and changes to salinity intrusion could be significant threats to the region's agricultural and fisheries productivity, as well as to the remaining natural coastal ecosystems.

The delta has a tropical monsoon climate, influenced by both the southwest and northeast monsoons. In general, the dry season runs from December to April, while the wet season is from May to November. The average annual temperature in the delta is close to 28°C. The mean monthly evaporation is around 150 millimeters. Monthly precipitation ranges from 0 millimeters in the dry season to around 250 millimeters in the wet season. There is a considerable spatial variation in annual rainfall across the delta. The average annual rainfall ranges from less than 1,500 millimeters in the central region and northwest to over 2,350 millimeters in the south.

Floods are a common feature in the delta, and something that local people have learned to cope with. Recently, the Government of Viet Nam adopted a "Living with Floods" Strategy for the Mekong Delta, recognizing the need to put more attention on flood protection and the conservation of natural systems and ecosystem services.

Climate Change Modeling and Emissions Scenarios

Greenhouse Gas Emissions Scenarios

In 2000, the Intergovernmental Panel on Climate Change (IPCC) published a series of projected greenhouse gas emissions scenarios that could be used to assess potential climate change impacts. The Special Report on Emissions Scenarios (SRES) grouped scenarios into four families of greenhouse gas emissions (A1, A2, B1, and B2) that explore alternative development pathways, covering a wide range of demographic, economic, and technological driving forces:

- A1 – the story line assumes a world of very rapid economic growth, a global population that peaks mid-century and the rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), nonfossil energy resources (A1T), and a balance across all sources (A1B).
- B1 – describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.
- B2 – describes a world with intermediate population and economic growth, emphasizing local solutions to economic, social, and environmental sustainability.
- A2 – describes a very heterogeneous world with high population growth, slow economic development, and slow technological change.

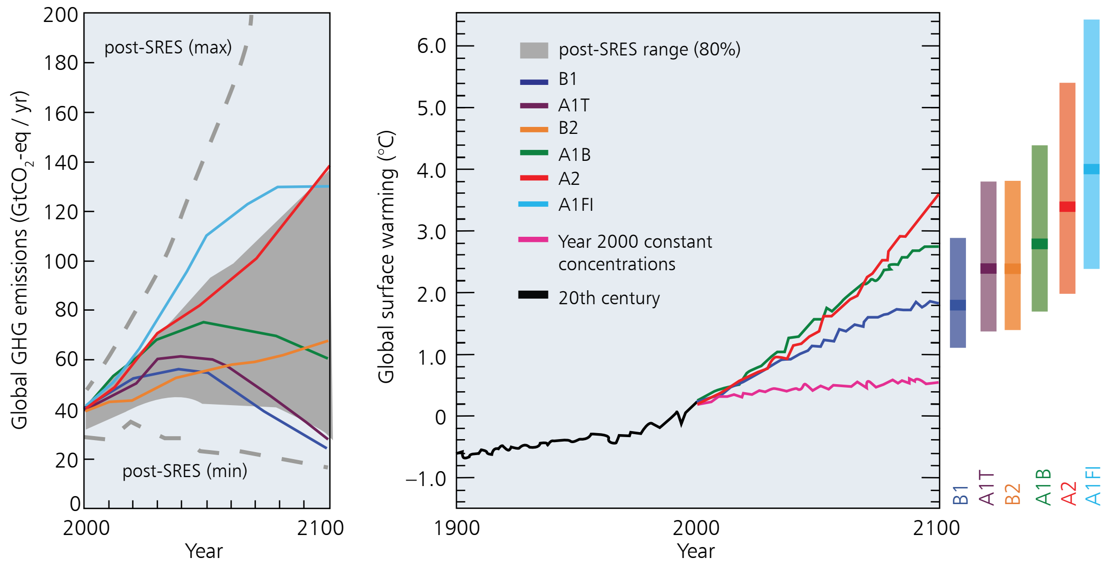
The emissions projections are widely used in the assessments of future climate change, and their underlying assumptions with respect to socioeconomic, demographic, and technological change serve as inputs to many climate change vulnerability and impact assessments. Greenhouse gas emissions trajectories under various scenarios are depicted in Figure 1.

Global emissions are currently tracking close to (or possibly higher than) the worst-case emissions scenario (i.e., the A1FI or A2), and it is unlikely that emissions will be contained to the low or medium emissions target by 2030.

The climate change and sea level rise scenarios developed and published for Viet Nam in 2009 were based on the low (B1), medium (B2), and high (A2, A1FI) scenarios. The average B2 scenario was recommended for all ministries, sectors, and localities to initially assess the impact of climate change and sea level rise and to build action plans to respond to climate change. Using results of previous studies as a basis, the 2011 updated climate change and sea level rise modeling selected the following greenhouse gas emissions scenarios: B1 (low scenario), B2, A1B (medium scenario), A2, and A1FI (high scenario).

For the purposes of this study, climate change modeling (including regional downscaling) has been completed by the Viet Nam National Institute of Meteorology, Hydrology and Environment (IMHEN) using the B2 and A2 scenarios, which have been used as inputs for the hydrological modeling. Coastal modeling has also been completed using the B2 scenario only. This is due to the very minor differences between the two scenarios up to 2050.

Figure 1 **Scenarios for Greenhouse Gas Emissions and Projected Change in Surface Temperature**



GHG = greenhouse gas, $GtCO_2$-eq/yr = gigaton of carbon dioxide equivalent per year, SRES = Special Report on Emissions Scenarios.
Source: IPCC (2007).

Previous Modeling

Based on the review of relevant literature relating to climate change impacts and adaptation and the preliminary analysis of secondary data for the Mekong Delta region undertaken by the project, it was evident that there are significant knowledge gaps and limitations surrounding the quantification of climate change impacts in Viet Nam and the Mekong Delta region. The main reason is that projecting the future impacts of climate change (for Viet Nam or anywhere else in the world) is an evolving science, and providing locally specific (i.e., less than the ca. 250 square kilometers general circulation model grid resolution) interpretations of those projections is even more complex. The official climate model prepared by the Government of Viet Nam uses MAGICC/SCENGEN 5.3[1] and identifies climate change and sea level scenarios for Viet Nam in the 21st century.

Climate Change Modeling (Regional Downscaling)

IMHEN recently completed statistical downscaling for the whole Mekong Delta for the primary climate variables, and we have utilized the statistically downscaled data for temperature and rainfall, together with the regionally downscaled scenarios for sea level rise (IMHEN 2010b) and the latest hydrological river flow scenarios developed for the Mekong mainstream above Kratie by the Mekong River Commission (MRC), in order to assess the impacts of climate change in the Mekong Delta and Ca Mau and Kien Giang provinces. The scenarios developed by the MRC were based on PRECIS[2] and have been used in a number of reports prepared by IMHEN relating

[1] MAGICC, developed by the US National Center for Atmospheric Research (NCAR), consists of a suite of coupled gas-cycle, climate, and ice-melt models integrated into a single software package. SCENGEN adds the climate change information from MAGICC to observed baseline climate data (1980–1999 means) to produce a range of geographically explicit climate change projections.

[2] PRECIS, developed at the UK Meteorological Office Hadley Centre, is a regional climate modeling system that uses dynamic downscaling driven by boundary conditions simulated by general circulation models (GCMs).

to climate change impacts in the Mekong River upstream of Viet Nam. The specific modeling applications that were selected for use in this study are outlined in Table 1. As of mid-March 2011, the official Digital Elevation Model for the Mekong Delta was released, and a copy was made available for use by the project.

Information for all downscaling except Japan's Meteorological Research Institute atmospheric general circulation model (MRI-AGCM) was produced for a baseline period (1980–1999, consistent with IPCC AR4) and future 20-year time slices centered on 2030, 2050, 2070, and 2090 (i.e., 2020– 2039, 2040–2059, 2060–2079, 2080–2099, respectively). For MRI-AGCM, the baseline (i.e., current) period is 1979–2003, and future scenarios are available for "near future" (2015–2039) and "distant future" (2075–2099). The spatial resolution of the climate change scenarios was to 20 kilometers (for outputs of MRI-AGCM), 25 kilometers (for outputs of PRECIS), and about 30–50 kilometers for outputs of statistical downscaling.

Table 1 **Regional Climate Modeling Method Used**

Variable	Modeling Method	Emissions Scenarios
Monthly, seasonal, annual average temperature and precipitation	Statistical downscaling using SimCLIM[a] which incorporates outputs from 21 GCMs used in IPCC AR4	A2, B2, B1
Annual average sea level rise	Dynamical downscaling using PRECIS	A1FI, B2, B1
Maximum and minimum monthly, seasonal, annual temperature	Dynamical downscaling using PRECIS	B2
Number of days >35°C	Output from Japan's MRI AGCM	A1B
Seasonal and annual average relative humidity and wind speed	Dynamical downscaling using PRECIS	B2

GCM = general circulation model, IPCC = Intergovernmental Panel on Climate Change, MRI AGCM = Meteorological Research Institute Atmospheric General Circulation Model.

[a] SimCLIM developed by CLIMsystems Hamilton, New Zealand, is a statistical downscaling modelling which incorporates outputs from 21 GCMs that are used in IPCC AR4.

Source: MONRE (2011).

Climate Change Variables

Temperature

The predicted increase in seasonal average temperature for both provinces for the two time periods 2030 and 2050 are presented in Table 2. As compared to the 1980–1999 baseline by 2050, under the medium B2 scenario, the average temperature is projected to increase by approximately 1.4°C in Ca Mau and 0.9°C in Kien Giang. Under the A2 scenario, the average temperature is projected to increase by 1.3°C in Ca Mau and 0.8°C in Kien Giang.

The expected average increase varies according to season with December to February temperatures showing the smallest increase and June to November showing the largest increase.

Table 2 **Average Temperature Increase from 2010 Baseline** (°C)

	Ca Mau				Kien Giang			
	B2 Scenario		A2 Scenario		B2 Scenario		A2 Scenario	
Season	2030	2050	2030	2050	2030	2050	2030	2050
Winter (Dec–Feb)	0.6	1.1	0.6	1.1	0.4	0.8	0.4	0.8
Spring (Mar–May)	0.7	1.2	0.7	1.1	0.4	0.7	0.4	0.7
Summer (Jun–Aug)	0.8	1.5	0.9	1.5	0.5	0.9	0.5	0.9
Autumn (Sep–Nov)	0.9	1.6	0.9	1.5	0.6	1	0.6	1
Average	0.7	1.4	0.8	1.3	0.5	0.9	0.5	0.8

Projected increases in seasonal average maximum and minimum temperatures for the two time periods of the study, 2030 and 2050, are shown in Table 3. The average maximum and minimum temperatures are modeled to increase by at least 0.8°C as compared to the baseline.

Table 3 **Average Maximum and Minimum Temperature Increase,** B2 Scenario

	Ca Mau				Kien Giang			
	Minimum		Maximum		Minimum		Maximum	
Scenario B2	2030	2050	2030	2050	2030	2050	2030	2050
Winter (Dec–Feb)	1.0	1.3	0.7	0.2	2.4	1.6	1.0	1.5
Spring (Mar–May)	0.9	1.7	0.2	0.8	–0.2	0.8	0.3	0.7
Summer (Jun–Aug)	1.4	2.0	0.8	1.7	2.2	3.0	0.6	1.5
Autumn (Sep–Nov)	1.5	1.7	1.5	1.4	1.3	0.9	1.4	2.1
Average	1.2	1.7	0.8	1.0	1.4	1.6	1.0	1.5

The following is a summary of the temperature data to the end of the century:

1. **According to the low emissions scenario (B1):** By 2100, the annual temperature is predicted to increase by about 1.5°C–2.0°C in Ca Mau and Kien Giang. The increase in Ca Mau is higher than in Kien Giang.

2. **In the medium emissions scenario (B2):** By 2100, the annual temperature is predicted to increase in both Ca Mau and Kien Giang by approximately 1.5°C–2.5°C relative to the baseline period. Again, the increase is greater for Ca Mau than for Kien Giang.

   The maximum temperature is predicted to increase by less than the minimum temperature. By 2100, the maximum temperature is projected to be higher than the current record by about 2°C–2.5°C compared with an increase of 3.5°C–4.0°C for the minimum temperature.

   By the end of the 21st century, the number of hot days (maximum temperature higher than 35°C) is predicted to increase by about 15–20 days relative to the baseline period in both Ca Mau and Kien Giang.

3. **For the high emissions scenario (A2):** By 2100, the increase is projected to be about 2.5°C–3.5°C in both Ca Mau and Kien Giang; however, it is higher in Ca Mau.

Rainfall

The projected changes in the monthly average rainfall and in seasonal average rainfall for the 2030 and 2050 decades for both Ca Mau and Kien Giang are presented in Table 4. As seen in the table, the biggest increase in rainfall is in the autumn months, while the biggest decrease is in the winter months, leading to a more marked change in the start of the dry season.

Table 4 **Change in Rainfall** (%)

	Ca Mau				Kien Giang			
	B2 Scenario		A2 Scenario		B2 Scenario		A2 Scenario	
Month	2030	2050	2030	2050	2030	2050	2030	2050
January	–3.7	–6.7	–3.7	–6.3	–5.8	–10.5	–5.9	–10.1
February	–2.2	–4.0	–2.3	–3.8	–2.1	–3.8	–2.1	–3.6
March	–4.1	–7.4	–4.1	–7.1	–10.8	–19.5	–10.9	–18.7
April	–2.6	–4.7	–2.6	–4.5	–4.0	–7.2	–4.0	–6.9
May	–0.2	–0.3	–0.1	–0.3	–0.3	–0.6	–0.4	–0.6
June	1.2	2.1	1.2	2.0	1.5	2.7	1.5	2.6
July	1.6	3.0	1.7	2.8	1.8	3.3	1.8	3.1
August	0.6	1.1	0.6	1.0	0.7	1.2	0.7	1.2
September	0.6	1.2	0.7	1.1	0.9	1.6	0.9	1.5
October	6.5	11.9	6.7	11.4	7.4	13.5	7.6	12.9
November	2.2	4.0	2.3	3.9	1.9	3.4	1.9	3.2
December	–5.1	–9.3	–5.2	–8.9	–3.6	–6.5	–3.6	–6.3
Winter (Dec–Feb)	–4.3	–7.8	–4.3	–7.4	–3.6	–6.6	–3.7	–6.3

continued on next page

Table 4 *continued*

Month	Ca Mau				Kien Giang			
	B2 Scenario		A2 Scenario		B2 Scenario		A2 Scenario	
	2030	2050	2030	2050	2030	2050	2030	2050
Spring (Mar–May)	–1.2	–2.3	–1.3	–2.2	–1.8	–3.2	–1.8	–3.1
Summer (Jun–Aug)	1.1	2.0	1.1	1.9	1.3	2.3	1.3	2.2
Autumn (Sep–Nov)	3.3	6.1	3.4	5.8	3.6	6.6	3.7	6.2
Average	1.3	2.4	1.3	2.3	1.5	2.8	1.5	2.6

The following is a summary of the rainfall data to the end of the century:

1. **According to the low emissions scenario (B1):** By 2100, rainfall is expected to increase by about 3%–4% in both Ca Mau and Kien Giang compared to the baseline.
2. **In the medium emissions scenario (B2):** Rainfall tends to increase in the rainy months (by up to 25% by 2100) and decrease in the dry months (from 30%–35%). By 2100, rainfall is projected to increase in both Ca Mau and Kien Giang with an increase of 5%–10% compared with the baseline period.

   By 2100, the heaviest daily rainfall decreases in both Ca Mau and Kien Giang at a rate of about 20%–30%. However, rainy days with rainfall anomalies of half or twice the current record will continue to exist.
3. **For the high emissions scenario (A2):** The annual rainfall would increase in the 21st century in both Ca Mau and Kien Giang; however, it is higher in Ca Mau.

Sea Level Rise

Table 5 shows the sea level rise (SLR) scenarios for the coast of Ca Mau to Kien Giang under the low, medium, and high scenarios:

Table 5 **Sea Level Rise** (m)

Emissions Scenario	Periods in the Future			
	2030	2050	2070	2090
Low (B1)	15	28	45	63
Medium (B2)	15	30	49	70
High (A1FI)	16	32	57	88

By the end of the 21st century, the sea level from Ca Mau to Kien Giang could rise up to 72 centimeters (low scenario), 82 centimeters (medium scenario), and 105 centimeters (high scenario) compared with 1980–1999.

For the purpose of this study, we are referencing the periods 2030 and 2050 under the high A2 scenario and the medium B2 scenario with corresponding sea level rise of 15 centimeters and 30 centimeters. Climate impact modeling and vulnerability and risk analysis are carried out for these two time periods and sea levels.

Wind Speed

The changes in seasonal mean wind speed for Ca Mau and Kien Giang for the B2 scenario are shown in Table 6. Average wind speed increases in the winter, spring, and autumn months but decreases in the summer months. Annual average wind speed increases in most areas of Ca Mau and does not have a clear trend in Kien Giang.

Table 6 **Change in Seasonal Mean Wind Speed (m/s), B2 Scenario**

	Ca Mau		Kien Giang	
	2030	2050	2030	2050
Winter (Dec–Feb)	0.6	0.6	0.3	0.2
Spring (Mar–May)	0.6	0.7	0.1	0.1
Summer (Jun–Aug)	–0.2	–0.2	–0.2	–0.2
Autumn (Sep–Nov)	0.2	0.1	0.2	0.2
Average	0.4	0.4	–0.1	–0.1

m/s = meter per second.

Known Issues with the Modeling Results

There are some aspects of climate change not covered by the modeling, and some of the results that have emerged from the downscaling are confusing and will require further detailed investigation to clarify:

- Impacts induced by climate change from other natural phenomena (e.g., El Niño/Southern Oscillation, etc.) are not assessed.
- The A2 temperature results are very close to the B2 results and in some cases not as warm, even up to 2050, which is contrary to IPCC (2007) projections.
- The change in temperature up to 2050 is sometimes not as large as the change up to 2030, which is inconsistent with the known physics of climate change.
- The projected rainfall change under A2 is sometimes less than the change under B2 (for both the seasonal and monthly projections).
- There is a lack of significant differences in wind speed between the 2030 and 2050 scenarios.
- The current hydro-meteorological observation network is insufficient and inadequately distributed across climate zones.

The discrepancies and highlighted issues reflect the nature of the modeling process that incorporated multiple downscaling methods.

Other Climatic Variables

- **Average surface air pressure** increases over the country.
- **Relative humidity** is projected to decrease in the dry months and increase in the rainy months. However, the annual relative humidity tends to decrease slightly over both provinces.

Impact Modeling

Two impact models have been used in this study:

1. The **IMHEN** hydrological model to simulate impacts associated with changes in hydrology, sea level rise, flooding and inundation, and saline intrusion. Under baseline (1980–1999 and for the 2000 flood event), 2030 (2020–2039) and 2050 (2040–2059) time horizons with flood inundation projections were produced for both the A2 and B2 emissions scenarios and salinity intrusion projections projected for the B2 scenario.

Hydrological modeling was performed using the Integrated Quality and Quantity Model (IQQM) to simulate the flow of water through the Mekong Delta river systems, making allowance for control structures such as dams and irrigation abstractions. Flow coming from the upper Mekong was obtained for Kratie from the MRC. Hydrodynamic modeling was also performed using the ISIS software, which enabled representation of the complex interactions caused by tidal influences, flow reversals between the wet and dry seasons, and overbank flow in the flood season. Salinity intrusion modeling was also performed using ISIS.

2. The **Institute of Coastal and Offshore Engineering** HydroGIS model to simulate coastal inundation associated with sea level rise and typhoons, storm surge simulation, and coastal erosion and sedimentation. A baseline scenario (2000–2009) was modeled, as was a future scenario for 2050 (2050–2059) for the B2 scenario.

This coastal modeling utilizes the MIKE 21/3 Coupled Model Flow Model to simulate the combined processes of hydrodynamics, wind induced waves, mud transport, sand transport, erosion/deposition, storm surges, and typhoons in the coastal zone near the shoreline of Kien Giang and western Ca Mau under current and projected future conditions.

Comparison of A2 and B2 Scenarios

The difference between predicted percentage changes for the two modeled scenarios A2 and B2 is shown in Table 7. There is little difference in the two scenarios for the 2030 period and only small differences for the 2050 period, except for the difference in sea level rise and inundation.

Table 7 **Difference between Predicted Percentage Change for A2 and B2 Scenarios** (%)

Variable	2030	2050
Sea Level Rise	1.0	14.0
Inundation Area	2.7	12.8
Annual Average Temperature	0.0	2.0
Average Maximum Temperature	0.0	1.5
Average Minimum Temperature	0.0	–3.2
Rainfall	0.0	0.0
Wind Speed	0.0	1.2

Climate Change Hazards

The climate change modeling indicates that there are a range of climate change–related hazards that may be relevant in the context of the Mekong Delta:

- Sea level rise (associated with gradual inundation and saline intrusion)
- Extreme weather events, such as typhoons, storm surges, storms, or floods (also associated with reduced salinity due to increased volume of freshwater)
- Increased average temperature, as well as increased temperature range (minimum and maximum)
- Reduced precipitation during the dry season and more marked transition between seasons
- Additional precipitation during the wet season (especially October)
- Changes in wind speed

The impacts of these hazards are outlined in Table 8 from a cross-sectoral perspective, which enables an analysis of the overall severity of the hazard for the target provinces. In reality, the most extreme hazards from climate change would be a combination of the events. For example, a sea level rise of 30 centimeters combined with a typhoon bringing additional rain and storm surges would have a total combined impact that would be greater than the individual events taken in isolation.

As the study focuses on the period to 2050, hazards such as increased temperature, changes to precipitation during the wet and dry seasons, or changes in wind speed are expected to be of relatively low impact during the study period, and therefore have not been included in the assessment of vulnerability for each province and district. These potential hazards would need to be considered for longer time frames.

Looking toward the end of the century, sea level rise and the changes in climate parameters are projected to be more extreme and a wider range of potential hazards would need to be considered. The report did not extensively cover ecological/natural resource impacts, and it is likely that the effects of climate change on natural systems will be significant in the longer time frame. This would include direct effects on natural systems and indirect effects on agricultural systems and the associated primary industries.

The following hazards are therefore used for vulnerability analysis:

- **Flooding and inundation** – includes sea level rise and increased rainfall or river flow.
- **Saline intrusion** – combines sea level rise with increased flow of water through river and canal system.
- **Storm surge** – combines overtopping of water due to a storm event with sea level rise and storm event or typhoon.

Typhoons are considered to have a very high potential impact; however, the ability to model typhoons at the moment is relatively poor, and, as such, whilst it is not possible to differentiate between districts or provinces with regard to their vulnerability to typhoons, it is recommended that further modeling of the potential changes to typhoon frequency, intensity, duration, and paths be conducted subsequent to this study so that the impact can be better understood to guide appropriate adaptation measures. Aside from storm surges, the effects of typhoons on land are therefore not included in the vulnerability analysis, but should be considered a hazard to the entire study area with potentially significant impacts.

M. Russell

Rural house in Chau Thanh inundated by wet season flooding that occurs over most of the delta.

Table 8 Cross-Sectoral Impacts of Hazards—Derived from Expert Opinion

Climate Change Hazard	Impact Severity	Energy and Industry	Urban Settlements and Transportation	Agriculture and Livelihoods	Socioeconomic Pattern
Sea Level Rise – 15 cm (inundation and salinity) *A2 2030 Predicted SLR*	Low	Power poles' lifetime is slightly reduced	Increased amount of short-term urban drainage issues at high tide/with heavy rain	Little impact	Some poor households may have trouble dealing with impacts
Sea Level Rise – 30 cm (inundation and salinity) *A2 2050 Predicted SLR*	Moderate	Some power system impacts, medium- and low-voltage system	Some low-lying roads might be affected Increased amount of short-term urban drainage issues at high tide/with heavy rain	Some rice paddies and shrimp ponds inundated Crops are damaged or yields reduced	Trend toward reducing agricultural activities and more services and industry
Sea Level Rise – 50 cm (inundation and salinity) *A2 2070 Predicted SLR*	High	Floor heights in factories need to be progressively raised, minor cost if piggybacked onto regular refurbishment cycles Some consolidation of factories to raised elevation sites and/or defendable industrial zones Some low-lying factories relocate to higher elevation/ more defendable sites at end of their economic lives	Low-lying urban areas flooded during high tides and heavy rainfall for short periods; will affect small but growing numbers of people Erosion of coasts protecting urban areas and roads; will increase in some areas (but may be accretion in other areas)	Need for higher and therefore less stable dikes for the three major livelihood systems Erosion of coasts reducing land that is available for shrimp farming Loss of mangroves reducing non-timber forest product availability	Significant relocation of all people and social and industrial fabric; 20% less agricultural gross domestic product and 10% reduction in services and industry

continued on next page

Table 8 *continued*

Climate Change Hazard	Impact Severity	Energy and Industry	Urban Settlements and Transportation	Agriculture and Livelihoods	Socioeconomic Pattern
Sea Level Rise – 50 cm (inundation and salinity) *A2 2070 Predicted SLR*		Slight decrease in life of power poles from increased inundation Low- and medium-voltage power distribution system to be adjusted as part of the normal replacement cycle to match new livelihoods and power load patterns Minor potential rust issue for older, less robust structures Salinity will limit extraction time from surface water sources (Kien Giang)	National/provincial roads under construction/ planned still function due to raised heights Newer bridges raised above SLR level Low lying modal interchanges (jetties, wharves) flooded; will affect users until rebuilt Erosion and overtopping of banks of rivers/ inland waterways; will mostly affect those living alongside Some water control devices become less efficient; may affect water transfer and water transport Salinity would increase corrosion of steel and concrete structures (e.g., power poles, transformers, wires, etc.)	Changes in ecology reducing harvest of shellfish and crabs (both juveniles for farming and mature) and native prawn resources Increase in salinity of groundwater leading to reduced crop yields and loss of fruit trees Salinity changes resulting in costs of change to new cropping systems Changes in canal salinity dynamics leading to changes in fish population dynamics (both freshwater and juvenile saltwater species) Reduction in yield of rice crops and possible dry season crop failure if salt intrusion lasts too long Increased costs in changing to new livelihood system, e.g. from rice to rice/ shrimp or from rice/ shrimp to intensive shrimp Increased variability at the salt/fresh interface increasing the risk of crop failure Failure of crop if increased saline intrusion stops irrigation	
Typhoon	Very high	Loss of power supply from wind damage	Damage to people and structures in urban areas from high winds and rain/ flooding	Reduction in yield/ loss of rice crop due to flooding Loss of shrimp crop in intensive system due to flooding or loss of power Damage to dikes in both rice and shrimp systems	Relocation of all people and social and industrial fabric; 40% reduction in agriculture and 30% reduction in services and industry

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Table 8 *continued*

Climate Change Hazard	Impact Severity	Energy and Industry	Urban Settlements and Transportation	Agriculture and Livelihoods	Socioeconomic Pattern
Typhoon		Slow restoration of rural power supply, especially if in the wet season; could be months until full power supply restoration in rural areas Economic impact of diesel standby generators needing to be used for shrimp and wet fish processing Increased price of ice from use of standby generators	Potential damage to flimsy/poorly designed structures such as typical bridges over canals and jetties; will disrupt travel in rural areas	Damage to fishing boats Loss of fishing time Possible changes to ocean habitat reducing fish catch Loss of non-timber forest products and other aquatic animals due to damage/flooding of forests and wetlands Loss of sandbanks for shellfish spawn capture Loss of offshore crab infrastructure and crop	
Flood	High	Potential loss of power to flooded areas from flooding of some 110/22-kilovolt substations if flood well above normal wet season levels. Limited long-term damage Temporary loss of industrial production from flooded factory sites Minimal impact as power system already built for seasonal flooding	Low-lying urban areas flooded during high tides and heavy rainfall for long periods (especially in Kien Giang from Mekong flows); may affect large and growing numbers of people National/provincial roads under construction/planned still function due to raised heights and may actually act as a barrier to water dispersal	Damage to dike structures Reduction in yield due to early/late rice harvest in some areas Complete loss of rice crop due to extended flooding period or flood damage Loss of shrimp crop due to fresh water intrusion Damage to fruit trees Loss of non rice crops	Significant relocation of all people and social and industrial fabric; 20% less agricultural gross domestic product and 10% reduction in services and industry
Heat Wave	Low	Increase in loads for ice making and air conditioning, but overall impact low compared to industrial power demands; any increase will be more regional leading to greater power cuts if heat wave comes during the dry season when Viet Nam's hydro capacity is reduced Reduced power system capacity	Heat sink effect in urban areas; can impact vulnerable persons during heat waves	Loss of shrimp crop due to increased disease risk Reduction in yield of rice crop Increased risk of fire in natural and planted forests	

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Table 8 *continued*

Climate Change Hazard	Impact Severity	Energy and Industry	Urban Settlements and Transportation	Agriculture and Livelihoods	Socioeconomic Pattern
Heat Wave		Increased frequency/duration of power cuts (regional not provincial or district issue)			
Storm Surge	High	As for flooding, some impact on energy and industry assets' corrosion as saltwater inundation rather than fresh water inundation in flood; coastal 110/22-kilovolt substations may have to come off-line; some longer-term impact from saltwater inundation	Low-lying coastal urban areas, notably centers such as Ha Tien, Rach Gia, Song Doc, and Nam Can; may affect large and growing numbers of people	Damage to dikes and pond infrastructure complete Loss of shrimp crop due to aerators failing if power fails Loss of other perennial crops Complete loss of established orchards Damage to fishing boats Loss of fishing time	Relocation of all people and social and industrial fabric; 40% reduction in agriculture and 30% reduction in services and industry

SLR = sea level rise.

Flooding and Inundation (from the IMHEN hydrological model)

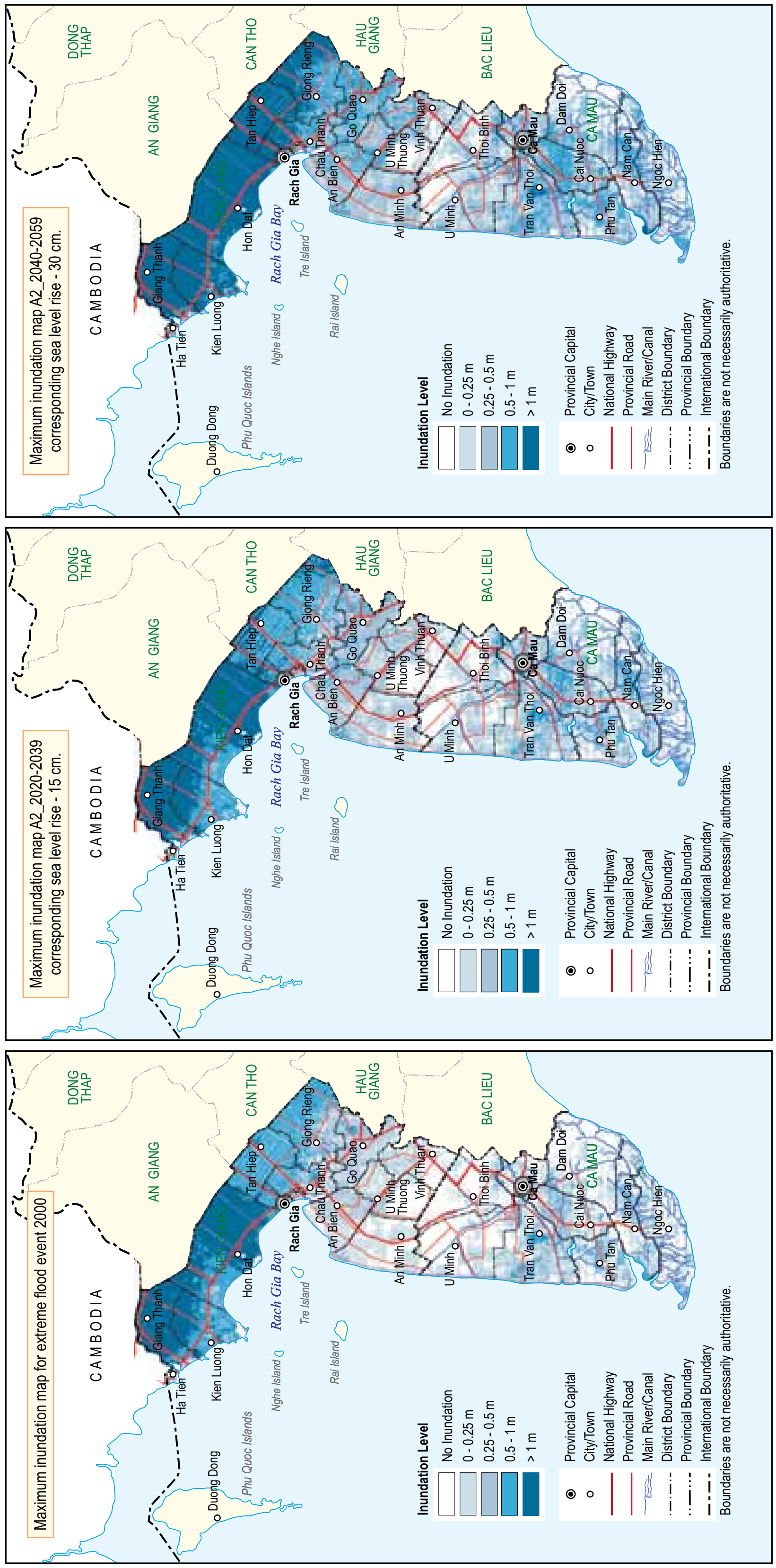
Flooding is already a regular seasonal feature of the Mekong Delta and people are accustomed to dealing with it on an annual basis.

The baseline map below shows the extent of the 2000 flood, which was an extreme event (considered to be a one in 100-year flood). This flood event has been combined with the projected sea level rise, and Mekong Basin rainfall and river flows from two climate scenarios (B2 and A2) to produce the flood maps for 2030 and 2050. The flood maps shown are for the A2 scenario. As these are based on an extreme flood event, the inundation depicted does not represent permanent inundation but shows expected inundation during periods of extreme flood. The frequency of the "one in 100-year flood" may or may not vary and would be dependent on rainfall across the whole Mekong basin, covering several countries (beyond the area of the study).

Modeling shows that significant increased inundation is projected to occur in the central delta and subsequently spread outward toward the coast. By 2050, flood events are projected to cover much of northern and western Kien Giang with depths over 1 meter in many areas. The southern districts of Kien Giang and much of Ca Mau experience less severe flooding of depths of less than 1 meter. Modeling indicates that a more extensive part of this area will experience inundation and to a greater depth.

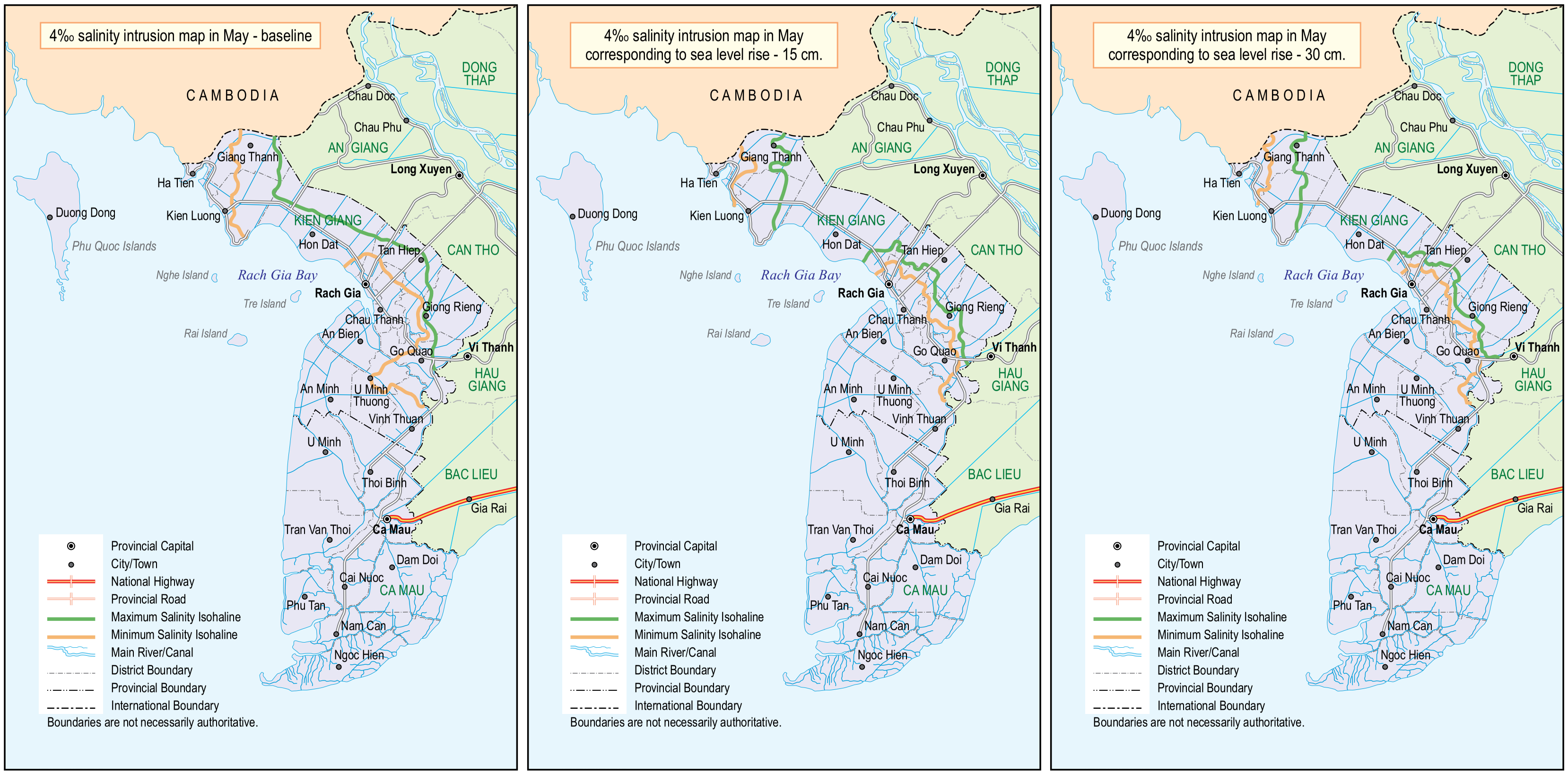
If inundation levels are deep, dikes along canals and around paddy fields can be overtopped leading to flooding of houses and crops. Floodwaters can damage dikes and other farm infrastructure.

Maps of Projected Flooding and Inundation for an Extreme Event in 2000, 2030, and 2050 (from the IMHEN hydrological model)



Maps of Projected Maximum Saline Intrusion in 2000, 2030, and 2050 (from the IMHEN hydrological model)

Projected 4 ppt Salinity Range in May (1980 - 1999) | Projected 4 ppt Salinity Range in May (2020 - 2039) | Projected 4 ppt Salinity Range in May (2040 - 2059)



Isohalines are lines of equal salinity concentration. In the maps, the 4 parts per thousand (ppt) isohaline is used. The maps show the projected variability of salinity for three 20-year periods. In some years, lower amounts of water flow and rainfall will result in saline water extending further inland than normal. The projected extent of this intrusion is shown by the maximum isohaline. In other years, higher-than-average river flows and rainfall will result in less saline intrusion. The projected extent of intrusion in these years is shown by the minimum isohaline.

Saline Intrusion (from the IMHEN hydrological model)

The maximum extent of saline intrusion occurs in the dry season when there is reduced flow of freshwater in canals and rivers from rainfall and the Mekong River. At the height of the dry season, the month of May, saline intrusion will vary depending on the rainfall of that season. The major ramification of salinity in Ca Mau and Kien Giang is related to agricultural production.

In Ca Mau and Kien Giang, there is already a large area that is affected annually by saline intrusion in the dry season. In parts of Ca Mau, farmers adjust to changes in salinity by shifting crops seasonally from shrimp production (from during the dry season to rice production for the wet season). The impact of this is that they are unable to produce a second rice crop in the dry season as farmers are able to elsewhere.

The level of salinity that affects agricultural production of crops such as rice is 4 parts per thousand (ppt).

The map "Salinity Range in May (2000–2010)" shows the range of 4 ppt saline intrusion over a 10-year period during the month of May each year.

The hydrological modeling indicates that in 2030 and 2050, coastal areas of Hon Dat in Kien Giang that are currently affected by saline intrusion will have a reduction of salinity during the dry season. During the wet season, the canals through Ca Mau and Kien Giang are full of freshwater help to drain rainwater away. They are full of either local rainfall or flow through the Mekong and major canal systems. The anticipated reduction of salinity in the Hon Dat district of Kien Giang is largely due to anticipated increased water flow through the river and canal system.

Storm Surge (from the Institute of Coastal and Offshore Engineering HydroGIS model)

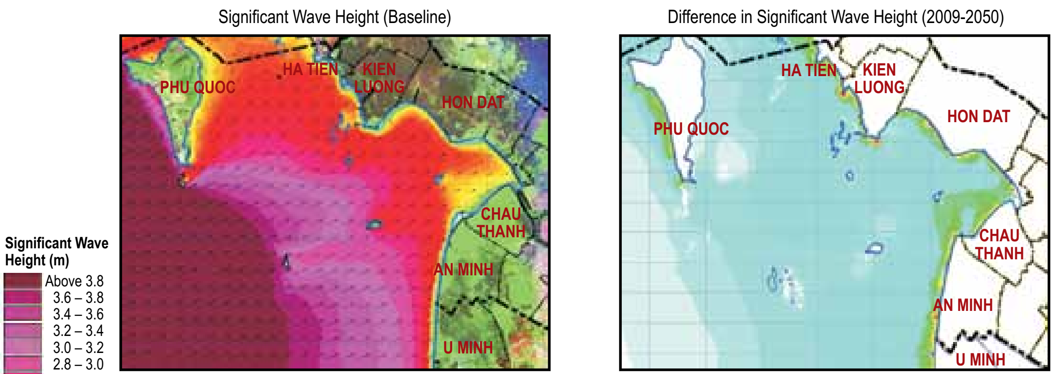
The delta experiences two different monsoons, the South West (SW) Monsoon (in the wet season) that blows onshore along the west coast of both provinces and the North East (NE) Monsoon (in the dry season) that blows onshore on the east coast of Ca Mau. Strong monsoon winds can lead to higher water elevations downwind. This produces a storm surge, which when combined with a high tide produces water levels that are elevated by up to 0.8–0.9 meters. Strong SW monsoons also create waves of over 3 meters offshore that impact on the west coast of both provinces as waves of around 1 meter. Strong northeast to east monsoons in the dry season bring large waves over 3 meters offshore and 2 meters at the shore to the east coast of Ca Mau.

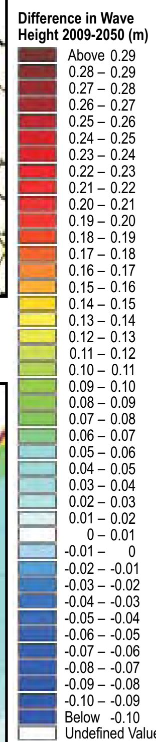
Large waves during a storm surge can cause destruction of exposed infrastructure along the coast. These waves will undermine mangroves and erode exposed earth banks. Waves will penetrate through a thin line of mangroves and erode earth dikes. Earth dikes that have been exposed by mangrove removal or erosion will be breached within a single wet season resulting in inundation of the production land behind the dike. The conversion of mangroves into aquaculture ponds has made considerably more infrastructure potentially exposed to storm surges.

Analysis of the projected changes to the key input variables to coastal modeling revealed minimal differences between 2030 and 2050 or between A2 and B2, so only 2050 and only the B2 scenario were modeled in detail. Rather than the standard baseline of 1980–1999, this modeling used 2000–2009 as a baseline.

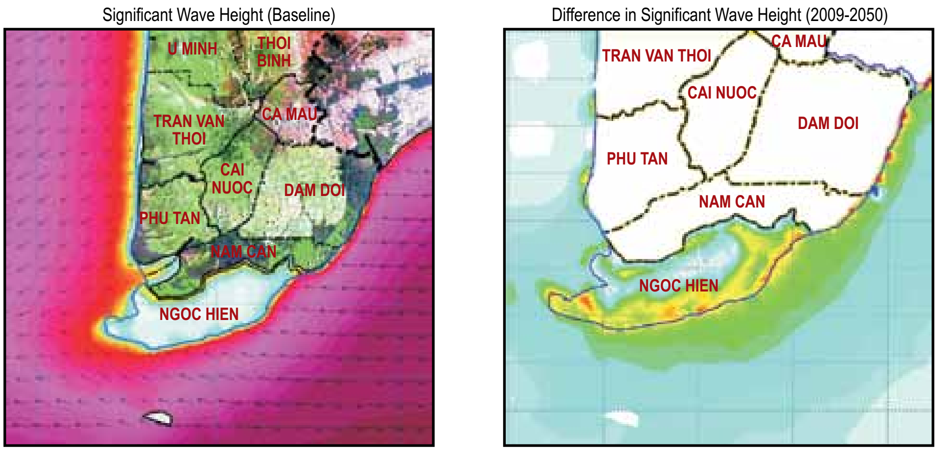
Modeling indicates that during strong SW monsoons conditions, waves 10–20 centimeters larger are projected to impact the coast in 2050. During strong NE monsoons conditions, waves 12–25 centimeters larger are projected to impact the eastern shoreline of Ca Mau in 2050.

South West Monsoon Conditions – Kien Giang

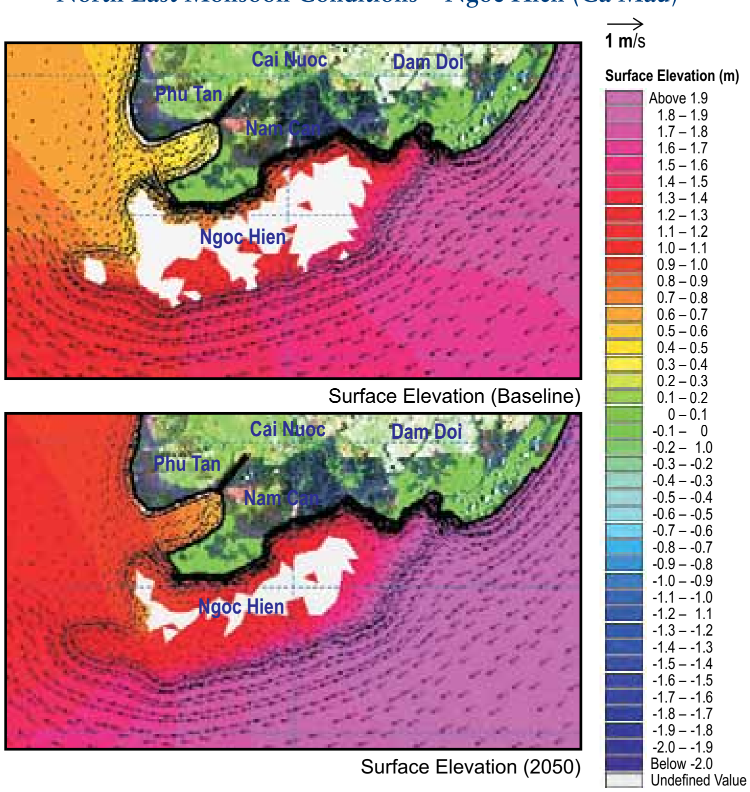




North East Monsoon Conditions – Ca Mau



North East Monsoon Conditions – Ngoc Hien (Ca Mau)



The sea level rise projected by climate models will increase the height of water levels during storm surges to over 1 meter. Water levels of this height combined with waves of 1–2 meters will lead to overtopping of dikes that are built to the current recommended dike standards. Waves will also be able to penetrate further into mangrove forests and a thin band a mangroves of 20–30 meters will not offer sufficient protection for dikes or pond bunds.

When winds are from the northwest, Ngoc Hien district (the island at the tip of Ca Mau province) is downwind of a considerable fetch and is subject to higher water elevation in strong northeast winds. Ngoc Hien is thus exposed to storm surges from strong monsoon winds from both SW and NW winds and is extremely vulnerable to the increased storm surges that will occur under the projected climate conditions of 2050 and beyond.

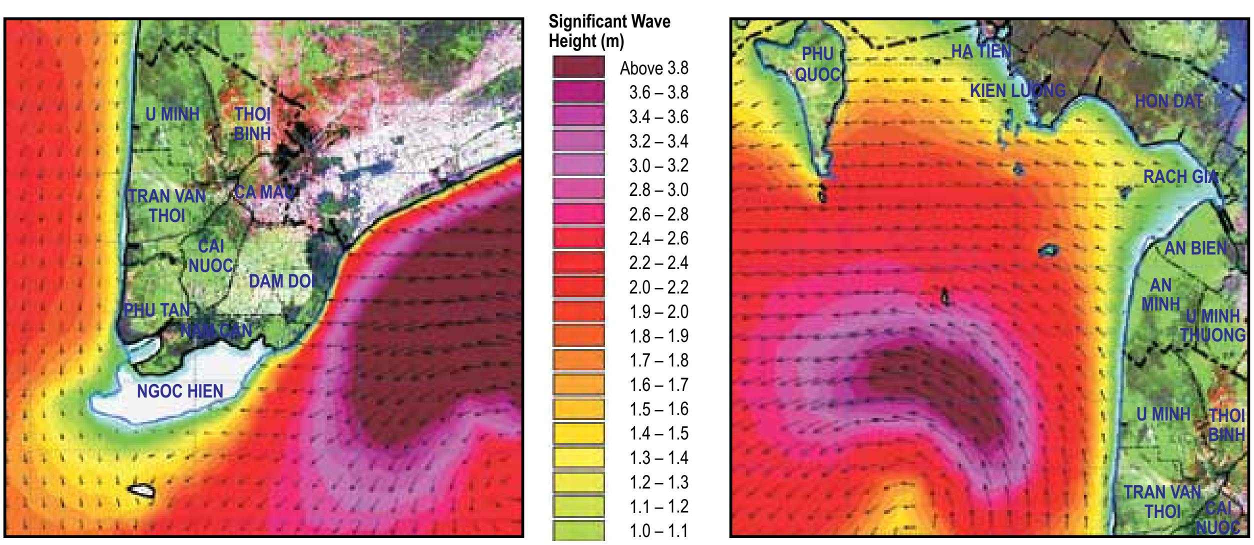
Typhoons
(from the Institute of Coastal and Offshore Engineering HydroGIS model)

In 1997, Typhoon Linda moved across the southern tip of the Ca Mau peninsula and caused widespread damage across the two provinces. It resulted in flooding, damage to mangrove and plantation forests, damage to housing and power infrastructure, and inundation and associated damage to agricultural production. It was reported that Typhoon Linda had a purely financial cost of some $593 million, mostly from destroyed/damaged housing.

Fishing villages along the coast on the mainland and particularly on the islands experienced widespread destruction with loss of housing and boats. This destruction would also have been accompanied by widespread coastal erosion and damage due to strong winds and inland flooding.

The greatest physical effects of Typhoon Linda on the mainland would have been felt on the lightly populated east coast of Ca Mau when the typhoon approached and crossed the coast. This occurred at high tide, and the strong onshore winds and associated low atmospheric pressure would have led to severe storm surge conditions. The accompanying wave field had a long fetch, which meant that waves of over 3 meters were directed onto the shore.

Significant Wave Heights during Typhoon Linda (1997)

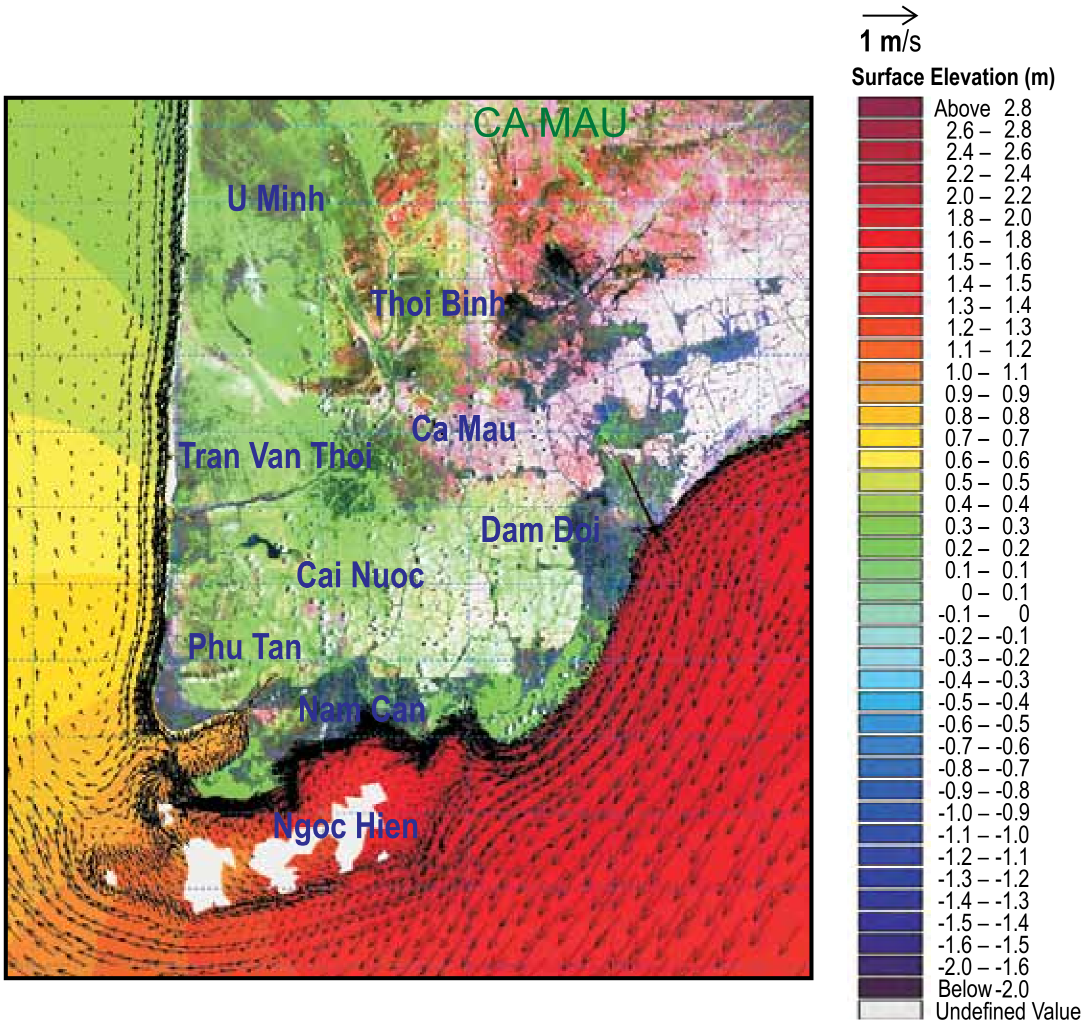


Ca Mau **Kien Giang**

The sea level rise projected by climate models means that storm surges during a typhoon will be enhanced. As shown in the figures for Ca Mau and Kien Giang, water surface elevation can be up to 2 meters high and combined with 4–5-meter waves will result in severe damage to coastal protection dikes, and fishing villages in estuaries and canal mouths along the entire coast. Ngoc Hien district (the island at the tip of Ca Mau province) will be almost completely inundated, and extremely strong currents are predicted to flow through the Grand River resulting in erosion along the southern border of Nam Can district.

If a typhoon with the same characteristics as Typhoon Linda were to cross the Ca Mau peninsular at high tide, the projected water surface elevation and currents in 2050 under a B2 scenario are modeled as shown.

Project Water Surface Elevation and Current for Typhoons—B2 Scenario, 2050

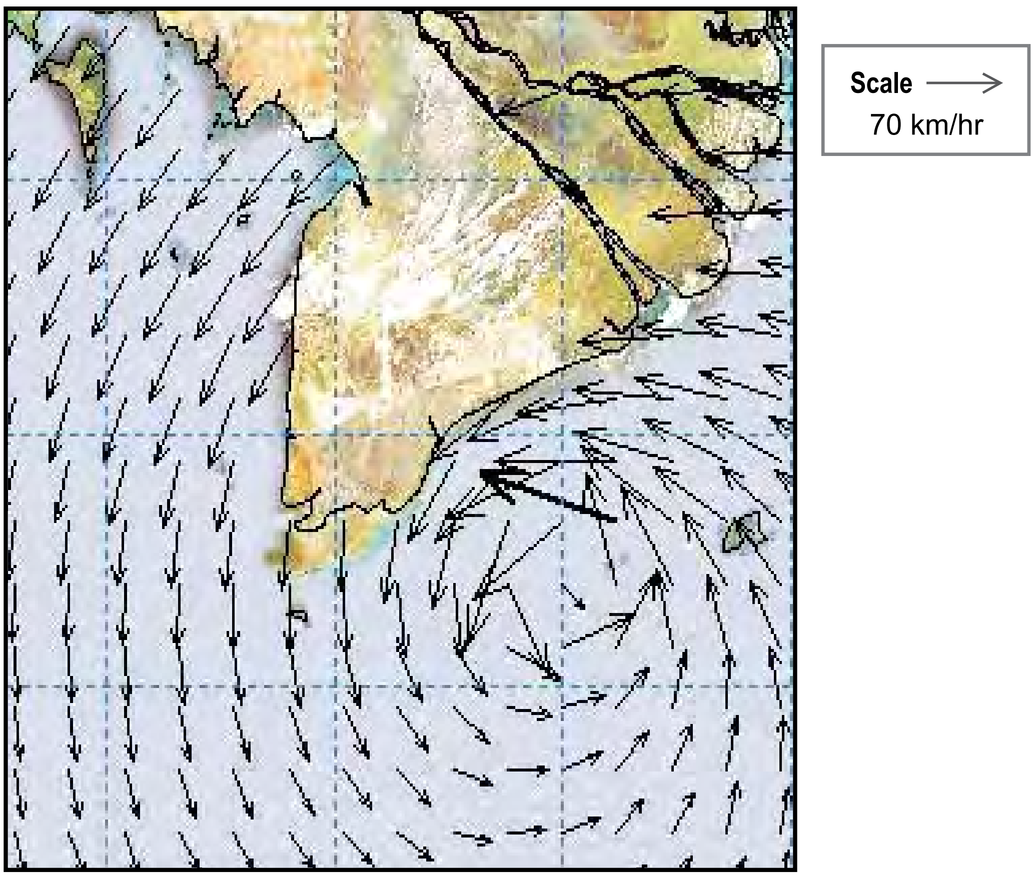


During Typhoon Linda, very strong onshore winds of over 140 kilometers per hour (km/h) battered the east coast of Ca Mau. Inland Ca Mau and southern Kien Giang experienced very strong winds and wind speeds over the rest of Kien Giang were over 70 km/hr.

The direction of winds around the cyclone meant that winds were offshore on the west coast, which limited the formation of storm surges and meant that large waves did not strike the shore.

Phu Quoc and the islands off Kien Giang would have experienced very strong winds.

Wind Fields during Typhoon Linda (1997)



Vulnerability Assessment

The primary purpose of the vulnerability assessment study is to identify and evaluate the net biophysical and social vulnerability of Ca Mau and Kien Giang provinces. In this context and for the purposes of this report, vulnerability is considered to be a function of:

- **exposure** to climatic hazards;
- **sensitivity** to the impacts of climate change hazards;
- the ability or **adaptive capacity** to respond to climate-related risks (including adaptive measures, coping strategies, or actions taken in reaction to the impacts or to mitigate the risks); and
- the frequency, magnitude, and extent of climate-related **risks** to the community, assessed in terms of the probability of occurrence (likelihood) and magnitude of hazards (consequence).

The vulnerability assessment process started with team meetings designed to develop questionnaires that were used to survey officials in the two provinces. The questionnaire was designed to ensure that the information required to provide data for measures and indices considered to be useful by the experts in each sector was included. The field district survey was executed in March and April 2011.

Statistical development indicators were used which included measures of human resources capacity (i.e., literacy rates, health statistics, etc.), economic capacity (i.e., per capita gross domestic product [GDP] and measures of income inequality), livelihood measures (diversity of occupations, income streams, number of adults in employment, etc.), and social capacity (population density, percentage of productive land), together with governance and institutional measures.

Analyzing Adaptive Capacity

A complete assessment of vulnerability must incorporate a measure of the capacity of human systems to respond to changes in the natural environment. Adaptive capacity can be defined as "the ability or capacity of a community to modify or change its behavior so as to cope with existing or anticipated external stresses." In the context of this study, adaptive capacity can be characterized as the ability of a community to undertake a set of potential actions that will reduce their exposure or sensitivity to climate change. In this light, it is imperative to outline the existing adaptation capacity within a community as part of the evaluation of vulnerability required by our comparative vulnerability risk assessment (CVRA) framework.

The CVRA method measures community adaptive capacity in the same manner as exposure and sensitivity. The approach incorporates a number of indicators that measure the capacity of a community to build resilience (such as income levels, number of income streams, and percentage of people in full employment). These measures are then incorporated into the district profiles.

Adaptive capacity can also reflect the abilities of provincial and district agencies or organizations responsible for managing natural and human systems. Their ability to adapt is determined by a range of issues, including their ability to collect and analyze information, communicate, plan, and implement adaptation strategies that ultimately reduce vulnerability to climate change impacts. As such, institutional capacity was not incorporated into the CVRA process.

The Vulnerability Ranking Process

The first phase of the vulnerability assessment is an evaluation of how specific systems, both natural and human (such as roadways, water resources, and industrial areas) were "exposed" to climate hazards and impacts.

Baseline vulnerability indicators describe the current situation and represent a measure of the current sensitivity and adaptive capacity. Maps of the current geographic extent of the exposure to the three climate change conditions provide hazard indicators. The baseline indicators used are as outlined in Table 9. For each of the five dimensions and sectors, the districts were evaluated as a function of their comparative vulnerability across the key indices. To do this, each district was first ranked by indicator, then an average comparative baseline exposure was calculated for each district.

In the second phase of the assessment, districts were rated according to their respective sensitivity (low to very high) to future hazard projections generated from the hydrological modeling and coastal modeling work.

Future projection indicators describe things that we can project forward. Population growth can be used to project changes in sensitivity indicators, and the output of the climate models showing future exposure to climate change impacts can be used to project changes in hazard indicators. The future projection indicators used are as outlined in Table 9. The area affected by each hazard can be used to estimate the number of potentially affected people. Hazard maps for flooding, inundation, saline intrusion, and storm surges for 2030 and 2050 were used to forecast vulnerability under future conditions.

These indicators were used to establish specific sectoral baseline characteristics for population, poverty, agriculture and livelihoods, energy and industry, and urban settlements and transportation. Future projection indicators were used to develop future vulnerability profiles, assess the future impacts, and measure risks associated with our different climate change scenarios for 2030 and 2050.

Assessment of Existing Control Measures

Vulnerability to a hazard will also depend on the extent to which populations and systems are exposed to the direct physical impacts of that hazard. Exposure will depend on a number of factors such as where populations live and how they protect their communities and livelihoods. Furthermore, the resilience of agricultural systems is determined by the extent to which existing coping measures, such as dikes and irrigation structures, are in place. The resilience of settlements and industry will depend on their location and the existence and status of dikes and other protection measures, while that of transport and energy infrastructure will depend on their location and building standards. These factors are specific to particular hazards and are not explicitly incorporated into the indices described.

Incorporating Control Measures in the Vulnerability Assessment

In order to incorporate measures of specific control factors in the vulnerability assessment, an appraisal of the existence and quality of hard measures to control the impacts of specific hazards was developed. Expert opinion was used to evaluate the adequacy of the control measures for each of the five sectors as outlined in Table 10. Information on control measures was obtained through discussions and interviews with authorities at provincial and district levels, as well as from literature reviews for each sector. The assessments assumed that no further adaptation response occurs to mitigate climate change impacts.

The expert opinion of the existence and quality of control measures in each time period was incorporated into the vulnerability assessment as a weighting factor in the vulnerability ranking.

Table 9 **Vulnerability Indicators**

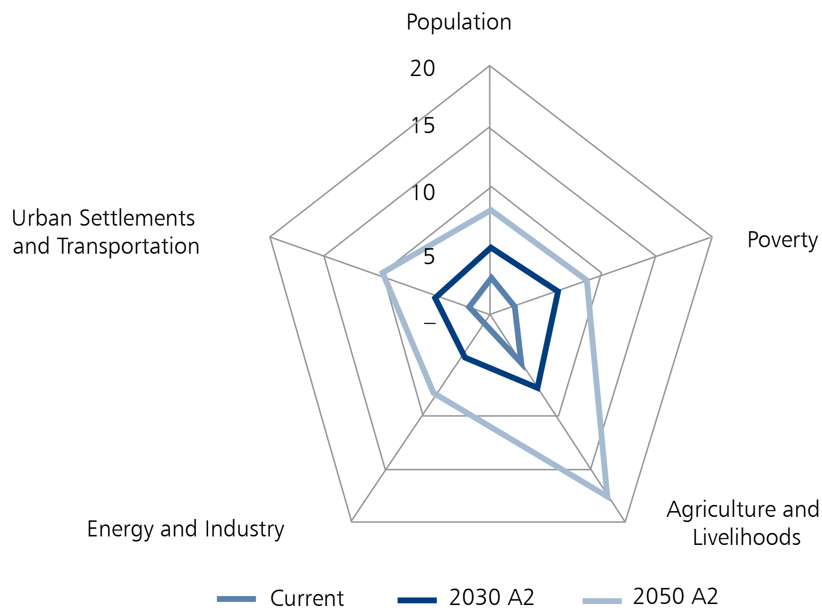
	Baseline Vulnerability Indicators	Future Projection Indicators
Population	Total population Population density Average family size Number of households Population at working age Average natural population growth rate	Total population Population density Number of people affected by each hazard Number of households affected by each hazard
Poverty	Annual average income per capita Number of poor households Percentage of poor households Number of teachers Number of doctors Agricultural land per person Percentage of ethnic households	Total number of poor households Density of poor households Number of poor households affected by each hazard Percentage of poor households affected by each hazard
Agriculture and Livelihoods	Number of rural households Number of livelihood streams Streams employing > 10,000 or producing >D250 billion Average annual gross domestic product per household Rice crop land per person Aquaculture land per person	Total population Agriculture land per person Number of rural people affected by each hazard Number of rural households affected by each hazard
Energy and Industry	Households reliant on industry Average annual gross domestic product per household contributed by industry Households connected to national grid Length of high/medium-voltage power lines Number of power plants/high-voltage substations Percentage of off-farm income Number of factories Number of different industries	Number of households reliant on industry Number of households connected to the national grid Number of industrial households Affected by each hazard Households connected to the national grid affected by each hazard Number of kilometers of high-voltage power lines affected by each hazard
Urban Settlements and Transportation	Urban population Urban households Urban area Percentage of urban area/population Sewer/septic tank Water supply Major waterways Major roads District roads Transport hubs	Urban population Urban area per person (hectare) Urban households affected by each hazard Population of settlements affected by each hazard Number of kilometers of road affected by each hazard

Table 10 **Components of Hard Control Measures Assessed by Expert Opinion**

Component	All Hazards	Inundation	Salinity	Storm Surge
Agriculture and Livelihoods	Crop handling and processing Rice varieties Cultivation methods	Dike system Warning system	Sluice gates	Coastal dike, Thick mangrove belt Warning system
Urban Settlements, Population, and Poverty	Suitable elevation of infrastructure	Urban drainage Adherence to suitable building codes	Water and sanitation infrastructure	Coastal protection infrastructure Warning system
Transportation, Energy, and Infrastructure	Suitable elevation of infrastructure Dikes	Adherence to suitable building codes	Suitable building materials	Coastal dike and protection systems

Figure 2 illustrates how the vulnerability assessment was used to develop vulnerability profiles for each district. Conceptualizing the dimensions of vulnerability using the radial graphs allowed for the examination and description of how the different aspects of vulnerability are related to each other, and the combination of findings from district and sectoral surveys with the outputs from the hydrological and coastal impact models. The shape and area of the vulnerability profile expressed in this form is proportional to sensitivity and exposure less the adaptive capacity. This approach links environmental and socioeconomic dimensions with the capacity for local communities and institutions to adapt to climate change.

Figure 2 Hypothetical District Vulnerability Profile



While the specific functional form of vulnerability will vary by context and location, the general relationship between the sectoral dimensions and indicators allows us to characterize the vulnerability profile for each district. The goal is not to simply define quantifiable measures, but rather to represent inter-relationships between natural and human systems in a standard form that can be used as a tool to compare and contrast vulnerability in both a temporal and geospatial context. The profile can be used to predict the changes in scale and extent of sectoral vulnerabilities over time and provide an insight into which sectors and locations to intervene to build climate change resilience.

For each province, the calculated vulnerability profiles were then mapped to show the spatial distribution of vulnerability.

Interpreting Vulnerability Profiles

The vulnerability profile illustrates the change in the vulnerability of a district over time in each of the five sectors. The shape of the profile for each time period can be interpreted on a sector-by-sector basis. Equal vulnerability for each sector will produce a balanced star shape, and deviations from the star indicate sectors that are more or less vulnerable. The following is the interpretation of the hypothetical example as illustrated:

Current situation: While the control measures currently in place keep the vulnerability of the district low across all sectors, the vulnerability of the agriculture and livelihoods sector is higher, and the vulnerability of the energy and industry sector is lower. An analysis of the values of the various indicators that make up each sector will reveal the factors that contribute to the different vulnerabilities. Low energy and industry vulnerability would likely reflect a low level of development in the province. Likewise, high vulnerability to agriculture could be due to a high reliance on rice-based systems that are exposed to inundation or salinity.

As the population grows and the exposure to hazards intensifies, districts become increasingly vulnerable and the ability of the existing control measures to cope with the projected impacts is reduced expanding the star in size.

2030: The district becomes increasingly vulnerable. While the profile maintains a similar shape, the vulnerability to poverty increases more than for the other sectors. This may be due to a high initial proportion of poor households that is projected to increase and become exposed to climate change hazards.

2050: Population growth, lack of adequate control measures, and increased exposure combine to raise vulnerability in all sectors. Agriculture and livelihoods show a more pronounced increase in vulnerability. The particular causes can be determined by an analysis of the indicators. One cause may be that vulnerability due to a large rural population and limited alternative income sources is exacerbated by a dwindling amount of available rural land per head of population.

M. Russell

Flood waters overtopping a canal bank, inundating housing and rice fields in Hon Dat.

Identifying and Analyzing Future Risk

Various risk assessment methods and tools have been developed around the world, encompassing a broad range of applications from crosscutting methods to specific sectoral methods from a local to global scale. Most methodologies are designed to evaluate risk according to morphological or economic terms, whereas social and ecological assessments have focused on vulnerability and sensitivity.

People are considered at *risk* when they are unable to cope with a hazard. A disaster occurs when a significant number of vulnerable people experience a hazard and suffer from severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external assistance.

Risk is defined in terms of the probability of a particular climatic outcome multiplied by the consequences of that outcome. For the purposes of this study, we focused on four main considerations for assessing risks relating to sea level rise, flooding, inundation, salinity, and the consequences of storm surges:

(i) the negative impacts on the sustainability of the local economy, and especially to household livelihoods;

(ii) the social vulnerability, e.g., the incidence of extreme events with respect to mortality or social disruption;

(iii) the negative impacts to human-made physical infrastructure and the intended service it provides to the community, industry, government, and the natural environment (including buildings, roads, ports, water and electricity infrastructure, etc.); and

(iv) the biophysical vulnerability that may be related to the disturbance of coastal and riverine environments and systems.

This study used the results from the exposure modeling together with the key observations and findings from the sectoral consultations and surveys to determine the relative levels of risk for a particular threat source—expressed as a function of "likelihood" and "consequence" to highlight the major risks at the district and provincial levels.

The risk assessment process involved rating the future risk, using the qualitative measures of "likelihood" and "consequence" (descriptors in Tables 11 and 12) of potential climate change impacts on each of the target sectors as highlighted in Table 13.

Table 11 Qualitative Measures of Likelihood

Level	Descriptor	Recurrent Risks	Single Events
5	Almost Certain	Could occur several times per year	More likely than not – probability greater than 50%
4	Likely	May arise about once a year	As likely as not – 50/50 chance
3	Possible	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
2	Unlikely	May arise once in 10–25 years	Unlikely but not negligible – probability low but noticeably greater than 0
1	Rare	Unlikely during the next 25 years	Negligible – probability very small, close to 0

Table 12 Quantitative Measures of Consequence

Level	Infrastructure Services	Community	Local Economy	Natural Environment
1 Insignificant	No infrastructure damage.	No adverse human health effects or complaints.	Minor negative impacts on key economic elements (i.e., rice production, aquaculture, tourism, fisheries).	No environmental damage.
2 Minor	Localized infrastructure service disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 5%–10%.	Short-term disruption to employees, customers, and entire community. Slight adverse human health effects or general amenity issues. Isolated but noticeable examples of decline in social cohesion.	Temporary disruption to one key economic element (i.e., agricultural production, tourism, fisheries).	Minor instances of environmental damage that could be reversed, i.e., negative impact on a specific species.
3 Moderate	Widespread infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Partial loss of local infrastructure. Early renewal of infrastructure by 10%–20%.	Frequent disruptions to employees, customers, or neighbors. General appreciable decline in social cohesion.	Temporary disruption to one or more key economic elements (i.e., agricultural production, tourism, fisheries).	Isolated but significant instances of environmental damage that might be reversed with intense efforts, i.e., reduced fish stock.
4 Major	Extensive infrastructure damage requiring extensive repair. Permanent loss of regional infrastructure services, e.g., a bridge washed away by a flood event. Early renewal of infrastructure by 20%–50%. Retreat of usable land, i.e., agricultural and residential land.	Permanent physical injuries and fatalities may occur from an individual event. Negative reports in national media. Severe and widespread decline in services and quality of life within the community.	A key element of the economy is disrupted for an extended period of time (i.e., phosphate mines, tourism, or fisheries).	Severe loss of environmental services and a danger of continuing environmental damage.
5 Catastrophic	Permanent damage and/or loss of infrastructure service across state. Retreat of infrastructure support and translocation of residential and commercial development.	Severe adverse human health effects, leading to multiple events of total disability or fatalities. Emergency response. Region would be seen as unable to support its community.	More than one key element of the economy is disrupted for an extended period of time (i.e., phosphate mines, tourism, fisheries).	Major widespread loss of environmental services and progressive irrecoverable environmental damage, i.e., death of coral reefs.

Table 13 **Risk Rating Matrix**

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Almost Certain (5)	M (5)	M (10)	H (15)	E (20)	E (25)
Likely (4)	L (4)	M (8)	H (12)	H (16)	E (20)
Possible (3)	L (3)	M (6)	M (9)	H (12)	H (15)
Rare (2)	L (2)	L (4)	M (6)	M (8)	M (10)
Unlikely (1)	L (1)	L (2)	L (3)	L (4)	M (5)

E: >20 Extreme risks; require urgent attention to implement adaptation options immediately.
H: 12–20 High risks; require attention to develop adaptation options in the near term.
M: 5–12 Medium risks; it is expected that existing controls will be sufficient in the short term but will require attention in the medium term and should be maintained under review.
L: <5 Low risks; control measures should be maintained under review, but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

Risk Values

As the spatial extent of the three major impacts under consideration can be mapped, a range of consequence ratings could be determined depending on the exposure to the impact. Similarly, the likelihood of each hazard could also be determined. The risk values used in the study are presented in Table 14. The consequences and likelihoods were considered using the current (2010) level of adaptation response to climate change and do not include any uptake of potential adaptation responses by 2030 and 2050.

Table 14 **Values of Likelihood and Consequence Used for Levels of Exposure to Each Climate Change Impact**

Hazard	Exposure	Consequence		Likelihood		Risk	
Inundation	< 25% of area	Insignificant	1	Possible	3	Low	3
	< 75% of area	Minor	2	Likely	4	Medium Risk	8
	>75% of area and deep	Moderate	3	Possible	3	Medium Risk	9
Salinity	< 50% of area	Insignificant	1	Almost Certain	5	Medium Risk	5
	>50% of area	Minor	2	Almost Certain	5	Medium Risk	10
Storm Surge	Localized	Minor	2	Rare	2	Low	4
	Widespread	Moderate	3	Rare	2	Medium Risk	6
	Extensive	Major	4	Rare	2	Medium Risk	8
	Permanent	Catastrophic	5	Rare	2	Medium Risk	10

Hot Spots

Risk hot spots are defined as those areas that inherently have the highest scale of hazard- and place-specific risk for the combined effects of climate change and are considered to be the highest-risk areas. They include urban settlements, specifically the transport, energy, and industrial infrastructure, and rural areas that are highly exposed to the impacts of climate change (such as areas affected by sea level rise and inundation). The areas shown in Table 15 have been identified as hot spots in the different sectors in two provinces.

Table 15 **Hot Spots Identified in the Vulnerability and Risk Analysis**

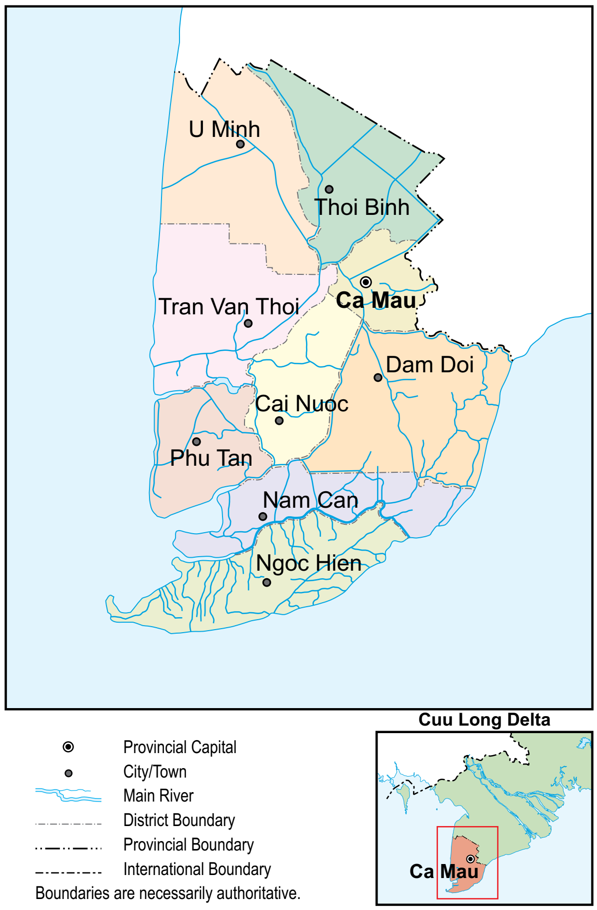
Population	Poverty	Agriculture and Livelihoods	Energy and Industry	Urban Settlements and Transportation
CA MAU PROVINCE				
Ca Mau	Ngoc Hien	U Minh	Dam Doi	Cai Nuoc
Tran Van Thoi	Dam Doi	Dam Doi	Tran Van Thoi	Tran Van Thoi
		Tran Van Thoi	Ca Mau	Ca Mau
KIEN GIANG PROVINCE				
Rach Gia	Chau Thanh	Hon Dat	Chau Thanh	Chau Thanh
Chau Thanh		Rach Gia	Hon Dat	Kien Luong
		Chau Thanh	Rach Gia	Ha Tien
		Kien Luong		Rach Gia
		Giong Rieng		
		Go Quao		
		Anh Bien		
		An Minh		

It must be stressed that the estimates developed for future vulnerability under different climate change scenarios are at a relatively coarse scale. Whilst vulnerability profiles were developed for both the A2 and B2 emissions scenarios for three time slices (current 2010, 2030, and 2050), only the A2 maps are presented in this report for illustrative purposes. These scenarios are considered mid-range (B2) and high (A2); however, as global emissions are currently tracking above the highest A1FI scenario, even the A2 hazard maps should be considered as potentially conservative with regard to actual climate impacts.

In reality, there was little appreciable difference between the vulnerability assessed under the A2 and B2 scenarios over the 2030 and 2050 time periods—and these differences were not sufficient to affect the vulnerability mapping to any appreciable degree.

Ca Mau Province

Map of Study Area



Administrative Center	Ca Mau City
Land Area (ha)	533,318
Population	1,218,500
Population Density (person/ha)	2.28
No. of Households	285,000
Average Family Size	4.27
Average Annual Per Capita Income	D18,757,400
GDP Contribution from Industry (HH)	D1,918,806
Unemployment Rate	6.0%
Education (teachers/1,000 persons)	8.8
Health (doctors/1,000 persons)	0.47
Ethnicity (% Kinh/non-Kinh)	96.6/3.4

GDP = gross domestic product, ha = hectare, HH = household.

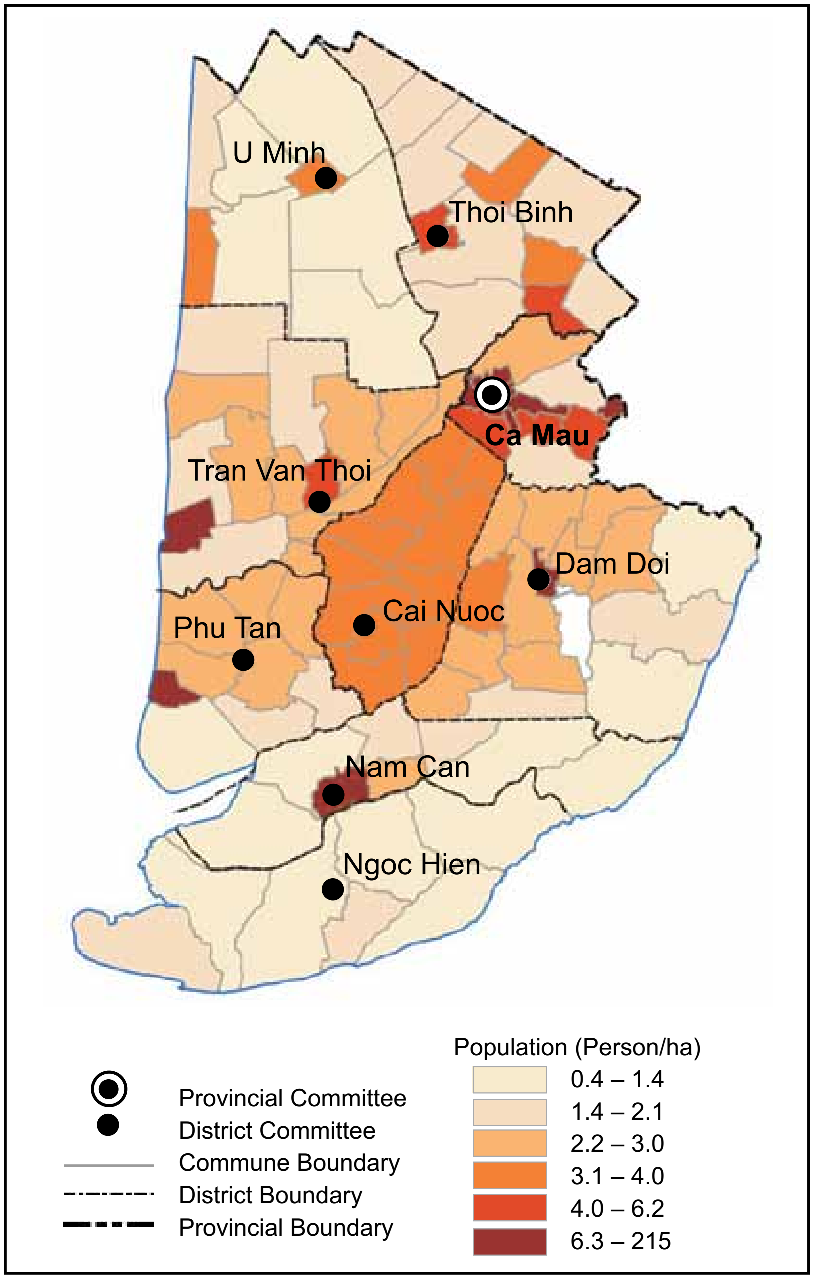
Population and Demographics

Ca Mau's total population is over 1.2 million (2010). The capital city is Ca Mau City, and there are 8 districts and 101 communes and towns. The average population density is 226 persons per square kilometer (km^2) which is lower than the national density (260 persons/km^2) and that of other provinces in the Mekong Delta (425 persons/km^2). Population growth is 1.3% per year and females account for 49.6% of the total provincial population.

Ca Mau City has the highest population density with 863 persons/km^2 followed by Cai Nuoc district and Tran Van Thoi district with population densities of 331 persons/km^2 and 260 persons/km^2, respectively. Ngoc Hien district has the lowest population density with only 107 persons/km^2. The urban–rural population is 20% versus 80%. Its immigration rate is 0.4% and emigration rate is 0.7%, resulting in a net migration rate of –0.3%. Ca Mau can be classified as a rural province with a high percentage of the population living in rural areas.

Commencing in 2000, the government implemented a wide array of interventions targeting the opening of the provincial economy. In particular, a significant area of rice paddies has been transformed for high-yielding shrimp cultivation. This has further improved Ca Mau's competitive advantages in shrimp cultivation with significant spin-offs and creation of induced jobs in upstream and downstream components of the value chain (transport, processing of shrimps, agro-processing).

Ca Mau Distribution of Population Density



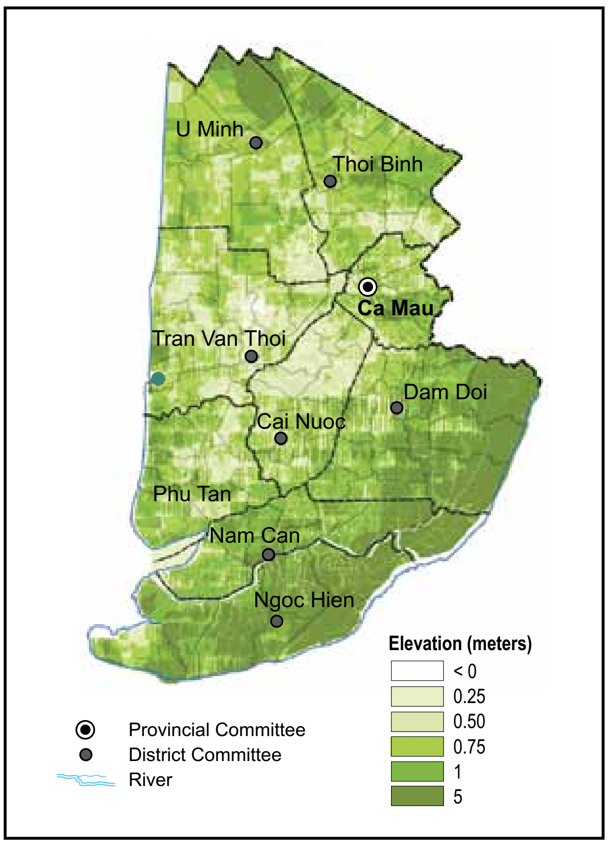
Topography

Ca Mau is the southernmost tip of the Mekong Delta floodplain. The area is low lying, with some elevation along the southeast coast. The district located at the very tip of Ca Mau, Ngoc Hien, is actually an island separated from the neighboring district, Nam Can, by a river. This area is inhabited but is technically classified as a marine area.

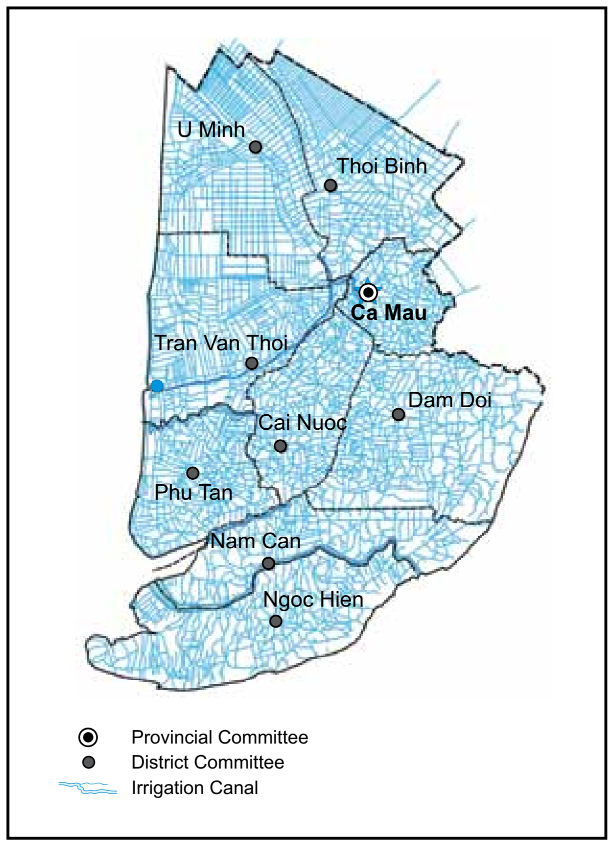
Irrigation System

Ca Mau has an extensive canal system crisscrossing the entire province. The canal system plays multifunctional roles of drainage, water storage, and transport. Major canal construction was started early in the 20th century by the French. This system has sluice gates that are coordinated in irrigation areas.

Ca Mau Topography



Ca Mau Irrigation System



Agriculture and Livelihoods

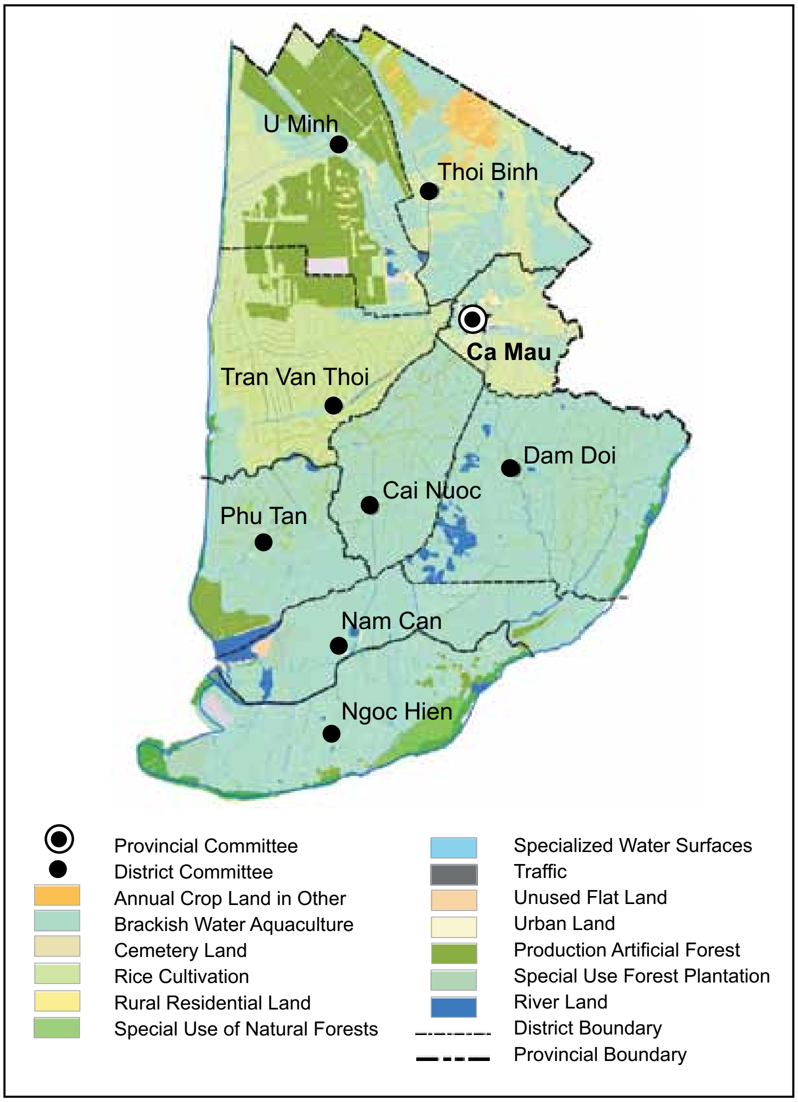
Ca Mau has an area of 533,318 hectares, with about 300,000 hectares used for aquaculture. The predominant crop is still rice, mainly double cropping in salt free zones. The total land area under rice is 130,000 hectares, divided into 70,000 hectares with double cropping and 60,000 hectares with single cropping only. Over the last decade (2000–2010), the area under cereal cultivation in Ca Mau has decreased by 43%. The province can be divided into three ecozones:

(i) The five southern districts of Cai Nuoc, Dam Doi, Nam Can, Ngoc Hien, and Phu Tan, experiencing minimal flooding but high salinity for long periods. This area is almost entirely under aquaculture.

(ii) The two northern coastal districts of Tran Van Thoi and U Minh with a mixture of forests, rice, and, increasingly, aquaculture. This area contains U Minh Ha National Park and most of the production forests of the province. A series of sluice gates along rivers and canals along the coastline is used to minimize saline intrusion to enable rice cultivation.

(iii) The two northeastern districts of Ca Mau and Thoi Binh that experience moderate flooding and saline intrusion. This area contains much of the extensive fruit production of the province and still has mostly rice crops around and north of Ca Mau City. Aquaculture is also becoming increasingly important in this ecozone.

Ca Mau Land Use



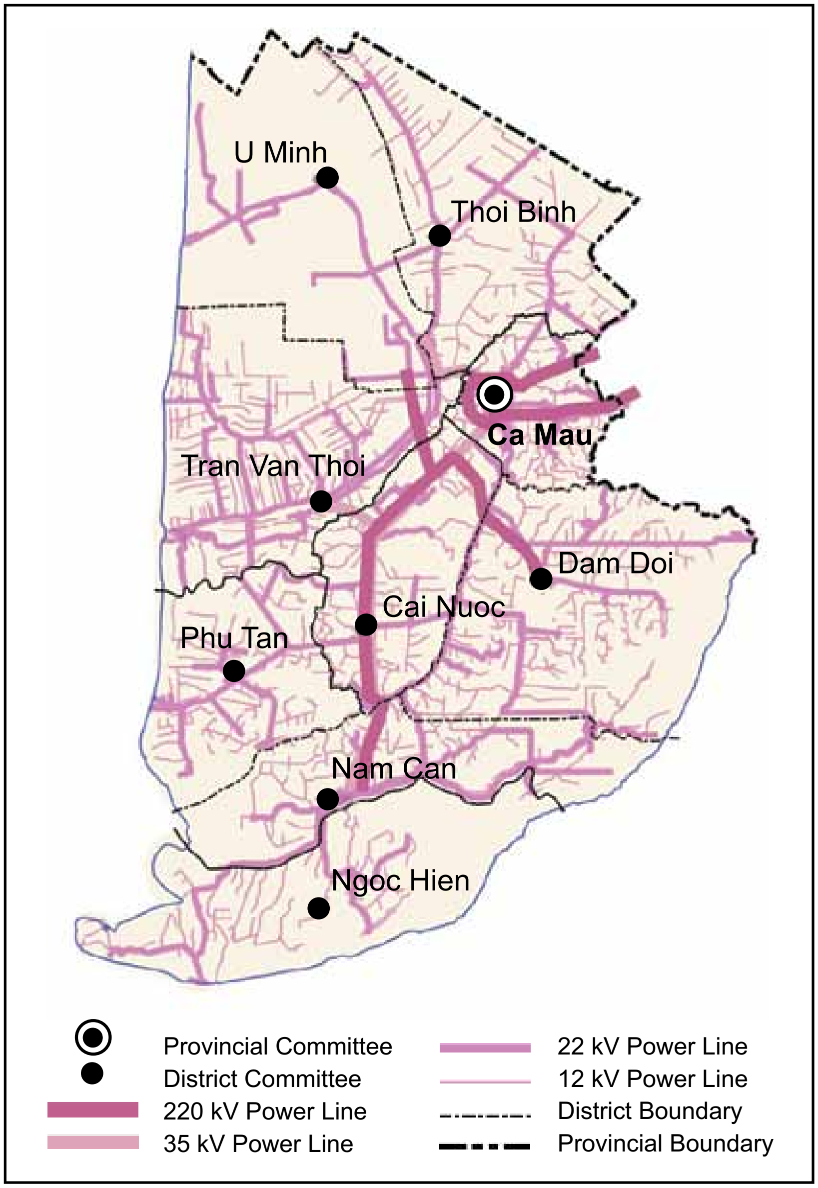
Energy and Industry

The largest single existing energy sector project in Ca Mau is the PetroVietNam (PVN) Ca Mau Gas-Power-Fertilizer Complex. This project comprises a 325-kilometer-long gas pipeline from the offshore PM3-CAA field shared with Malaysia (the pipeline was completed in 2007 at a cost of $300 million) and the gas-power-fertilizer complex itself in Khanh An commune, U Minh District, 9 kilometers northwest of Ca Mau City.

The Ca Mau Gas-Power-Fertilizer Complex is located at the confluence of the Ong Doc, Cai Tau, and Trem rivers and is affected by the tides of the southwestern sea with a maximum tidal amplitude of 60 centimeters. In addition, the area around the site is usually flooded for 2–3 months during the rainy season with general flooding depth of 30–50 centimeters (CPMB–RDCPSE 2006). Total capital investment is $1,760 million–$2,060 million.

The Ca Mau 1 and 2 power plants comprise two separate 750-megawatt combined-cycle gas turbine plants designed to run on natural gas and diesel oil. The Ca Mau 1 power plant was approved in October 2001. The feasibility study was completed in 2005, and construction for Ca Mau 1 started in 2006 and for Ca Mau 2 in 2007. The two plants were completed in 2007 and 2008, respectively, with 720 megawatts of net export power output per plant over a 25-year design life with total investment capital for the two power stations of $860 million.

Ca Mau Electricity System



Transport Network

Amongst the nine districts in the province, Ca Mau City has a high level of centrality in terms of its provision of high-level services and is a magnet for investment and residency compared to other centers. In the five official standard classes of urban centers, Ca Mau City is the only one not considered as Class 5.

Ca Mau City is the administrative and commercial center: It is also the main location for processing of the outputs from the region's primary sector. It is located inland but is well served regionally with access by both water and road (Highway 1 linking east to Can Tho).

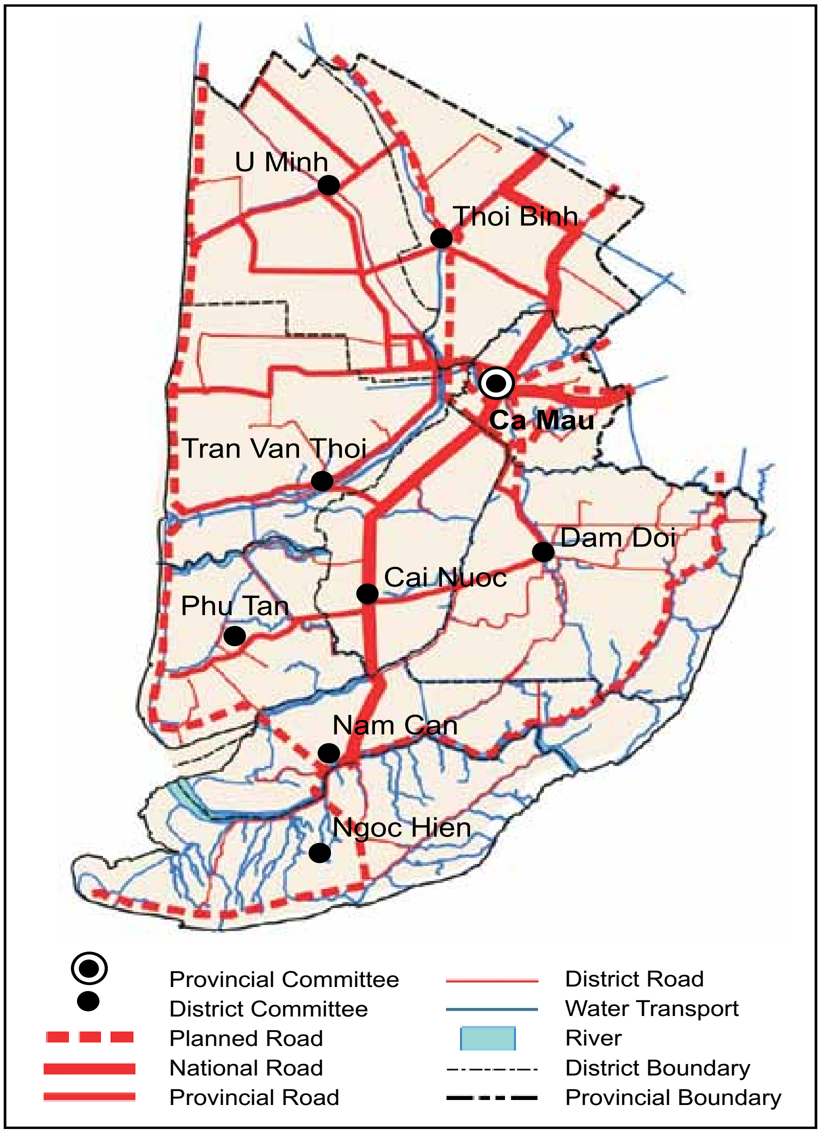
Nam Can town, the southern port, has been chosen as one of 15 coastal economic zones identified in the country. It is currently a key transit center for aquaculture products in the southern part of the province.

As the main port on the west coast, Song Doc town has Marine Economic Town status but is not the district's administrative center (Tran Van Thoi town). It serves as the base for small (<2,000 tons) fishing boats.

Water is key to the transport of heavy/bulky products to processing centers because it

- can take bigger loads,
- is cheaper (up to 60% according to discussions with the Department of Transportation),
- can reach remote areas whereas the road system has limited access, and
- is convenient as it allows goods to be delivered door to door with minimal effort.

Ca Mau Transport Network



Population Vulnerability

Population vulnerability refers to the vulnerability of people and populations in the study area to the effects of climate change, and recognizes that there are distinct regional differences in the demographic composition and trends (such as the migration of people toward coastal urban areas, which yields a greater-than-average growth of the population in some districts). Population growth is a major driver for change in the delta, especially in terms of increasing the number of people and households exposed to climate change hazards, but it also increases demands on the available natural resources and implications on sustainable livelihoods. The relationship between population change and the associated demographic trends will affect the ability of local communities and households to build resilience to climate change. Over the long term, population growth in the study area is likely to contribute to and exacerbate not only the vulnerability to climate change, but the difficulties in adapting to the potentially detrimental changes in climate. In this context, a district is considered to be vulnerable if it exhibits characteristics such as high population numbers, rates of growth, or large family size. Using the comparative indicators and measures provided, it is possible to estimate or rate the relative population vulnerability at the district levels.

The population vulnerability map was derived primarily from the population and demographic data collected during the district survey. For each province, we ranked the districts out of 40 according to these indicators and found the following results:

- The current population vulnerability for all the districts in Ca Mau was low.
- By 2030, the vulnerability of two out of nine districts in Ca Mau was assessed as being medium.
- By 2050, three districts—Ca Mau City, Dam Doi and Tran Van Thoi in Ca Mau—were assessed as being highly vulnerable and a further two districts were assessed as exhibiting medium vulnerability.

Population Vulnerability—A2 Scenario (Baseline, 2030, 2050)

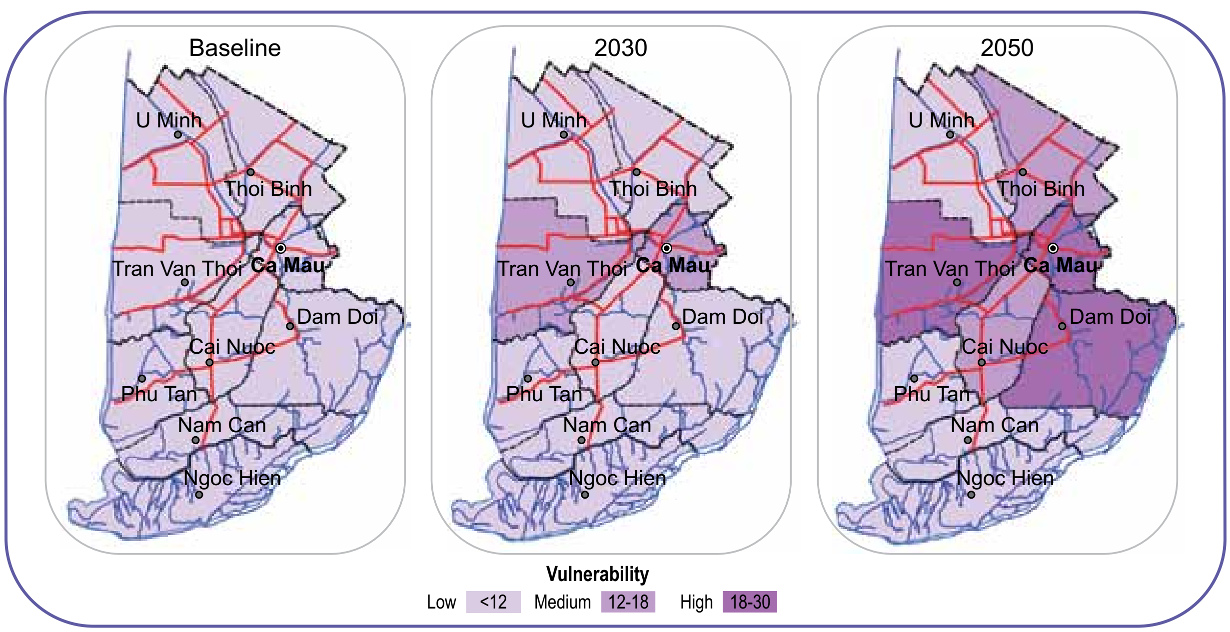
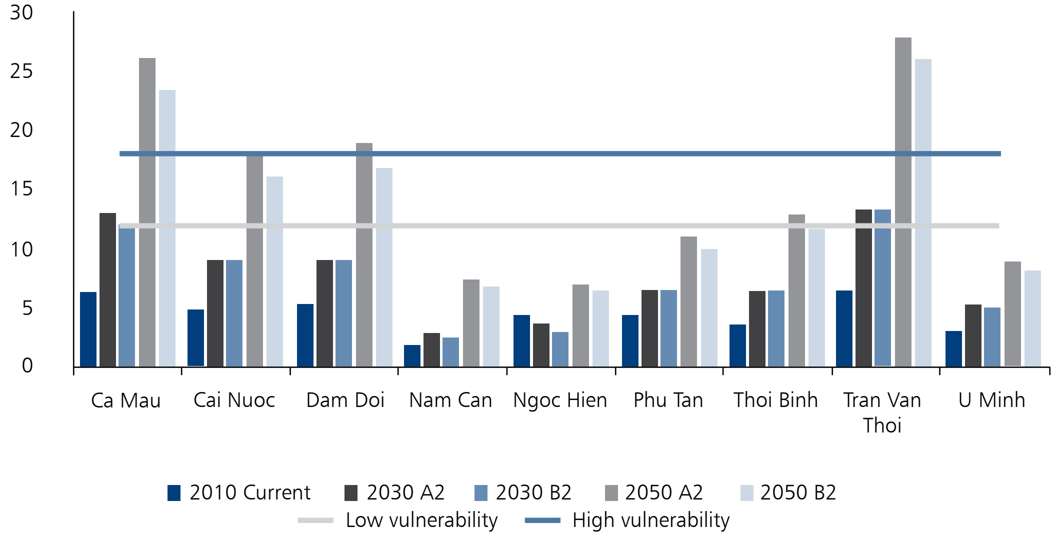


Figure 3 **Population Vulnerability**



Risks

Table 16 Risk of Climate Change on Population Dimensions

Climate Change Impact	Sectoral Component: Urban Settlements	Rural Households	Migration Patterns
Temperature	Low	Low	Low
Sea Level Rise	High	High	High
Flooding and Inundation	High	High	High
Salinity	Low	Medium	Medium
Storm Surge	Medium	Medium	High
Typhoons	High	High	High

The primary risks to population in the study area relate to the combined effects of sea level rise, flooding, and inundation, and the impacts associated with extreme events. The risks associated with salinity and temperature are relatively minor in comparison.

Hot Spots

The most vulnerable districts in Ca Mau with regard to population are Ca Mau City and Tran Van Thoi.

Ca Mau: A large existing population density, combined with a high migration rate, results in high vulnerability for this sector. However, the low number of rural households keeps the present vulnerability low, but exposure and sensitivity to inundation will increase into the future and is likely to be significant by 2050. The large population, the large area of the urban area, and the concentration of transport hubs increase vulnerability in this sector. In all sectors except poverty, vulnerability increases in the future due to population growth and inward migration, which emphasizes the current susceptibility to impacts.

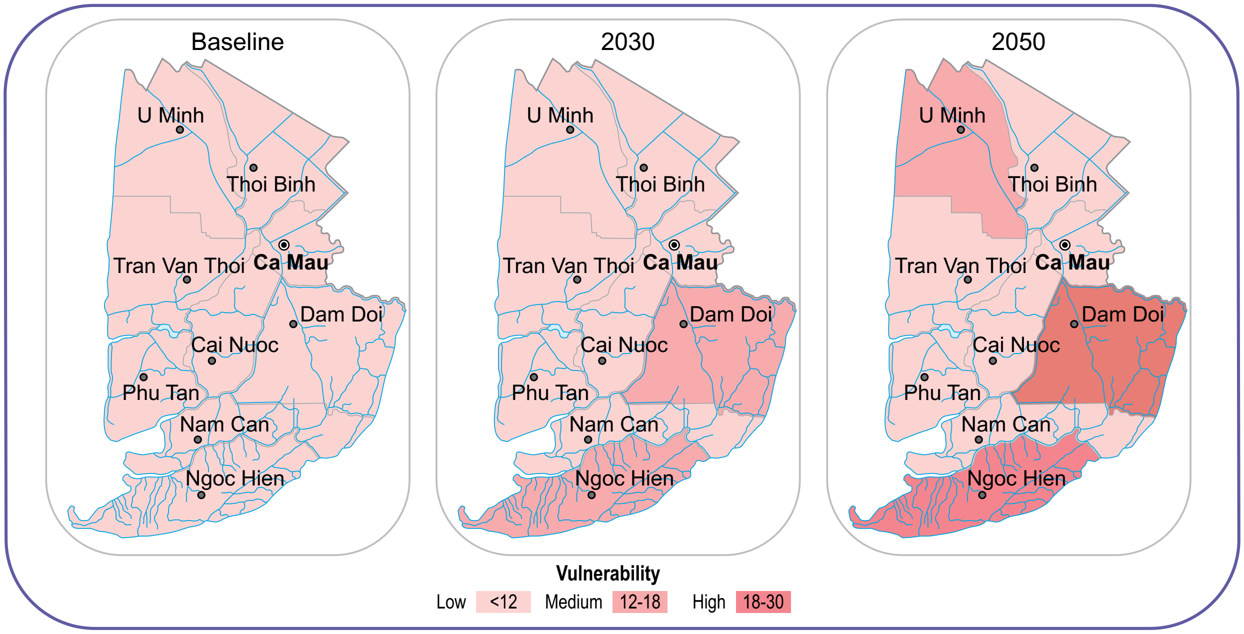
Tran Van Thoi: A coastal town subject to storm surges with a large population and inward migration. With 46% of the area currently subject to inundation, the initial high exposure increases to 80% in the future, as inundation and storm surges affect larger areas. Combined with a lower-than-average income, more poor households, and less access to health services than the other urbanized districts, the result is in high exposure and sensitivity.

Poverty Vulnerability

Poverty vulnerability refers to the vulnerability of poor and near-poor households and people in the study area to the effects of climate change and recognizes that the incidence of poverty varies across the region, due to a range of "special difficulties" such as ethnicity, lack of access to agricultural land, education and health services, fresh drinking water, power, and markets. Poverty diminishes the resilience and adaptive capacity of people and households, especially where people lack savings and capital for investments to adopt better production technology and also lack awareness and knowledge of adaption options available. Like population, poverty encompasses dimensions relevant to climate change vulnerability, such as the vulnerability to impacts and future shocks—and the ability to build resilience and adapt to climate change. In this study, we recognize that poverty is multidimensional and includes health, wealth, education, and access to natural resources in addition to income. Combining information on these indicators with different poverty measures at the commune level allows us not only to understand the spatial patterns of poverty but allows us to analyze the vulnerability of the poor and near poor communities and households to climate change impacts and hazards into the future.

This study used a combination of the standard indicators for Viet Nam (such as household income levels; ethnicity; education, literacy, and access to schools; and access to health services) together with access to land resources. With future projections of population growth, we were able to estimate or rate the relative poverty vulnerability at the district levels, and comparative vulnerabilities of each district are represented geographically in the map. We assume that estimates of relative poverty levels will stay the same (i.e., without poverty reduction interventions).

Poverty Vulnerability—A2 Scenario (Baseline, 2030, 2050)

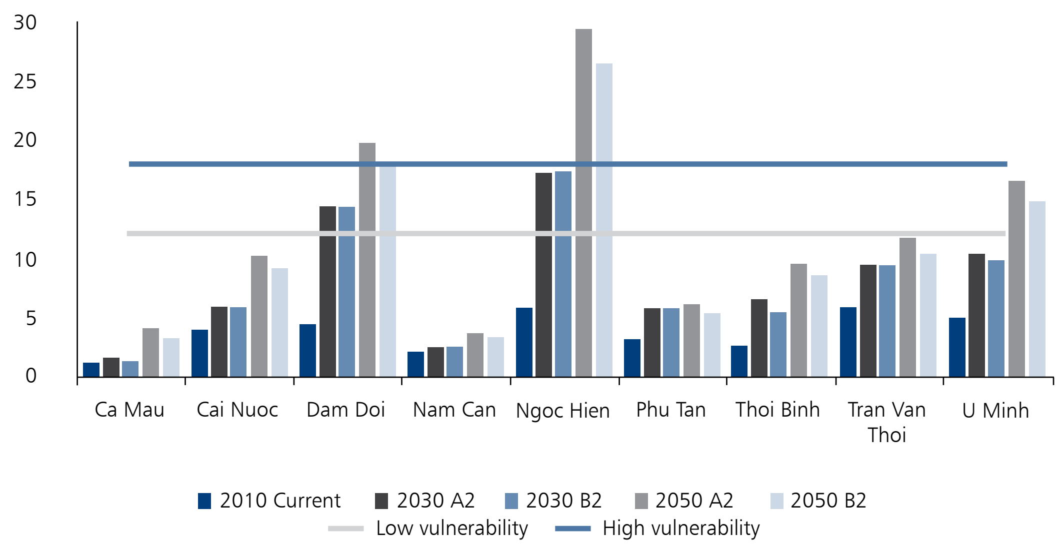


For each province, we ranked the districts out of 40 according to these indicators and found the following results:

- The current poverty vulnerability for all the districts was low.
- By 2030, the vulnerability in two out nine districts—Dam Doi and Ngoc Hien—was assessed as being medium.
- By 2050, U Minh was assessed as being medium and Dam Doi and Ngoc Hien were assessed as being highly vulnerable.

Whilst all the indicators of poverty are important, the primary driver of poverty vulnerability proved to be access to land resources. As access to productive land is important for reducing rural poverty, the impacts of climate change on the productivity of land will further constrain efforts to combat rural poverty. In almost all districts, limited space is either a problem now, or will be in the near future. In the Mekong Delta, pressure on space will increase dramatically in future, and this in turn will place unparalleled pressure on household livelihood systems and the regional economy in general.

Figure 4 **Poverty Vulnerability**



Risks

The primary risks to poverty in the study area relate to the combined effects of sea level rise, flooding, and inundation, and the impacts associated with extreme events. The risks associated with salinity and temperature again are minor in comparison.

Table 17 Risk of **Climate Change on Poverty Dimensions**

	Poverty Dimensions		
Climate Change Impact	Household Incomes	Health and Education	Ethnic Minorities
Temperature	Low	Medium	Low
Sea Level Rise	High	High	Medium
Flooding and Inundation	High	High	Medium
Salinity	Medium	High	Low
Storm Surge	High	Medium	Low
Typhoons	High	High	High

Hot Spots

The most vulnerable districts in Ca Mau with regard to poverty are Dam Doi and Ngoc Hien.

Dam Doi: A high number of poor households that is only slightly ameliorated by a moderate access to health and education. Low population growth reduces the effect of increases in inundation by 2050.

Ngoc Hien: A very low average income and a high number of poor households with limited access to health and education lead to increasing vulnerability as exposure to inundation and storm surges increase. The very high population growth increases the effect.

In Viet Nam, poverty is officially measured by a standard government measure. According to Decision 170/2005/QD-TTg, poor households in rural areas have a monthly income per person of below D200,000 and in urban areas below D260,000.

Agriculture and Livelihoods Vulnerability

Agriculture and livelihoods vulnerability refers to the vulnerability of agricultural farming, infrastructure, and livelihood systems in the study area to the effects of climate change, and recognizes that in Viet Nam the single farmer household is recognized as the basic economic unit upon which the agriculture sector is built at the commune, district, and provincial levels. It is also central to understanding the current and future effects of climate change. In this context, a household agricultural and livelihood system is considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible. Household vulnerability is determined by access to resources (land and water), the level and diversity of income sources (occupations), and the availability of productive assets and infrastructure.

We measured agriculture and livelihoods vulnerability by combining data and information from the district and sectoral surveys, including human assets (occupations, access to employment, adults at working age, etc.), natural assets (water, land, aquatic, etc.), and economic (sectoral productivity, GDP, and productive assets) and financial capital (household wealth characteristics), together with water-reliant livelihood strategies.

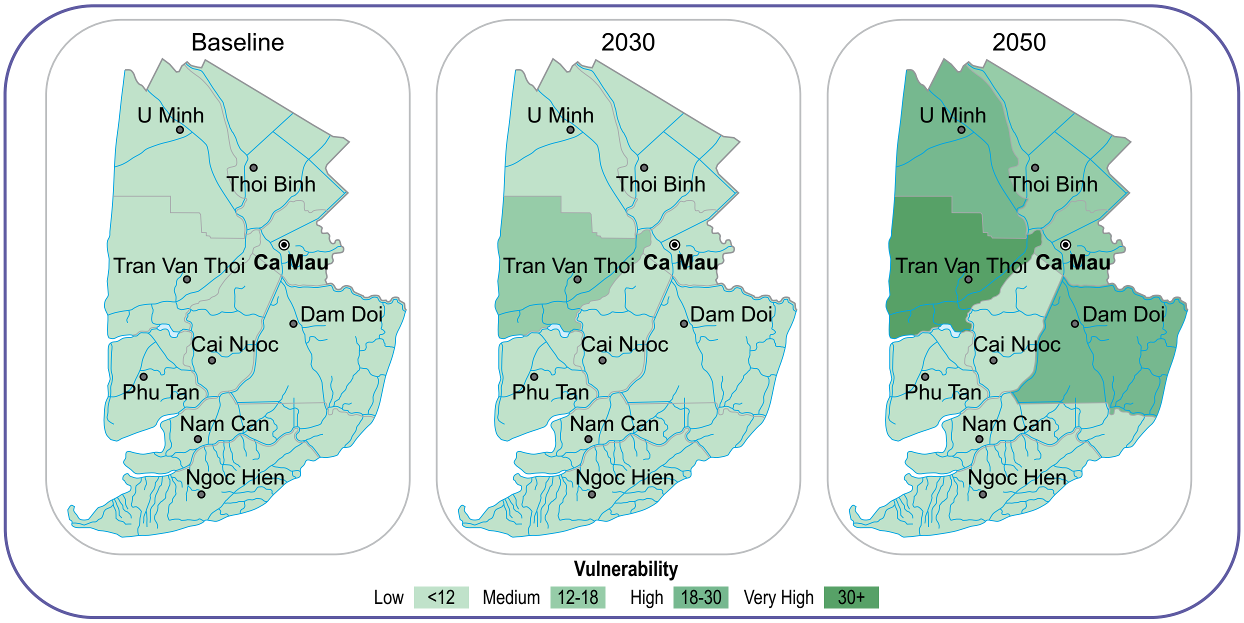
The overall distribution of the agriculture and livelihoods vulnerability for Ca Mau and Kien Giang provinces was assessed as a function of the key indicators mentioned and the existing and projected climate exposure and hazards for sea level rise, inundation, and salinity. The assessment is based on the assumption that the current demonstrable vulnerability in the agriculture sector is the best available basis for assessing the future climatic risks for that sector.

We ranked the districts in the study area according to their relative exposure to flooding, inundation, salinity, and storm surges and found the following results:

- The level of exposure to climate hazards such as flooding, inundation, and salinity, together with a heavy dependence on natural resources for their livelihoods make rural communities in both Ca Mau and Kien Giang vulnerable.
- However, the overall agriculture and livelihoods vulnerability for all districts was assessed as being low to medium, primarily because of the level of control, adaptation, and resilience exhibited in all districts except Ngoc Hien.
- It is expected that the situation will show little change by 2030 except for an increase to medium for the rice dominated Tran Van Thoi.
- By 2050, the rating for six mainland districts is expected to increase from medium to high, primarily due to the increase in the level of exposure to flooding and inundation, and the heavy reliance on water-based livelihood and agricultural systems. Tran Van Thoi is expected to rise to very high.

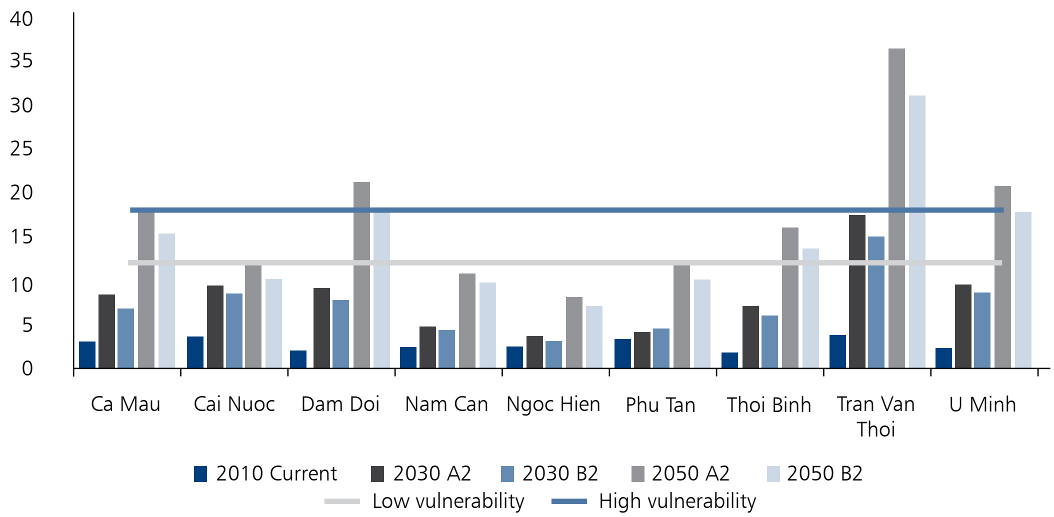
Rural households in Ca Mau tend to rely heavily on climate-sensitive resources, such as agricultural land, and climate-sensitive activities, such as rice farming and aquaculture. Climate change impacts such as flooding and inundation, salinity, and storm surges reduce the availability of these local natural resources, limiting the options for rural households that depend on natural resources for consumption or income generation.

Agriculture and Livelihoods Vulnerability—A2 Scenario (Baseline, 2030, 2050)



The most vulnerable districts (e.g., U Minh) are those with a large number of households that are highly dependent on water-reliant farming systems (such as the rice-based system) and are most exposed to river based flooding and inundation. The coastal districts, whilst being adversely affected by salinity and storm surges, were assessed as less vulnerable, primarily due to the higher level of control and/or protection afforded by the sea dike and sluice gate system.

Figure 5 Agriculture and Livelihoods Vulnerability



Risks

The main risks to agriculture and livelihoods in Ca Mau relate to the combined effects of increased temperature, flooding and inundation, and the impacts associated with extreme events. The risks associated with salinity and sea level rise are generally minor in comparison due to the control measures currently in place.

Table 18 Risk of Climate Change to the Agriculture and Livelihoods Sectors

	Agriculture	Livelihood		
Climate Change Impact	Rice-Based System	Rice/Shrimp System	Aquaculture	Household GDP
Temperature	High	High	High	High
Sea Level Rise	High	Medium	Medium	Medium
Flooding and Inundation	High	Medium	Medium	High
Salinity	Medium	Medium	Low	Medium
Storm Surge	Medium	High	High	High
Typhoons	High	High	High	High

GDP = gross domestic product.

Hot Spots

U Minh: A high rural population with low incomes is offset by a high number of possible income sources and available land. Exposure to inundation salinity and storm surges leads to high vulnerability in the future.

Dam Doi: A high number of income streams reduces the current vulnerability, but the large population decreases the availability of land for primary production, thus increasing vulnerability.

Tran Van Thoi: A high number of rural households and a moderate income increase vulnerability as the area impacted by inundation increases to 80% in the future.

Energy and Industry Vulnerability

Energy and industry vulnerability refers to the vulnerability of industrial and energy generation and transmission infrastructure and services to the effects of climate change and recognizes that industry and energy generation are important drivers for the economic development, growth, and sectoral transition in the Mekong Delta necessary to build resilience and adaptive capacity into the future. In this context, industry and energy infrastructure and services are considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible.

We measured energy and industry vulnerability by combining data and information from the district and sectoral surveys, including human assets (percentage of population working in industry, households reliant on industry), natural assets (diversity of industrial development, power generation capacity), and economic (sectoral productivity, average annual gross domestic product (GDP) per household contribution from industry) and financial capital (investment levels, household connections, levels of service, etc.), together with the nature, location, and extent of industrial zones, energy generation, and power transmission infrastructure.

Energy and Industry Vulnerability—A2 Scenario (Baseline, 2030, 2050)

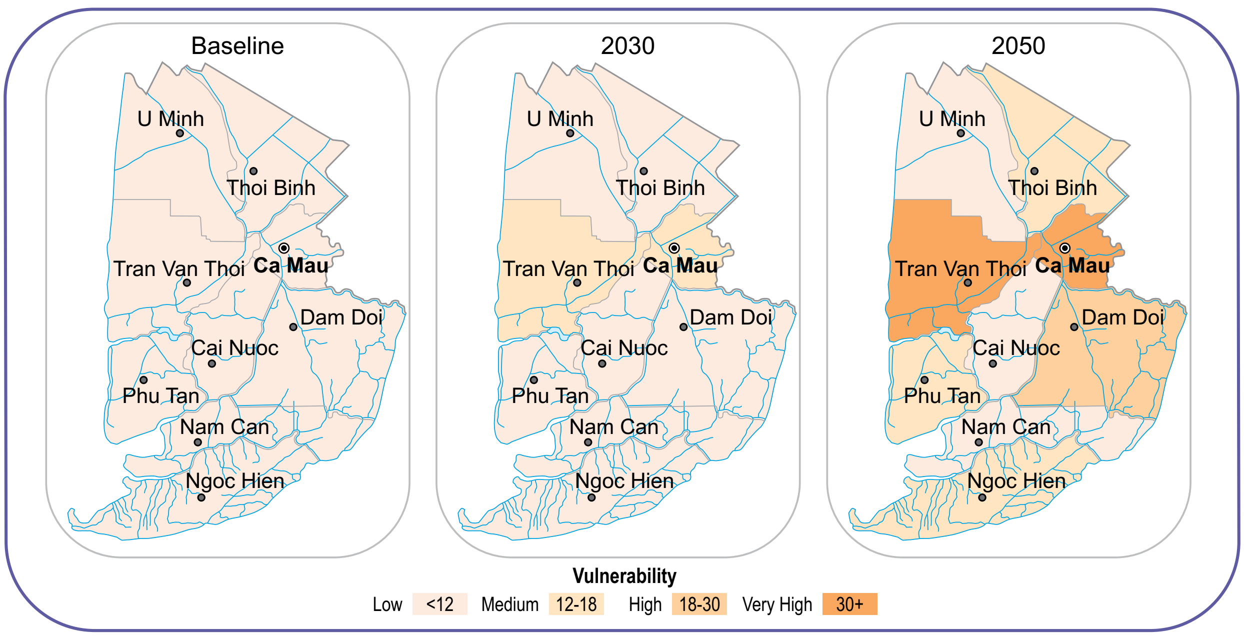
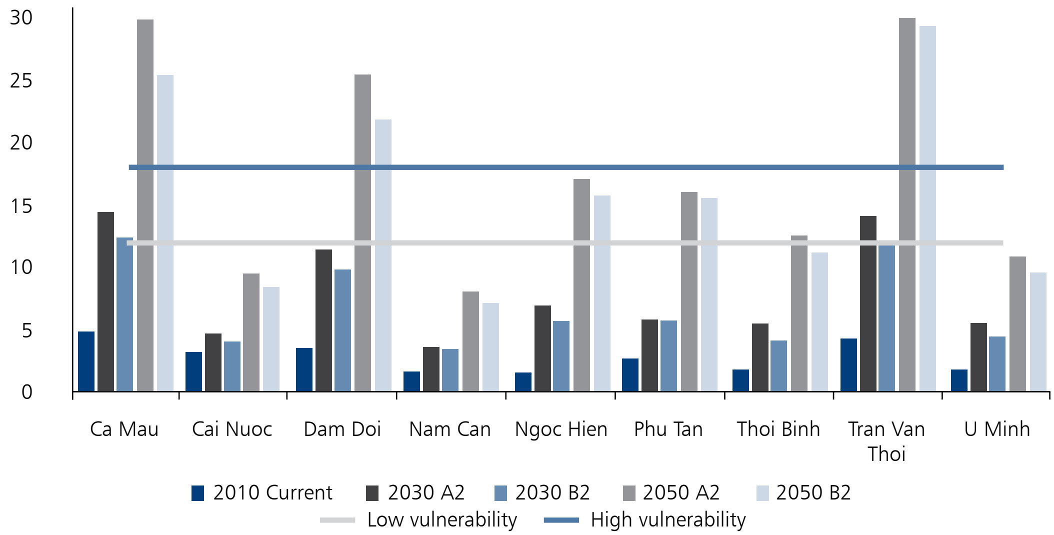


Figure 6 **Energy and Industry Vulnerability**



We ranked the districts in the study area according to their relative exposure to flooding, inundation, salinity, and storm surges and found the following results:

- The current energy and industry vulnerability for all districts in Ca Mau was considered to be low.
- However, this is expected to increase by 2030, and two districts—Ca Mau City and Tran Van Thoi—were assessed as being medium.
- By 2050, the rating for six districts in Ca Mau—Ca Mau City, Tran Van Thoi, Phu Tan, Thoi Binh, Ngoc Hien, and Dam Doi—are expected to increase to medium or high, primarily due to the exposure of surface water resources to sea level rise and the combined effects of flooding, saline intrusion, and storm surges.

Risks

The primary risks to industry and energy infrastructure in the study area relate to the combined effects of sea level rise, flooding and inundation, and the impacts associated with extreme events. The risks associated with salinity and temperature again are minor in comparison.

Table 19 **Risk of Climate Change to the Energy and Industry Sectors**

	Industry Type			Power Infrastructure	
Climate Change Impact	Primary Industry	Manufacturing and Construction	Services Industry	Power Generation Facilities	Power Transmission
Temperature	High	Medium	Low	Medium	Low
Sea Level Rise	High	Medium	Medium	Medium	Low
Flooding and Inundation	High	Medium	Medium	Medium	Medium
Salinity	Medium	Medium	Low	Low	Low
Storm Surge	Medium	Medium	Medium	Medium	Low
Typhoons	High	High	Medium	High	High

The most vulnerable districts are those with a large number of households that are highly dependent on local industry for employment or income and are most exposed to sea level rise, flooding, inundation, and extreme events and their effects on industrial areas, factories, and power generation and supply infrastructure and services. The coastal districts, whilst being adversely affected by salinity and storm surges were assessed as less vulnerable, primarily due to the higher level of control and/or protection afforded by the sea dike and sluice gate system.

Hot Spots

Dam Doi: While industry has a low contribution to the district economy, the high population means that a large number of households are reliant on a few industries. Combined with a poor electrical connection rate but a large amount of electrical infrastructure potentially affected by inundation, salinity, and storm surges, vulnerability increases in the future.

Tran Van Thoi: A large contribution to gross domestic product (GDP) from industry and an abundance of energy infrastructure lead to high vulnerability, which increases with inundation and storm surges.

Ca Mau City: The aggregation of industry and electricity infrastructure in the city and the reliance of household incomes on industry mean that Ca Mau City is vulnerable in this sector, especially to extreme events. The extent increases in the future, particularly due to flooding.

Urban Settlements and Transportation Vulnerability

Urban settlements and transportation vulnerability refers to the vulnerability of urban settlements and transportation to the effects of climate change. It recognizes the need to protect people and property and the importance of the transportation system to support and promote regional development and economic growth in the Mekong Delta.

In this context, urban settlements and transportation infrastructure are considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible.

We measured urban settlements and transportation vulnerability by combining data and information from the district and sectoral surveys, including human assets (percentage of urban population), natural assets (percentage of urban area), and economic (value of goods shipped) and financial capital (urban infrastructure and levels of service), together with the nature, location, and extent of the transport network and infrastructure.

We ranked the districts in the study area according to their relative exposure to flooding, inundation, salinity, and storm surges and found the following results:

- The high levels of exposure to climate hazards such as flooding, inundation, and salinity, together with high sensitivities in relation to high urban populations and densities, mean that from an urban settlement perspective, Ca Mau City, and its semi-urban hinterlands of Tran Van Thoi and Cai Nuoc are vulnerable.
- The overall urban settlement and transportation vulnerability for all districts were assessed as being low to medium, primarily because of the level of control, adaptation, and resilience exhibited in all districts.
- It is expected that the situation will show little change by 2030.
- By 2050, the rating for six districts is expected to rise to medium or high, primarily due to the increase in the level of exposure of urban areas, industrial areas, and power infrastructure to flooding.

The most vulnerable districts are those with high levels of urban infrastructure, buildings, and urban households, which are highly exposed to flooding, inundation, and storm surges. The coastal districts, whilst being adversely affected by salinity, were assessed as less vulnerable, primarily due to the higher level of control and/or protection afforded by the sea dike and sluice gate system. The rating for Ngoc Hien with no protection from a coastal dike is also expected to increase to highly vulnerable by 2050.

Urban Settlements and Transportation Vulnerability—A2 Scenario (Baseline, 2030, 2050)

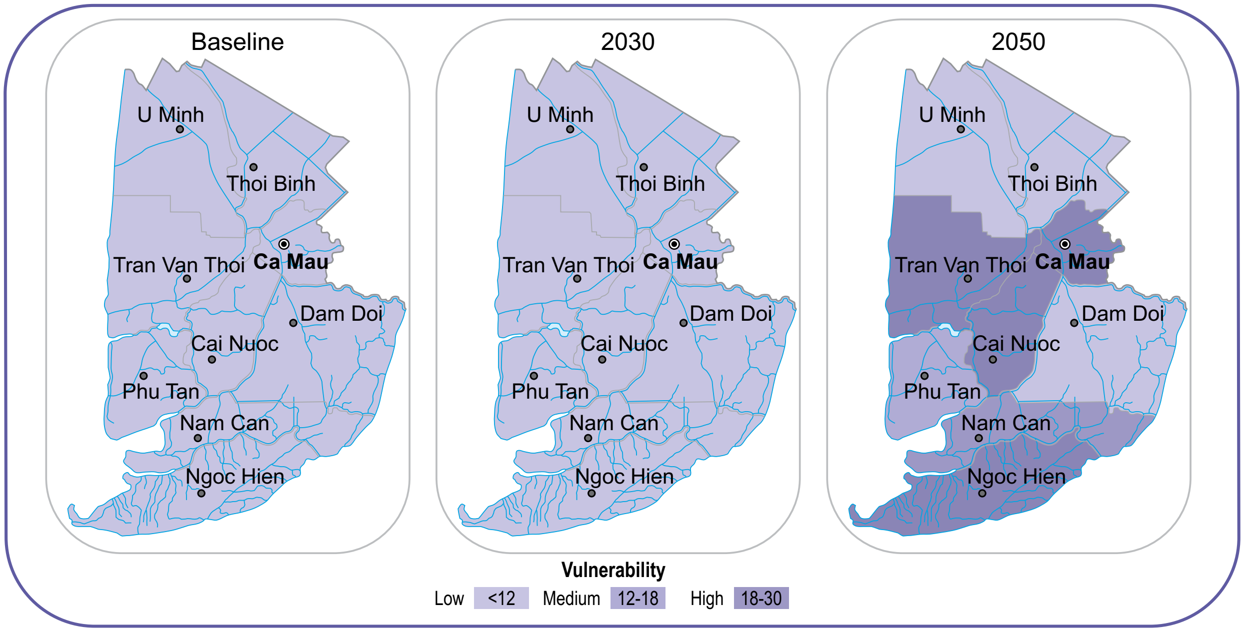
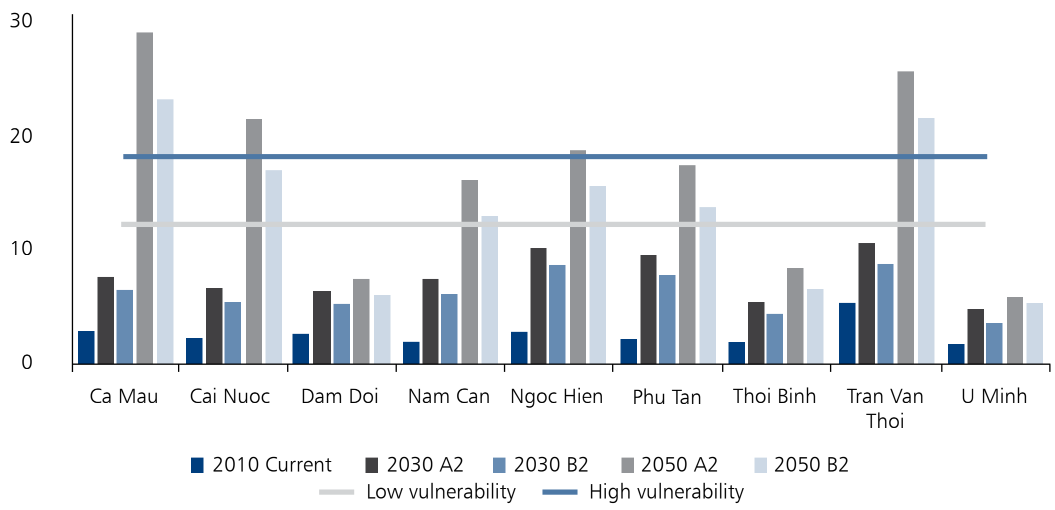


Figure 7 Urban Settlements and Transportation Vulnerability



Risks

Much of the infrastructure associated with urban settlements and transport in the study area was assessed as being at low risk from climate change impacts. The primary risks relate to the impacts associated with extreme events and the combined effects of sea level rise and flooding and inundation.

Table 20 **Risk of Climate Change to the Urban Settlements and Transportation Sectors**

	Settlements			Transportation		
Climate Change Impact	Building	Water Supply	Waste and Sanitation	Road Transport	Waterway Transport	Ports and Harbors
Temperature	Low	Low	Low	Medium	Low	Low
Sea Level Rise	High	Medium	Medium	Medium	Medium	High
Flooding and Inundation	High	Medium	Medium	Medium	Medium	Low
Salinity	Medium	Medium	Low	Medium	Low	Low
Storm Surge	High	Low	Low	Medium	Medium	High
Typhoons	High	Medium	Medium	Medium	High	High

Hot Spots

The following districts were identified as the most vulnerable in Ca Mau:

Ca Mau City: The high population, large urban area, and concentration of transport hubs increase vulnerability in this sector.

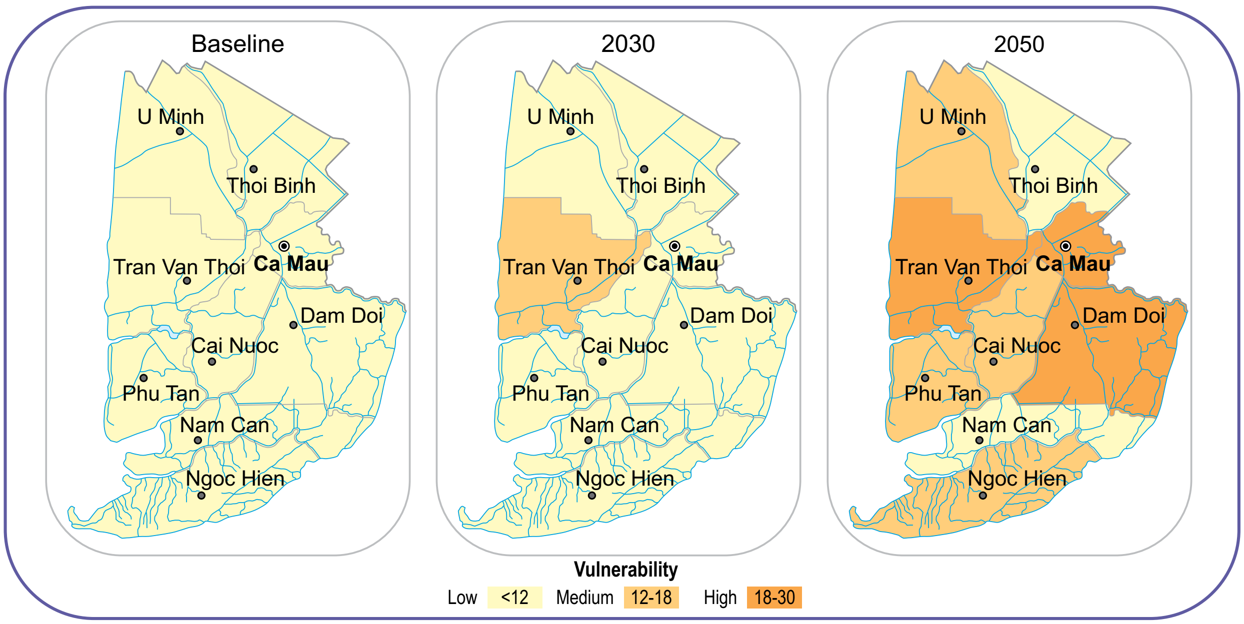
Cai Nuoc: A moderate urban population and poor sewage connections lead to high vulnerability that increases with extensive flooding in the future.

Tran Van Thoi: A high urban population in two towns, one of which is on the coast, leads to high vulnerability. Limited infrastructure and protection of the urban center from inundation and storm surges mean that vulnerability is low, which increases as inundation and storm surges affect larger areas.

Regional Vulnerability Synthesis

The first phase of the vulnerability assessment began with an evaluation of how specific systems, both natural and human, such as roadways, water resources, and industrial areas, etc., were exposed to climate hazards and impacts. To this end, a composite of the vulnerability indicators for the main sectoral areas and hazard categories was used to assess the vulnerability of both the natural and human systems in the study area in terms of exposure and sensitivity and to measure risk and adaptive capacity. The vulnerability rankings for each of the districts were based on a standard set of indicators so that their vulnerability could be compared not only between districts but also across sectors. The assessment was supplemented by expert judgment and feedback from the key stakeholder groups and government agencies. Vulnerability rankings were averaged across the five sectors to produce a vulnerability synthesis ranking.

Vulnerability Synthesis—A2 Scenario (Baseline, 2030, 2050)



Comparison of the rankings for the different districts clearly shows that current overall vulnerability to climate change for the majority of districts is low to medium. However, into the future, the vulnerability for many districts was assessed as being medium to high. The vulnerability assessment identifies three districts as being highly vulnerable to the impacts of climate change by 2050.

Summary of Sector Control Measures

Exposure to salinity is widespread throughout the entire province and is considered to have potentially major impacts. However, control measures—particularly in the form of livelihoods being adapted to brackish conditions—are in place to some extent throughout the province. Flooding and inundation is also considered to have potentially major impacts particularly on agriculture and aquaculture systems, although the impacts are currently largely controlled.

While all of the coastal districts are exposed to coastal erosion, the sea dike system, with an average height above sea level of 1.2 meters, currently provides adequate protection for all the coastal districts except Ngoc Hien, and for most districts, the impacts were assessed as intermediate and/or partly controlled at present.

The impacts of climate change hazards on the population sector were considered to be minor or intermediate and are largely controlled at present. Overall the protection measures were assessed as being moderate in this sector. In the poverty and income sector, impacts ranged from minor to major and while the impacts from erosion and storm surges are currently well controlled, the control measures for salinity and flooding impacts are inadequate. Overall, the protection measures were assessed as being moderate in this sector.

The impacts of climate change hazards on the agriculture and livelihoods sector ranged from minor through to major and, while the impacts from storm surges are currently well controlled, the control measures protecting against other hazards are inadequate, particularly those against flooding and salinity. Overall, the protection measures were assessed as being low in this sector. In both the energy and industry and the urban settlements and transport sectors, the impacts of salinity are largely controlled and adequate control measures were in place for the impacts of the other hazards. Overall, the protection measures were assessed as being high.

As previously noted, these climate change impacts are not new to the people of the delta, and, with the exception of Ngoc Hien, most of the districts have control measures in place to deal at least partly with the level of impacts to which they are currently exposed. This is not to say that coastal and flood protection is adequate. Projected increases in sea level mean that upgrading of both the sea dike system and the flood control system is urgently needed.

Table 21 **Summary of Adequacy of Control Measures Across All Sectors**

	Impacts				
Sector	Erosion and Sedimentation	Flooding and Inundation	Salinity	Storm Surge	Overall Adequacy of Control Measures
Population	•	••	••	•	Moderate
Poverty and Income	•	••	•••	•	Moderate
Agriculture and Livelihoods	••	•••	•••	•	Low
Industry and Energy	•	•	••	•	High
Urban Settlements and Transportation	•	•	••	•	High

•	Minor exposure and/or well controlled
••	Intermediate exposure and/or largely controlled
•••	Major exposure but partly controlled
••••	Major exposure and little control measures in place

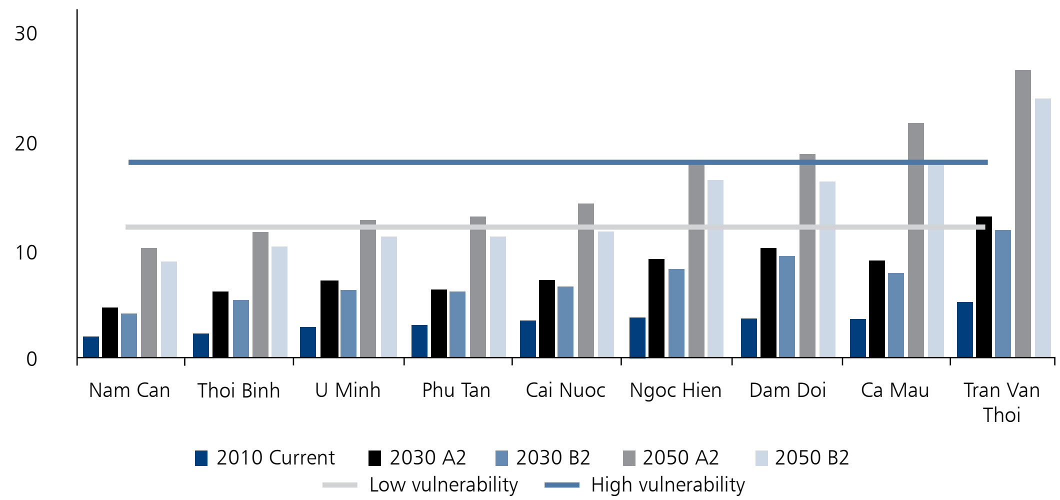
Highly Vulnerable Districts

In Ca Mau Province, the following districts have been identified as being expected to have a high level of overall vulnerability to climate change across the various sectors in this study:

- Tran Van Thoi
- Ca Mau
- Dam Doi

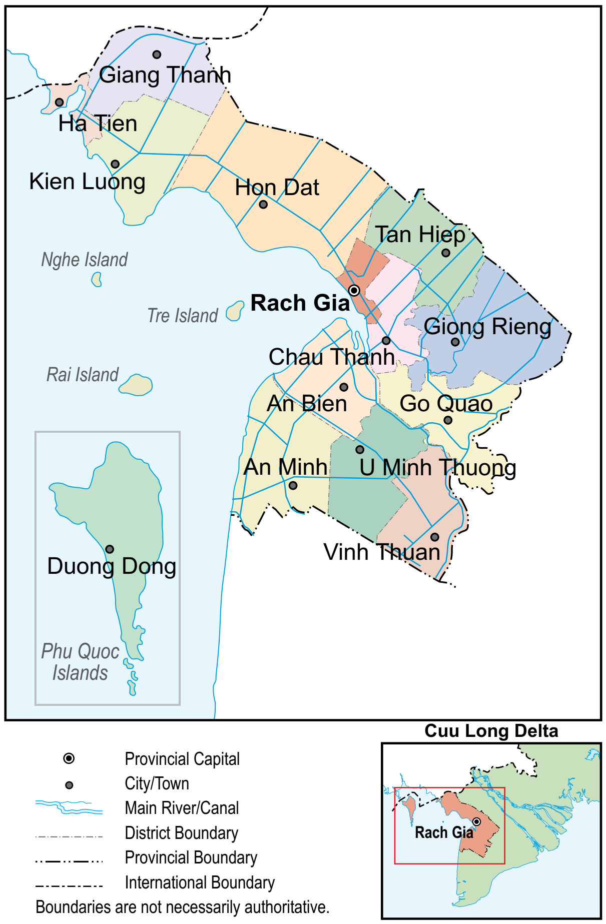
The vulnerability ratings for all the mainland districts would have been much higher in the absence of the sea-dyke flood control system.

Figure 8 **Ca Mau Vulnerability Synthesis**



Kien Giang Province

Map of Study Area



Administrative Center	Rach Gia
Land Area (ha)	634,000
Population	1,706,000
Population Density (persons/ha)	2.69
No. of Households	393,792
Average Family Size	4.26
Average Annual Per Capita Income	D20,294,000
GDP Contribution from Industry (HH)	D1,928,367
Unemployment Rate	1.8%
Education (teachers/1,000 persons)	8.8
Health (doctors/1,000 persons)	0.22
Ethnicity (% Kinh/non-Kinh)	86.4/13.6

GDP = gross domestic product, ha = hectare, HH = household.

Population and Demographics

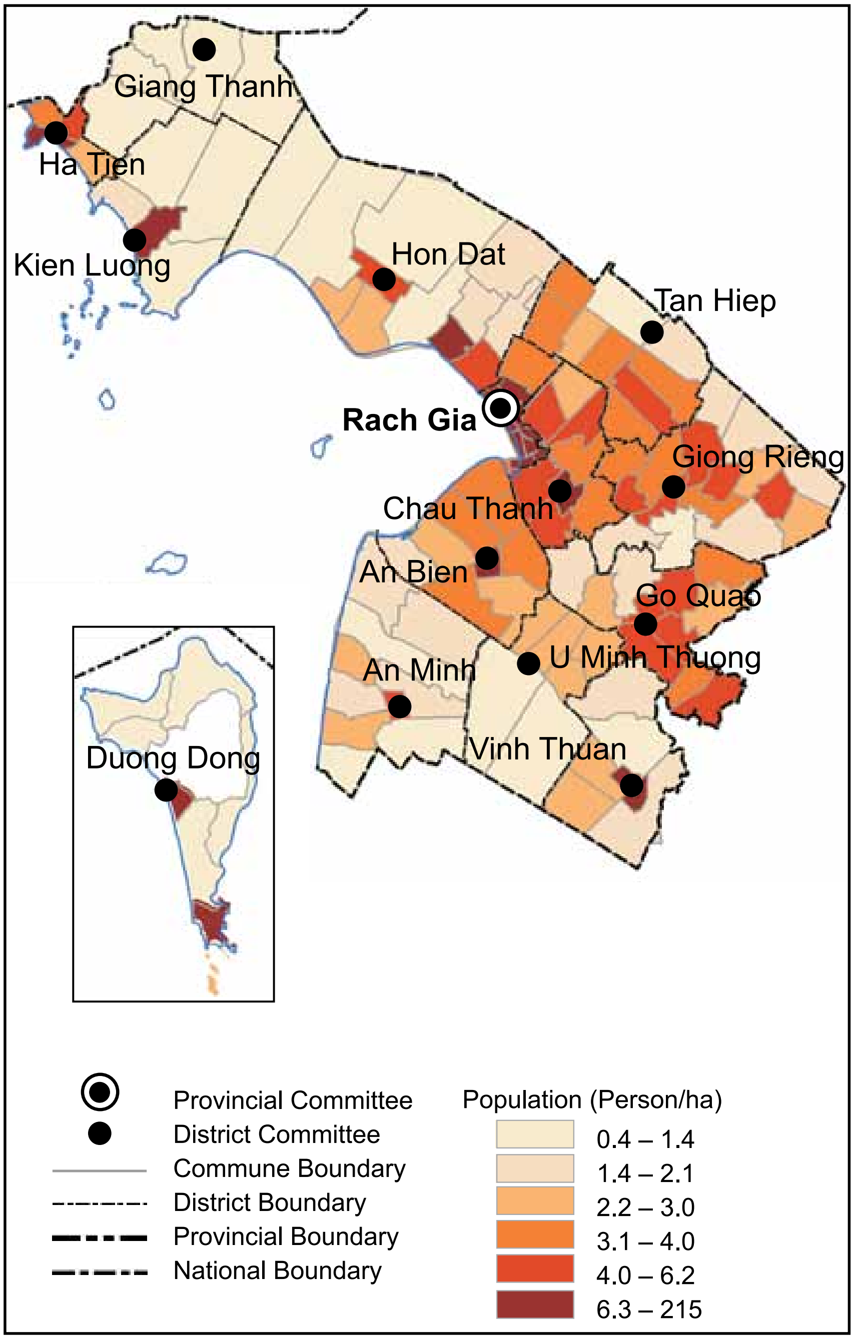
The total population of Kien Giang is 1.6 million people in 13 districts and 118 communes. With 266 persons per square kilometer, it has a lower population density than other provinces in the Mekong, reflecting its rural nature and emphasis on aquaculture. Of the population, 73% live in rural areas and only 27% in cities or municipalities. Its population growth in recent years has been 1.3% with a net annual emigration of –0.7%, mainly emigrating to Ho Chi Minh City in search of better paying jobs.

Ethnic minority numbers are a small percentage of the total population (13.6%). However, they do have a higher incidence of poverty rates than average, with more than 30% of minorities living in poverty.

Kien Giang is the country's second largest aquaculture production center. In addition, it has a deep-sea port at Ha Tien and a buoyant tourism industry in Phu Quoc. These economic drivers result in robust economic growth and ample employment opportunities in both downstream and upstream activities in the value chain.

Agriculture as an economic sector accounts for 42% of provincial GDP, whilst it employs 56% of the population. This discrepancy hints at low productivity levels and relatively low added-value per employee. In contrast, the contribution to GDP by tourism (represented in the services sector) is on par with its employment generation (32%).

Kien Giang Distribution of Population Density



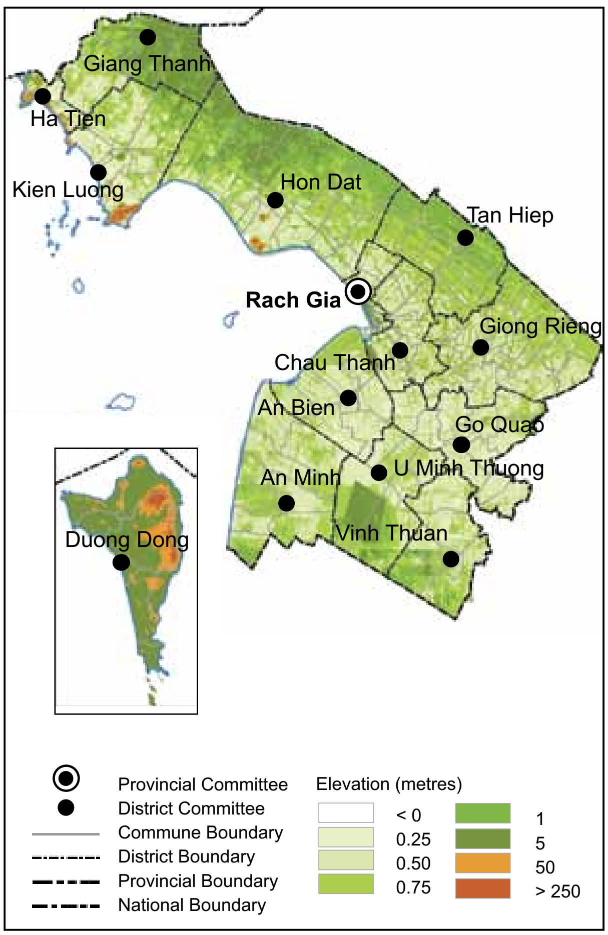
Topography

Kien Giang is a province on the Western coast of the Mekong Delta floodplain. Apart from a few isolated hills that rise above the floodplain, the area is low-lying with increasing elevation to the northeast. Kien Giang also includes the Phu Quoc and Kien Hai islands.

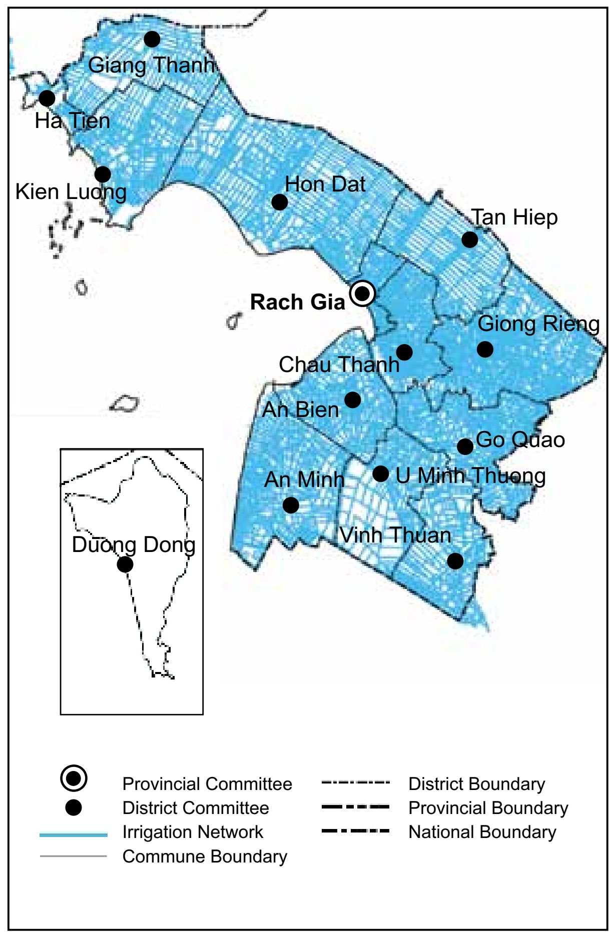
Irrigation System

Kien Giang has an extensive canal system crisscrossing the entire province. The canal system plays multifunctional roles of drainage, water storage, and transport. Major canal construction was started early in the 20th century by the French. This system has sluice gates that are coordinated in irrigation areas.

Kien Giang Topography



Kien Giang Irrigation System



Agriculture and Livelihoods

Kien Giang has a total area of 634,000 hectares, with agriculture the most important component of the primary production sector (443,000 hectares). The land use of the province is shown in the map. Rice farming is the main agricultural activity. The province can be divided into three ecozones:

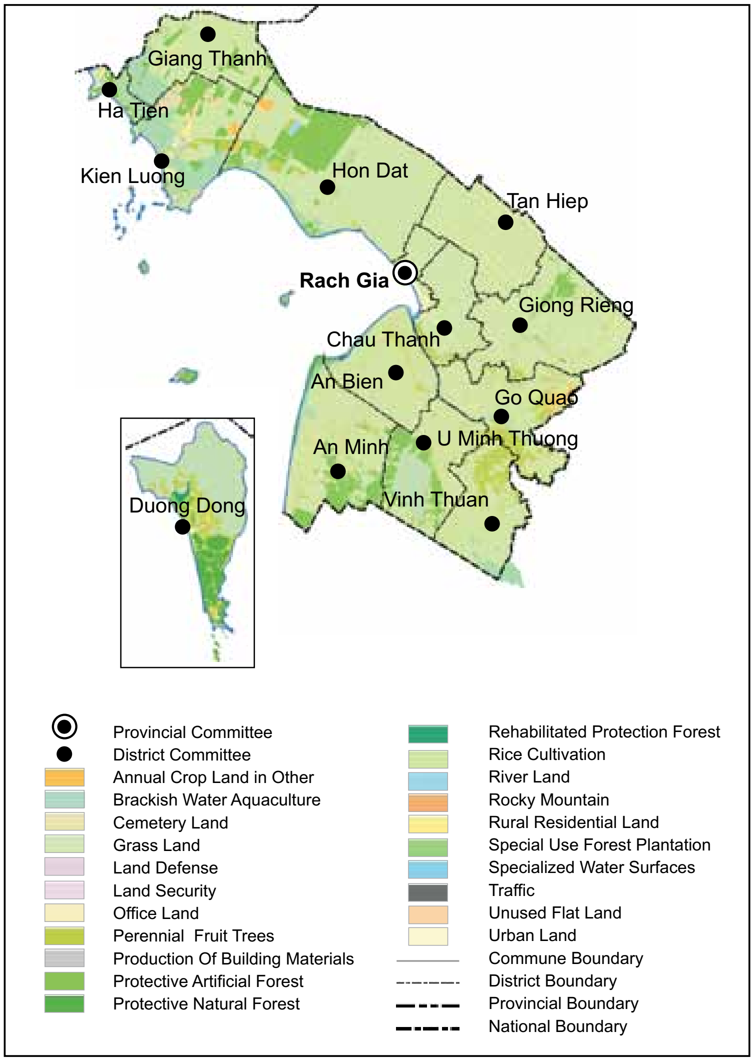
(i) The **Kien Luong/Hon Dat Square**, bordering Cambodia and An Giang, is affected by flooding every year and divided into a more saline area southwest of Hon Dat's main canal/road and a freshwater area to the northeast of this alignment. This area is affected by flooding from September to November, with 62,000 hectares under rice with harvests of 3.5 tons per hectare.

(ii) The **central eastern districts** between the Can Tho border and east of the Cai Lon River, containing Tan Hiep, Chau Thanh, Giong Rieng, and Go Quao, form a region which experiences flooding but is beyond the extreme salinity areas.

(iii) The **U Minh Thuong NP and An Bien/An Minh area** west of the Cai Lon River has 64,000 hectares of mostly rice/shrimp cultivation that is heavily affected by saline water.

Flooding affects most of the inland parts of the province every year. Long-lasting and deep floods were not stated as significant problems by province authorities because the majority of livelihoods in the delta is agricultural. Awareness is high of the issue in the Department of Agriculture and Rural Development and wider society. Traditional rice/shrimp grown in An Minh and An Bien is considered desirable because it preserves rice production and supplies free feed for shrimps.

Kien Giang Land Use



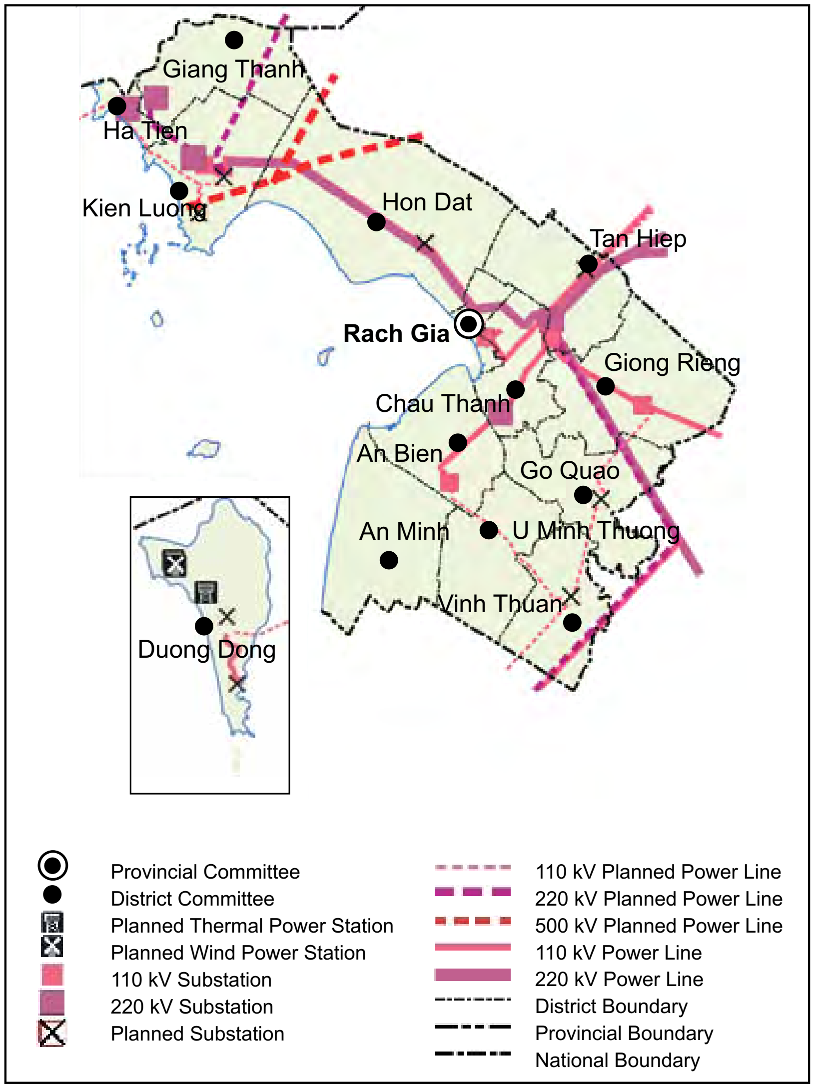
Energy and Industry

Kien Giang has a modern and extensive power distribution system. Medium (22/12.7 kV) and low voltage (380/220 V) poles mostly date from 1997 and later and have a 10-year design life. They should last longer in practice as few poles dating back to 1997 have yet been replaced. The high-voltage 110 kV (and some old 35 kV) and the medium-voltage 22/12.7 kV provincial distribution system towers/poles and transformers should have a 30-year economic life. The power distribution system is generally technically reliable. The estimated total capital investment is $35 million. Kien Giang is connected by 110 kV inter-province high-voltage systems and to the 220 kV national backbone power grid to the rest of Viet Nam.

There are around 20 power outages, each of half- to full-day duration, in the dry season every year when the national Viet Nam Electricity (EVN) grid runs out of generating capacity from its hydropower stations in central and northern Viet Nam. Many industries therefore have backup diesel generators.

In addition to Phu Quoc island, nine small islands have their own diesel generator–powered stand-alone electricity grids funded by Kien Giang province. Since July 2004, Phu Quoc's electricity supply has been provided by the new Phu Quoc diesel power plant. This plant is managed by the Kien Giang EVN and is located 5 kilometers from the main Duong Dong town on Phu Quoc.

Kien Giang Electricity Network



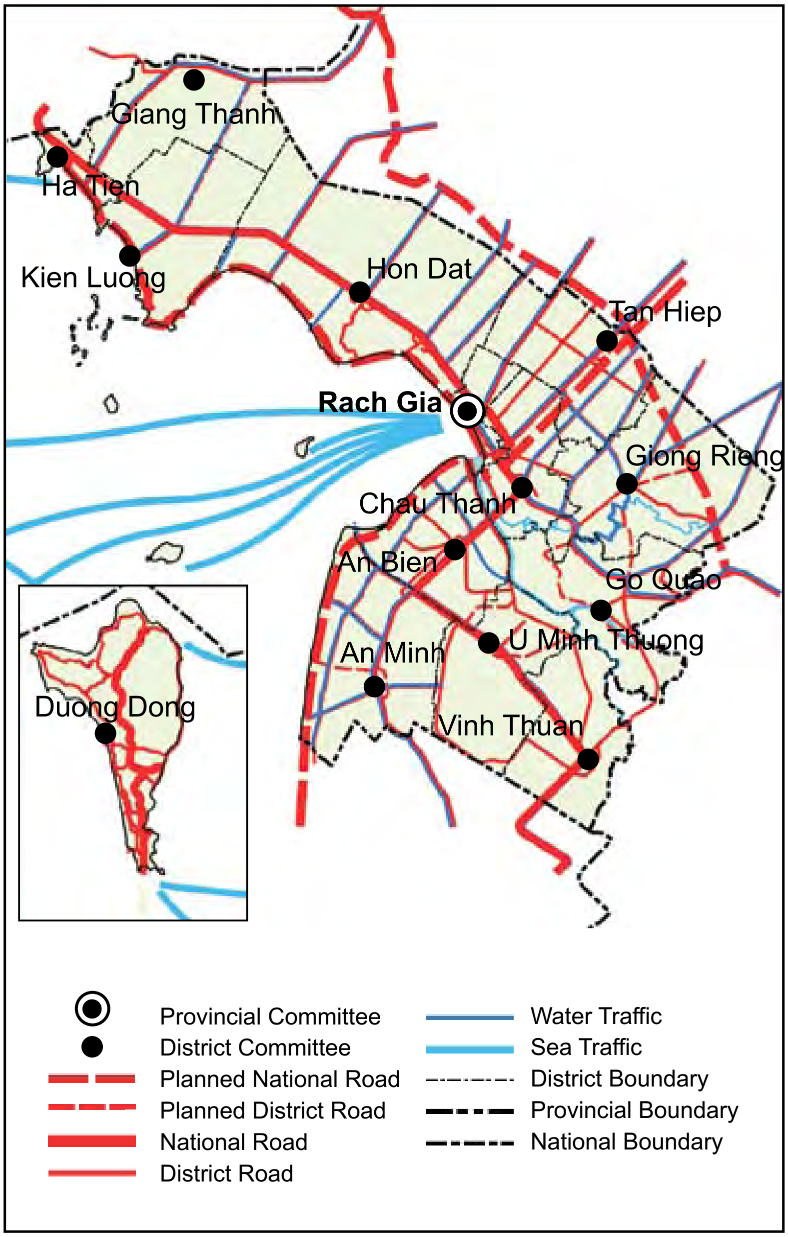
Transport Network

There are three major population magnets within the 15 districts of Kien Giang: the cities of Rach Gia (on the coast in the center of the province); Ha Tien (at the northern tip on the Cambodian border); and the island of Phu Quoc, which consists of several small towns (including the capital Duong Dong) and villages.

The transport of goods throughout Kien Giang mostly takes place by road except that of agricultural products (it being the largest rice-growing area in the country) and construction materials, for which the Cai Lon River south of Rach Gia and the canal from Rach Gia to Ha Tien (originally constructed in the 1930s to carry fresh water to Ha Tien) are used. Water transport is a key means of access through the channels into rural areas where there are few roads (there are 83,000 inland boats). National roads 80 and 63 are the main routes along the coast serving all the main urban centers, with the other main route being national road 61, which links eastward to Can Tho.

There is one main inland port at Tac Cau south of Rach Gia for 500–1,000-ton boats. Marine fish landed in the province is taken to Tac Cau as it has an industrial zone for fish processing. Much is also sent onward from there to Can Tho and Ho Chi Minh City inside polystyrene containers on refrigerated trucks. The cheaper catch is sold locally. Rach Gia itself is only used for ferries. The lack of a mainland deep-water port has been noted as a key factor restricting the province's growth, despite its key location on the Cambodian border.

Kien Giang Traffic System



Population Vulnerability

Population vulnerability refers to the vulnerability of people and populations in the study area to the effects of climate change, and recognizes that there are distinct regional differences in the demographic composition and trends (such as the migration of people toward coastal urban areas, which yields a greater-than-average growth of the population in some districts). Population growth is a major driver for change in the delta, especially in terms of increasing the number of people and households exposed to climate change hazards, but it also increases demands on the available natural resources and implications on sustainable livelihoods. The relationship between population change and the associated demographic trends will affect the ability of local communities and households to build resilience to climate change. Over the long term, population growth in the study area is likely to contribute to and exacerbate not only the vulnerability to climate change, but also the difficulties in adapting to the potentially detrimental changes in climate. In this context, a district is considered to be vulnerable if it exhibits characteristics such as high population numbers, rates of growth, or large family size. Using the comparative indicators and measures provided, it is possible to estimate or rate the relative population vulnerability at the district levels.

The population vulnerability map was derived primarily from the population and demographic data collected during the district survey. For each province, we ranked the districts out of 40 according to these indicators and found the following results:

- The current population vulnerability for all the districts in Kien Giang was low.
- By 2030, the vulnerability of two out of 15 districts in Kien Giang was assessed as being medium.
- By 2050, in Kien Giang, the ratings for Rach Gia and Chau Thanh are expected to increase from medium to high and very high, primarily due to a combination of high population growth and limited land area.

Population Vulnerability—A2 Scenario (Baseline, 2030, 2050)

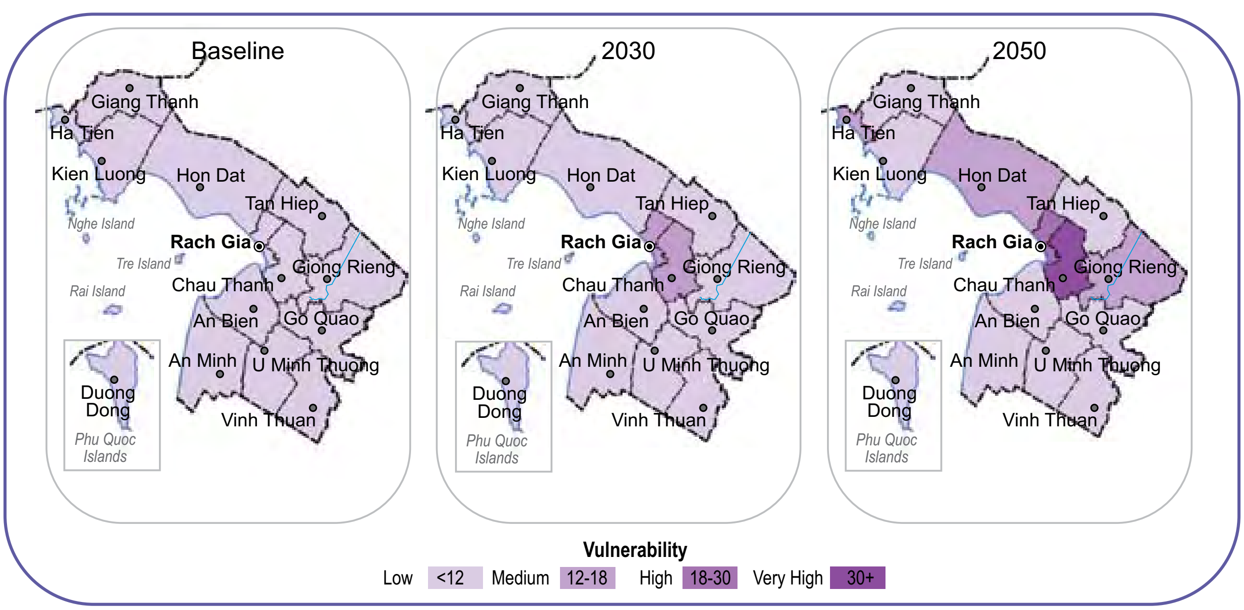
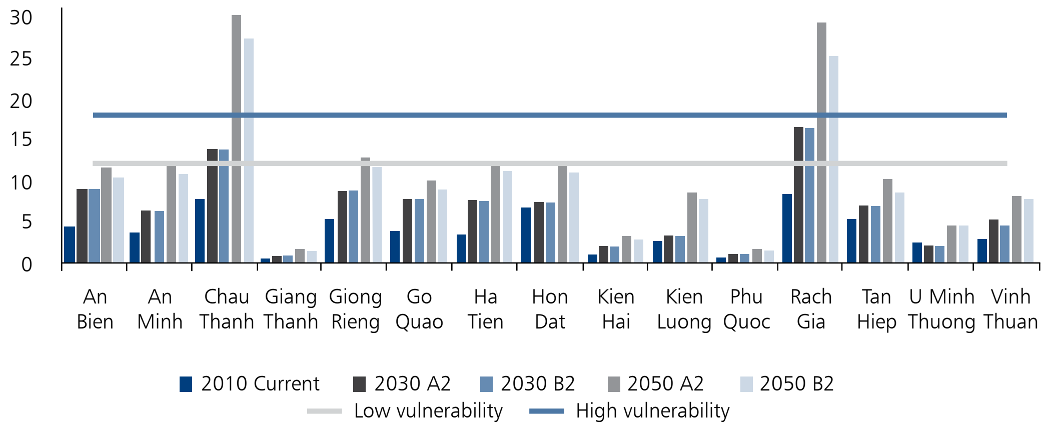


Figure 9 **Population Vulnerability**



Risks

The primary risks to population in the study area relate to the combined effects of sea level rise, flooding and inundation, and the impacts associated with extreme events. The risk associated with salinity and temperature is relatively minor in comparison.

Table 22 **Risk of Climate Change on Population Dimensions**

Climate Change Impact	Sectoral Component		
	Urban Settlements	Rural Households	Migration Patterns
Temperature	Low	Low	Low
Sea Level Rise	High	High	High
Flooding and Inundation	High	High	High
Salinity	Low	Medium	Medium
Storm Surge	Medium	Medium	High
Typhoons	High	High	High

Hot Spots

The most vulnerable districts in Kien Giang with regard to population are Rach Gia City and Chau Thanh.

Rach Gia: Highly vulnerable due to an existing high population and high population density combined with a high rate of inward migration. This is compounded by a high level of exposure to flooding, inundation, salinity, and storm surges, and results in high vulnerability.

Chau Thanh: A large rural population, high population density, and high growth rate combine and it is already highly exposed to flooding, inundation, salinity, and storm surges. This will increase in the future as a greater area is subject to impacts. High numbers of poor and ethnic households, low income, and limited availability of agricultural land lead to high vulnerability that increases in the future as population increases and a greater area is subject to impacts especially up to 2030.

Poverty Vulnerability

In this study, we recognize that poverty is multidimensional and includes health, wealth, education, and access to natural resources in addition to income. We have used a combination of the standard indicators for Viet Nam (such as household income levels; ethnicity; education, literacy, and access to schools; and access to health services) together with access to land resources.

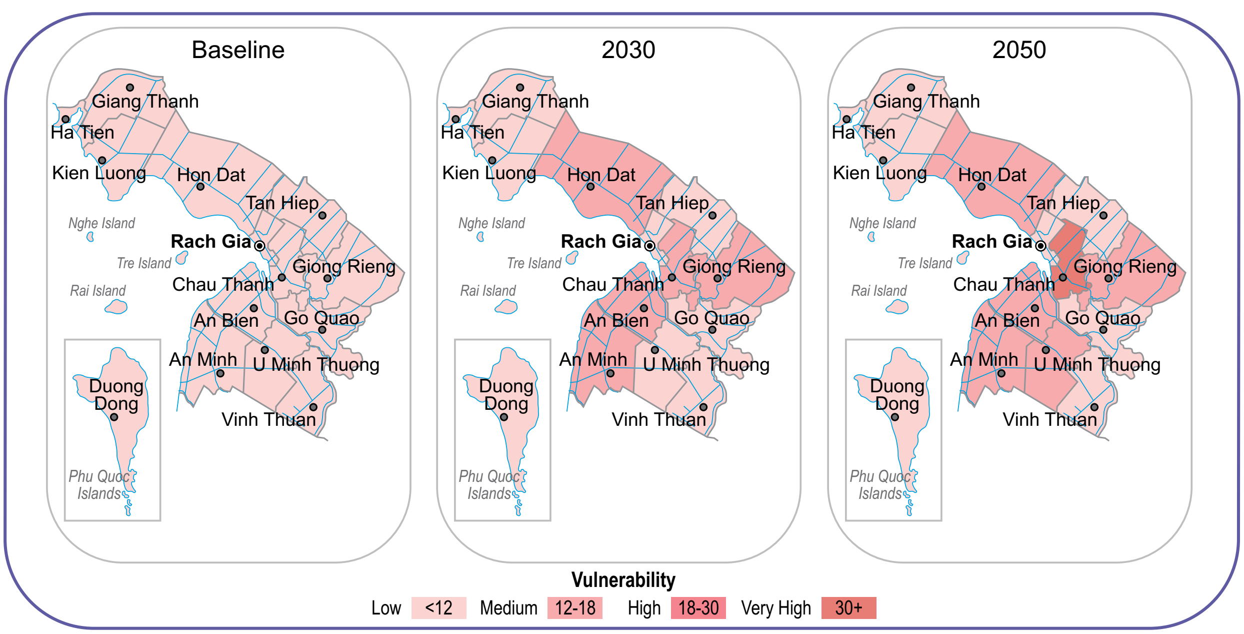
Using the indicators together with future projections of population growth, we were able to estimate or rate the relative poverty vulnerability at the district levels, and comparative vulnerabilities of each district are represented geographically in the map. We assume that estimates of relative poverty levels will stay the same (i.e., without poverty reduction interventions).

For each province, we ranked the districts out of 40 according to these indicators and found the following results:

- The current poverty vulnerability for all the districts in Kien Giang was low.
- By 2030, 5 out of the 15 districts in Kien Giang were assessed as being medium (i.e., Giong Rieng, An Bien, An Minh, Hon Dat, and Chau Thanh).
- By 2050, Chau Thanh in Kien Giang was assessed as being highly vulnerable.

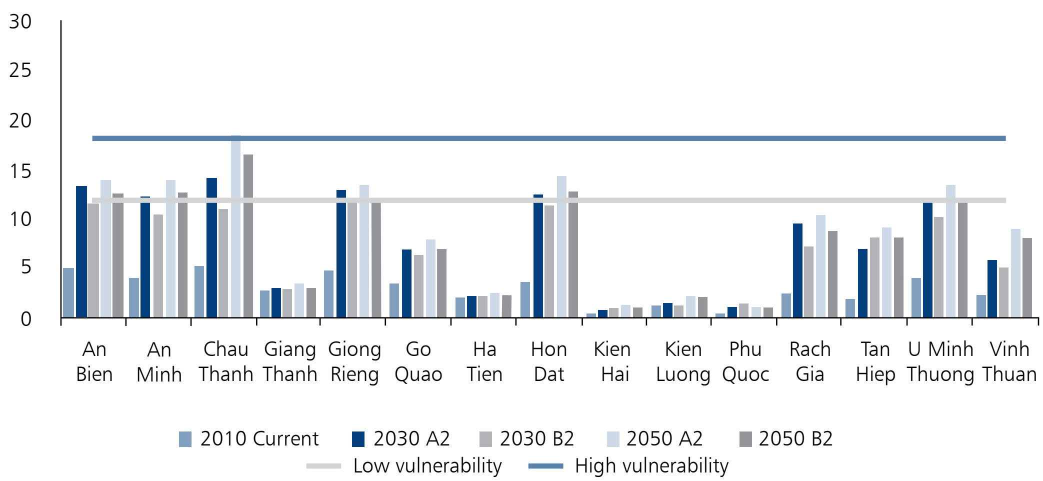
Whilst all the indicators of poverty are important, the primary driver of poverty vulnerability in Kien Giang proved to be access to land resources. As access to productive land is important for reducing rural poverty, the impacts of climate change on the productivity of the land will further constrain efforts to combat rural poverty.

Poverty Vulnerability—A2 Scenario (Baseline, 2030, 2050)



In almost all districts, limited space is either a problem now, or will be in the near future. In the Mekong Delta, pressure on space will increase dramatically in the future, and this in turn will place unparalleled pressure on household livelihood systems and the regional economy in general.

Figure 10 **Poverty Vulnerability**



Risks

Table 23 **Risk of Climate Change on Poverty Dimensions**

Climate Change Impact	Poverty Dimensions: Household Incomes	Poverty Dimensions: Health and Education	Poverty Dimensions: Ethnic Minorities
Temperature	Medium	Medium	Low
Sea Level Rise	High	High	Medium
Flooding and Inundation	High	High	Medium
Salinity	Medium	High	Low
Storm Surge	High	Medium	Low
Typhoons	High	High	High

The primary risks to poverty in the study area relate to the combined effects of sea level rise, flooding, and inundation and the impacts associated with extreme events. The risks associated with salinity and temperature again are minor in comparison.

Hot Spots

The most vulnerable district from a poverty perspective was assessed as being Chau Thanh.

Chau Thanh: High numbers of poor and ethnic households, low income, and limited availability of agricultural land lead to high vulnerability that increases in the future as population increases and a greater area is subject to impacts especially up to 2030.

Agriculture and Livelihoods Vulnerability

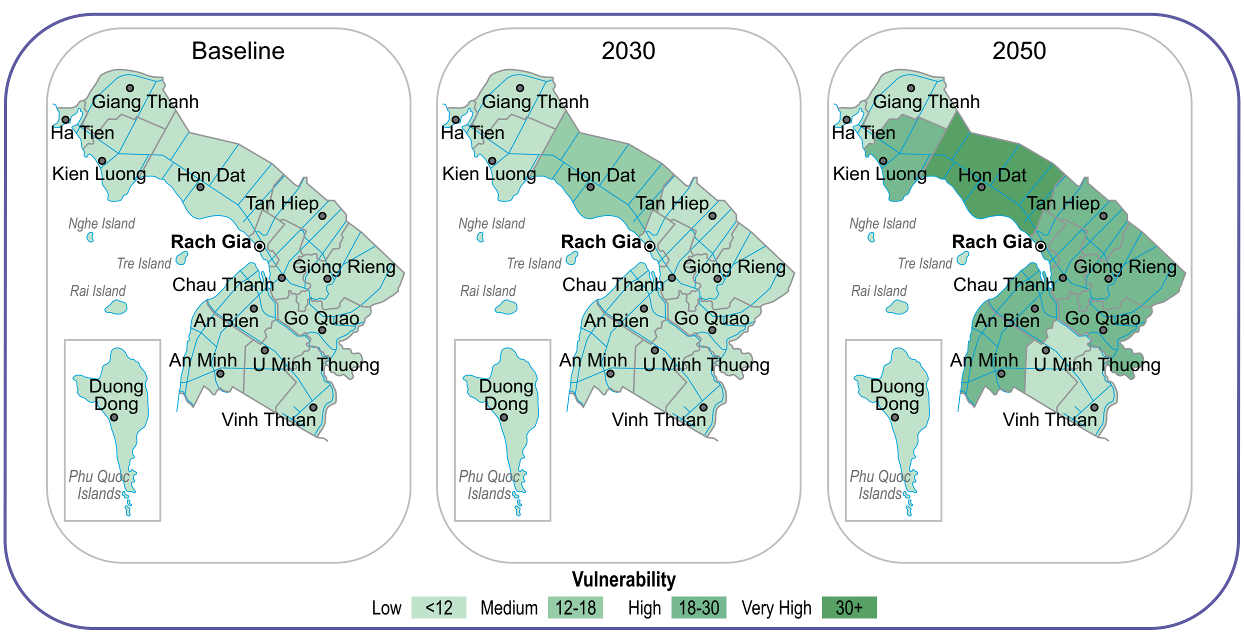
Agriculture and livelihoods vulnerability refers to the vulnerability of agricultural farming, infrastructure, and livelihood systems in the study area to the effects of climate change, and recognizes that in Viet Nam the single farmer household is the basic economic unit upon which the agriculture sector is built at the commune, district, and provincial levels. It is also central to understanding the current and future effects of climate change. In this context, a household agricultural and livelihood system is considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible.

We measured vulnerability by combining data and information from the district and sectoral surveys, including human assets (occupations, access to employment, adults at working age, etc.), natural assets (water, land, aquatic, etc.), and economic (sectoral productivity, GDP, and productive assets) and financial capital (household wealth characteristics), together with water-reliant livelihood strategies.

The districts were ranked in the study area according to their relative exposure to flooding, inundation, salinity, and storm surges, and we found the following:

- The level of exposure to climate hazards such as flooding, inundation, and salinity, together with a heavy dependence on natural resources for their livelihoods, make rural communities vulnerable.
- However, the overall agricultural and livelihoods vulnerability for all districts in Kien Giang were assessed as being low—primarily because of the level of control, adaptation, and resilience exhibited in all districts.

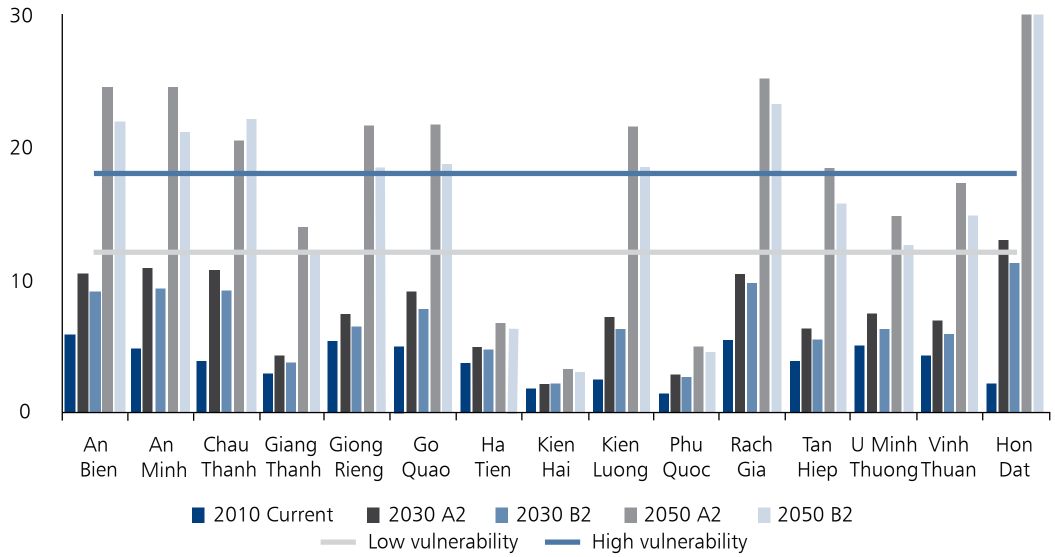
Agriculture and Livelihoods Vulnerability—A2 Scenario (Baseline, 2030, 2050)



- It is expected that this situation will change by 2030, with Hon Dat's exposure assessed as being medium.
- By 2050, the rating for Hon Dat is assessed as being very high and that for all mainland districts except Ha Tien is expected to increase to medium or high, primarily due to the increase in the level of exposure to flooding and inundation, and the heavy reliance on water-based livelihood and agricultural systems.

The most vulnerable districts are those with a large number of households that are highly dependent on water-reliant farming systems (such as the rice-based system) and those most exposed to river-based flooding and inundation. The coastal districts, whilst being adversely affected by salinity and storm surges, were not assessed as very highly vulnerable, primarily due to the higher level of control and/or protection afforded by the sea dike and sluice gate system.

Figure 11 **Agriculture and Livelihoods Vulnerability**



Risks

The main risks to agriculture and livelihoods in Kien Giang relate to the combined effects of increased temperature, flooding and inundation, and the impacts associated with extreme events. The risks associated with salinity and sea level rise are generally minor in comparison due to the control measures currently in place.

Table 24 **Risk of Climate Change to the Agriculture and Livelihoods Sectors**

Climate Change Impact	Agriculture Livelihoods Rice-Based System	Rice/Shrimp System	Aquaculture	Household GDP
Temperature	High	High	High	High
Sea Level Rise	High	Medium	Medium	Medium
Flooding and Inundation	High	Medium	Medium	High
Salinity	Medium	Medium	Low	Medium
Storm Surge	Medium	High	High	High
Typhoons	High	High	High	High

GDP = gross domestic product.

Hot Spots

The following districts were assessed as being the most vulnerable from an agricultural and livelihood perspective:

An Bien: A high rural population with low incomes is offset by available land per head of population. Exposure to all three hazards leads to high vulnerability in the future.

An Minh: A high rural population with low incomes is offset by good availability of land per head of population.

Rach Gia: A low number of rural households keeps the present vulnerability low, but increasing exposure to inundation and saline intrusion increases vulnerability in the future.

Hon Dat: Low population density and good access to agricultural land lead to low initial vulnerability. A high growth rate of the mostly rural population and an increase in exposure to inundation and storm surge increase vulnerability in the future.

Chau Thanh: High vulnerability due to a high rural population and low annual income are ameliorated by a high number of other income streams. However, vulnerability increases in the future as a greater area of agricultural land is subject to impacts.

Giong Rieng: A very large rural population and low annual income are exposed to inundation and salinity leading to high vulnerability as both population and the area exposed to inundation increase.

Go Quao: A high reliance on agriculture is ameliorated by moderate GDP and household access to land. Vulnerability increases in the future due to a gradual increase in the area affected by inundation and salinity.

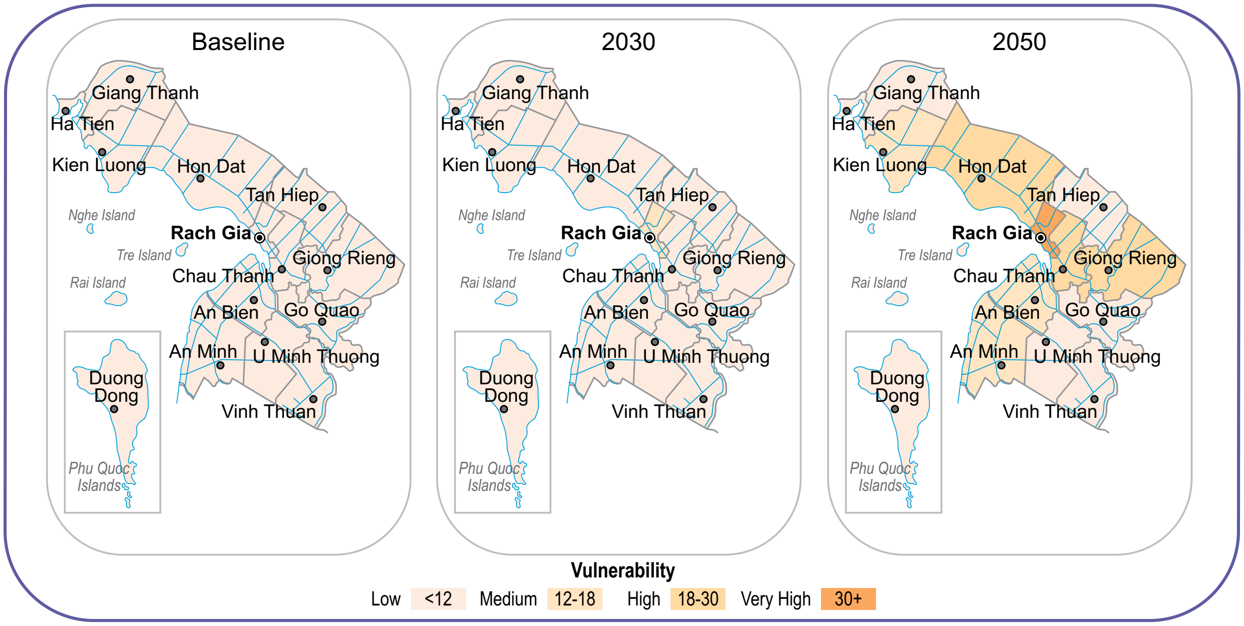
Energy and Industry Vulnerability

Energy and industry vulnerability refers to the vulnerability of industrial and energy generation, transmission infrastructure and services to the effects of climate change and recognizes that industry and energy generation are important drivers for the economic development, growth, and sectoral transition in the Mekong Delta necessary to build resilience and adaptive capacity into the future. In this context, industry and energy infrastructure and services are considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible. We measured energy and industry vulnerability by combining data and information from the district and sectoral surveys, including human assets (percentage of population working in industry, households reliant on industry), natural assets (diversity of industrial development, power generation capacity), and economic (sectoral productivity, average annual GDP per household contribution from industry) and financial capital (investment levels, household connections, levels of service, etc.), together with the nature, location, and extent of industrial zones, energy generation, and power transmission infrastructure.

We ranked overall vulnerability of each district according to the indicators and found the following results:

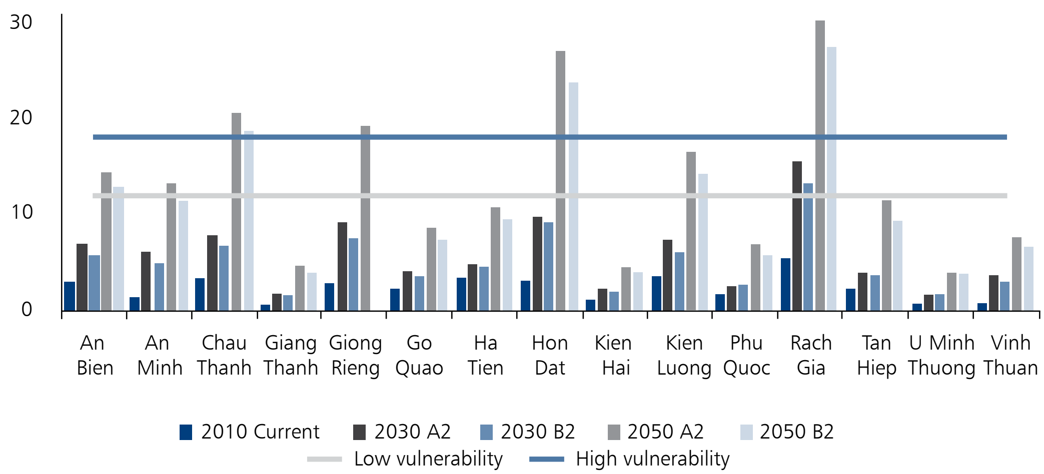
- Industry vulnerability for all districts in Kien Giang is currently low.
- It is expected that the situation will show little change by 2030, with only that for Rach Gia City increasing to medium.
- By 2050, the ratings for six districts (An Minh, An Bien, Kien Luong, Giong Rieng, Chau Thanh, and Hon Dat) are expected to increase to medium or high, primarily due to the exposure of surface water resources to sea level rise and the combined effects of flooding, saline intrusion, and storm surges. The combined effects of these hazards on the concentration of industry and energy infrastructure in coastal Rach Gia City result in an increase in vulnerability to very high.

Energy and Industry Vulnerability—A2 Scenario (Baseline, 2030, 2050)



The most vulnerable districts are those with a large number of households that are highly dependent on local industry for employment or income and are most exposed to sea level rise, flooding, inundation, and extreme events and their effects on industrial areas, factories, and power generation and supply infrastructure and services. The coastal districts, whilst being adversely affected by salinity and storm surges, were assessed as less vulnerable, primarily due to the higher level of control and or protection afforded by the sea dike and sluice gate system.

Figure 12 **Energy and Industry Vulnerability**



Risks

The main risks to industry and energy infrastructure in the study area relate to the combined effects of sea level rise, flooding, inundation, and the impacts associated with extreme events. The risks associated with salinity and temperature again are medium in comparison except for the risk that increased temperature poses to primary industry (processing of agricultural, fisheries, and timber products).

Table 25 **Risk of Climate Change to the Energy and Industry Sectors**

	Industry Type			Power Infrastructure	
Climate Change Impact	Primary Industry	Manufacturing and Construction	Services Industry	Power Generation Facilities	Power Transmission
Temperature	High	Medium	Low	Medium	Low
Sea Level Rise	High	Medium	Medium	Medium	Low
Flooding and Inundation	High	Medium	Medium	Medium	Medium
Salinity	Medium	Medium	Low	Low	Low
Storm Surge	Medium	Medium	Medium	Medium	Low
Typhoons	High	High	Medium	High	High

Hot Spots

The following were identified as the most vulnerable districts in Kien Giang:

Chau Thanh: A high contribution to GDP from industry and the presence of energy infrastructure leads to high vulnerability. Vulnerability increases in the future as a greater area is subject to impact.

Hon Dat: The large population means that a large number of households are reliant on industry, increasing vulnerability in the future as population and exposure of the extensive power infrastructure increases.

Rach Gia: The aggregation of industry and electricity infrastructure in the city and the reliance of household incomes on industry mean that Rach Gia is vulnerable. The combined effect of the three impacts increases the vulnerability over time.

Urban Settlements and Transportation Vulnerability

Urban settlements and transportation vulnerability refers to the vulnerability of urban settlements and transportation to the effects of climate change. It recognizes the need to protect people and property and the importance of the transportation system to support and promote regional development and economic growth in the Mekong Delta.

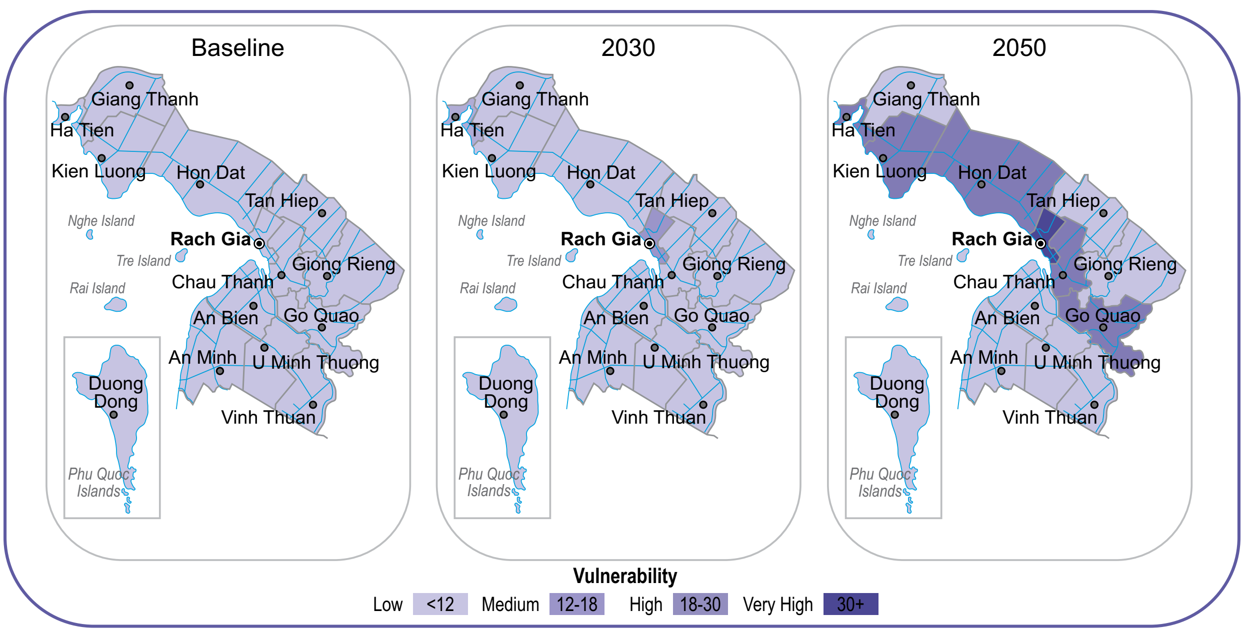
In this context, urban settlements and transportation infrastructure are considered to be vulnerable if there is a high probability of loss or damage from climate change, from which there is a high probability of not recovering quickly or fully because the effects are either irreversible or the opportunities of recouping the losses are negligible.

We measured urban settlements and transportation vulnerability by combining data and information from the district and sectoral surveys, including human assets (percentage of urban population), natural assets (percentage of urban area), and economic (value of goods shipped) and financial capital (urban infrastructure and levels of service), together with the nature, location, and extent of the transportation network and infrastructure.

We ranked overall vulnerability of each district according to the indicators and found the following:

- The overall urban settlements and transportation vulnerability for all districts in Kien Giang is currently assessed as being low, primarily because of the level of control, adaptation, and resilience exhibited in all districts.

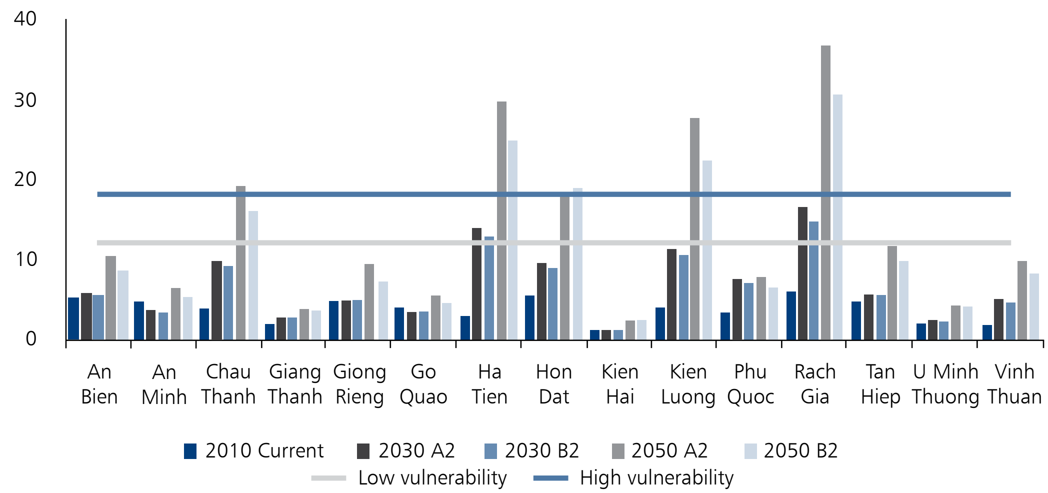
Urban Settlements and Transportation Vulnerability—A2 Scenario (Baseline, 2030, 2050)



- It is expected that this situation will change by 2030, with the cities of Ha Tien and Rach Gia rising to medium vulnerability due to their exposure to storm surges.
- By 2050, the rating for four coastal districts is expected to increase to high, primarily due to the increase in the level of exposure to storm surges, inundation, and flooding. The combined effects of these hazards on the coastal city of Rach Gia result in an increase in vulnerability to very high.

While this study has highlighted the strong vulnerability of rural populations in the study area to climate change, our assessment clearly shows that the city of Rach Gia and the other large towns of Ha Tien and Kien Luong face major vulnerabilities themselves, with the potential to affect large numbers of people and households. The most vulnerable districts are those with high levels of urban infrastructure, buildings, and urban households, which are highly exposed to flooding, inundation, and storm surges.

Figure 13 **Urban Settlements and Transportation Vulnerability**



Risks

The primary risks to urban settlements and transportation infrastructure in the study area relate to the combined effects of sea level rise, flooding, inundation, and the impacts associated with extreme events. The risks associated with salinity and temperature again are medium in comparison.

Table 26 **Risk of Climate Change to the Urban Settlements and Transportation Sectors**

	Settlements			Transportation		
Climate Change Impact	Building	Water Supply	Waste and Sanitation	Road Transport	Waterway Transport	Ports and Harbors
Temperature	Low	Low	Low	Medium	Low	Low
Sea Level Rise	High	Medium	Medium	Medium	Medium	High
Flooding and Inundation	High	Medium	Medium	Medium	Medium	Low
Salinity	Medium	Medium	Low	Medium	Low	Low
Storm Surge	High	Low	Low	Medium	Medium	High
Typhoons	High	Medium	Medium	Medium	High	High

Hot Spots

The following districts in Kien Giang were assessed as being the most vulnerable:

Rach Gia: The high population, combined with a relatively large concentration of urban and transportation infrastructure, makes it both highly exposed and sensitive to a range of climate change impacts, especially flooding and inundation.

Chau Thanh: Despite a relatively small urban area, the large, densely settled population and the presence of transportation infrastructure increases vulnerability in this sector. In all sectors, vulnerability increases in the future due to high population growth which emphasizes the current susceptibility to all three impacts.

Kien Luong: Moderate urbanization and poor access to water and sanitation lead to increased vulnerability in the future.

Ha Tien: The high level of urbanization makes the district highly vulnerable. The urban area is increasingly exposed to all three impacts in the future.

Regional Vulnerability Synthesis

The first phase of the vulnerability assessment began with an evaluation of how specific systems, both natural and human, such as roadways, water resources, and industrial areas, etc., were exposed to climate hazards and impacts. To this end, a composite of the vulnerability indicators for the main sectoral areas and hazard categories was used to assess the vulnerability of both the natural and human systems in the study area in terms of exposure and sensitivity and to measure risk and adaptive capacity. The vulnerability rankings for each of the districts were based on a standard set of indicators so that their vulnerability could be compared not only between districts, but also across sectors. The assessment was supplemented by expert judgment and feedback from the key stakeholder groups and government agencies. Vulnerability rankings were averaged across the five dimensions and sectors to produce a vulnerability synthesis ranking.

Comparison of the rankings for the different districts clearly shows that current overall vulnerability to climate change for the majority of districts is low. However, into the future, vulnerability in many districts was assessed as being medium to high. The vulnerability assessment identifies three districts as being highly vulnerable to the impacts of climate change by 2050.

Vulnerability Synthesis—A2 Scenario (Baseline, 2030, 2050)

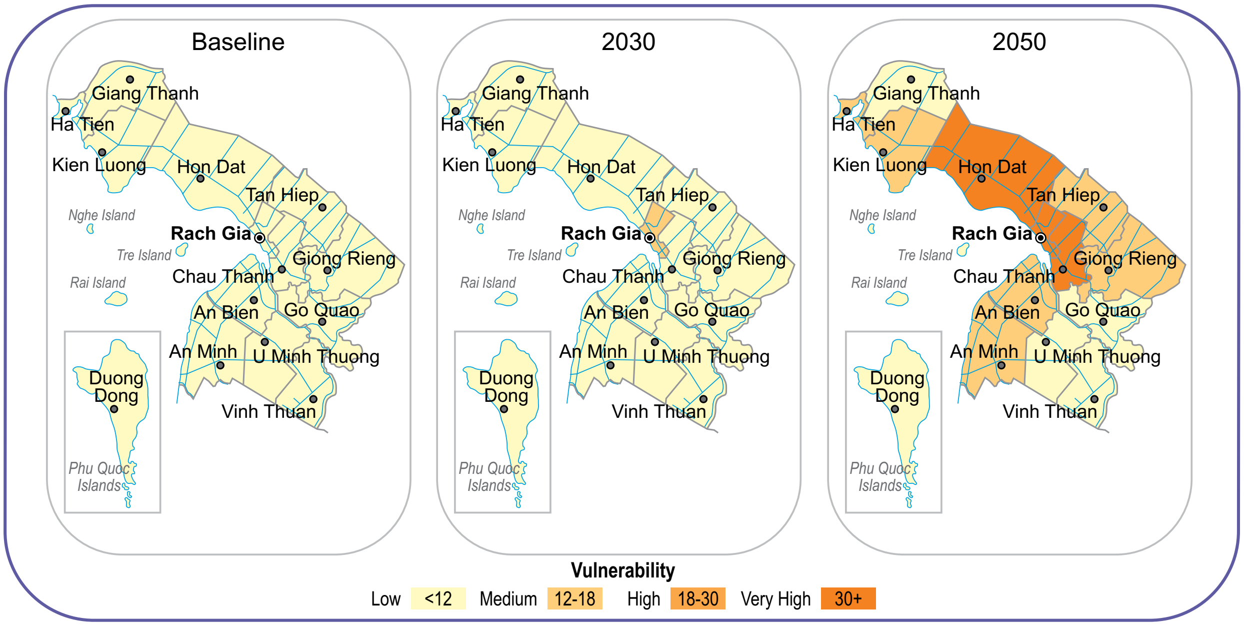
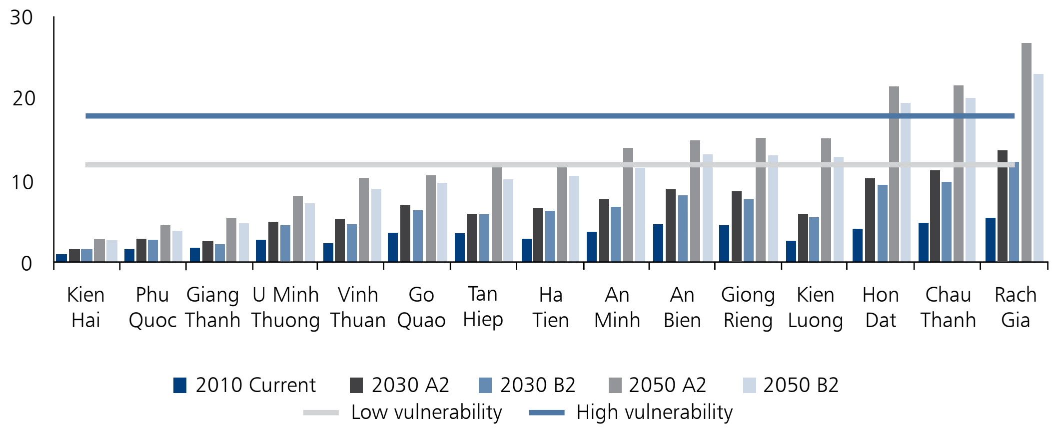


Figure 14 **Kien Giang Vulnerability Synthesis**



Summary of Sector Control Measures

In terms of magnitude and extent, river flooding and inundation clearly represent the greatest threats to Kien Giang and 12 of the 15 districts were assessed as having major exposure to flooding and inundation with few control mechanisms in place. All of the coastal districts are exposed to coastal erosion. However, the sea dike system, with an average height above sea level of 1.2 meters, currently provides adequate protection for all the coastal districts except the island districts of Phu Quoc and Kien Hai. For most districts, the impacts were assessed as intermediate and/or partly controlled. The sea dike also currently offers protection from storm surges. While the exposure to salinity is widespread and considered to have potentially major impacts for just about all of the mainland districts, control measures are largely in place and the impacts are generally only moderate.

The impacts of climate change hazards on the population sector were considered to be minor or intermediate and are largely controlled at present. Overall, the protection measures were assessed as being moderate in this sector. In the poverty and income sector, impacts ranged from minor to major. While the impacts from erosion and storm surges are currently well controlled, the control measures for flooding and salinity impacts are inadequate. Overall, the protection measures in this sector were assessed as being moderate.

The impacts of climate change hazards on the agriculture and livelihoods sector ranged from minor to major. While the impacts from storm surges are currently well controlled, the control measures protecting against the other hazards are inadequate, particularly against flooding and salinity. Overall, the protection measures in this sector were assessed as being low and those in both the energy and industry and the urban settlements and transport sectors were assessed as being high.

As previously noted, these climate change impacts are not new to the people of the delta and most of the districts have control measures in place to deal at least partly with the level of impacts to which they are currently exposed. This is not to say that coastal and flood protection is adequate. Projected increases in sea level mean that upgrading of both the sea dike system and the flood control system is urgently needed, as are coastal and erosion control measures for both Phu Quoc and Kien Hai islands.

Table 27 **Summary of Adequacy of Control Measures Across All Sectors**

Sector	Impacts: Erosion and Sedimentation	Flooding and Inundation	Salinity	Storm Surge	Overall Adequacy of Control Measures
Population	•	••	••	•	Moderate
Poverty and Income	•	••	•••	•	Moderate
Agriculture and Livelihoods	••	•••	•••	•	Low
Industry and Energy	•	•	•	•	High
Urban Settlements and Transportation	•	•	•	•	High

•	Minor exposure and/or well controlled
••	Intermediate exposure and/or largely
•••	Major exposure but partly controlled
••••	Major exposure and little control

Highly Vulnerable Districts

In Kien Giang, the following districts have been identified as being expected to have a high level of overall vulnerability to climate change across the various sectors in this study:

- Chau Thanh
- Rach Gia
- Hon Dat

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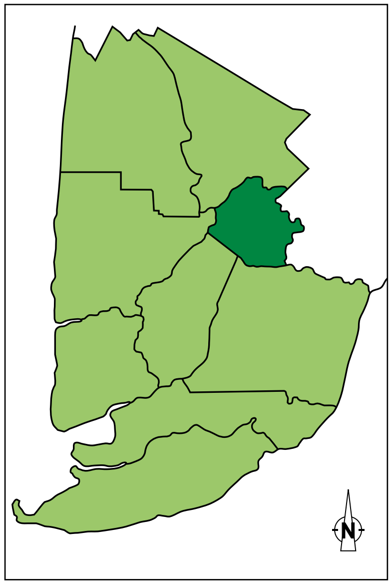
Appendix 1

Ca Mau Province District Summaries

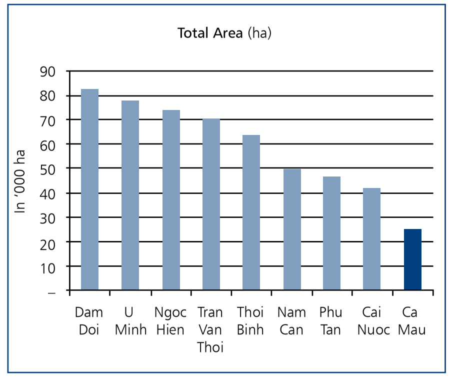
Ca Mau City

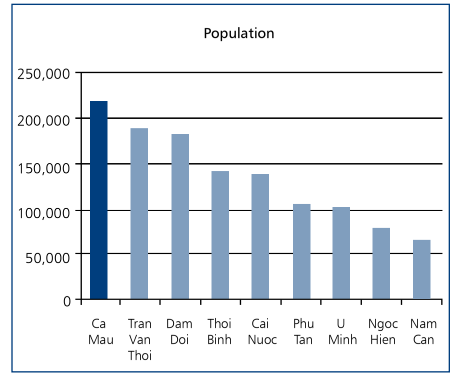


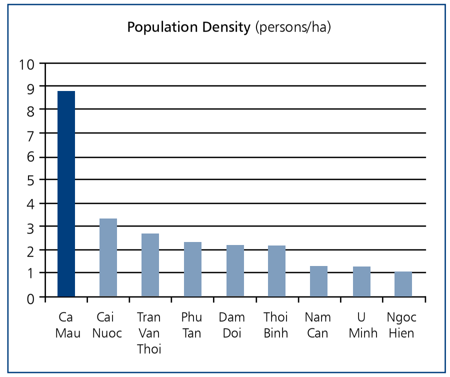
Administrative Center	Provincial Capital
Land Area (ha)	24,929
Population	218,148
Population Density (persons/ha)	8.75
No. of Households	53,229
Average Family Size	4.10
Average Annual Household Income	D50,035,000
GDP Contribution from Industry (HH)	D11,529,938
Unemployment Rate	No Data
Education (teachers/1,000 persons)	9.4
Health (doctors/1,000 persons)	1.34
Ethnicity (% Kinh/non-Kinh)	99.1/0.9

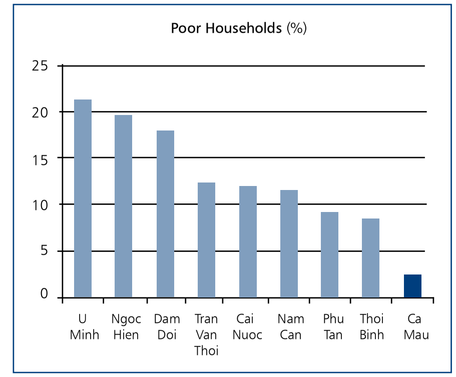
GDP = gross domestic product, ha = hectare, HH = household.

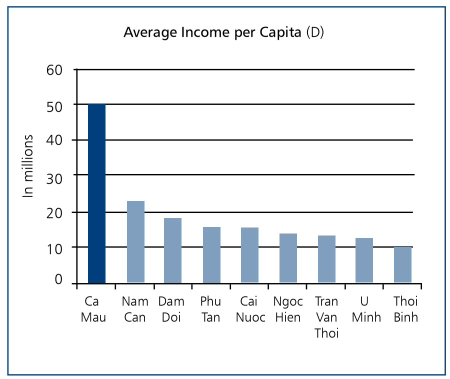
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	Low
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	Medium
	No. of Doctors	Low
	Agricultural Land per Person	High
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	High
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	High
	No. of Factories	High
	No. of Different Industries	Medium
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	High
	% of Urban Area/Population	High
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	–
	Major Roads	Medium
	District Roads	Low
	Transport Hubs	High

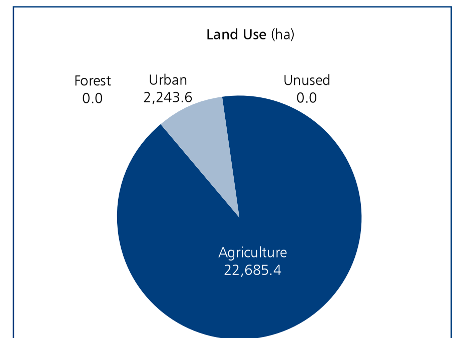








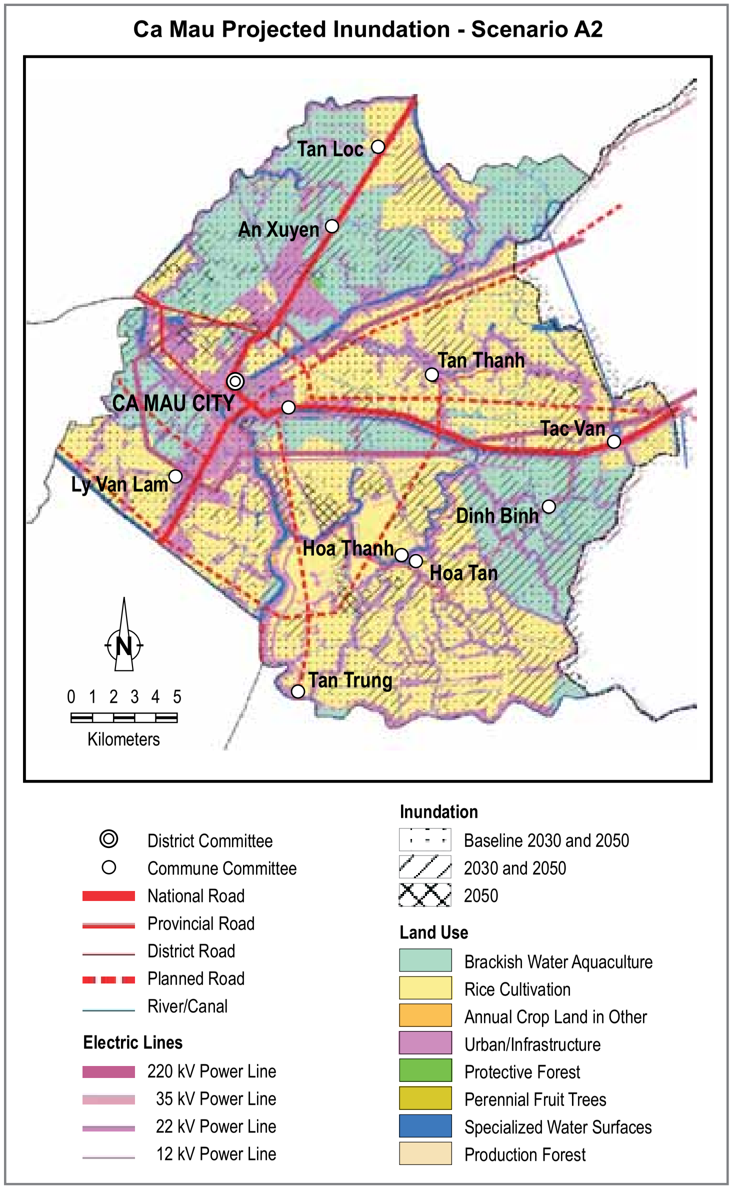




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	64.41	9.14	23.23	36.26
Power (km)	347.20	69.61	172.00	234.45
Agriculture Area (km^2)	117.11	18.72	60.95	82.35
Aquaculture Area (km^2)	61.68	13.28	33.56	45.16
Residential and Commercial Land (km^2)	14.90	2.79	7.45	10.84

km = kilometer, km^2 = square kilometer.



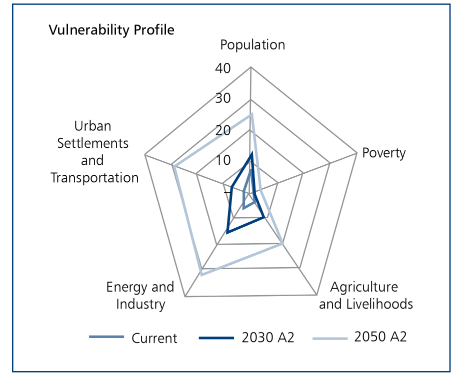
Population: A high-density, large existing population combined with large inward migration results in high vulnerability for this dimension.

Poverty: High incomes, a low number of poor households, and good access to health and education lead to low vulnerability in this dimension.

Agriculture and Livelihoods: A low number of rural households keeps the present vulnerability low, but exposure to inundation and saline intrusion increases vulnerability in the future especially by 2050.

Energy and Industry: The aggregation of industry and electricity infrastructure in the city and the reliance of household incomes on industry mean that Ca Mau City is vulnerable in this sector, especially to extreme events. The extent increases in the future particularly due to flooding.

Urban Settlements and Transportation: The high population, large urban area, and concentration of transport hubs increase vulnerability in this sector.



In all sectors except poverty, vulnerability increases in the future due to population growth and inward migration, which emphasizes the current susceptibility to impacts.

Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	19	100	0
	2030	25	100	0
	2050	71	100	0
Risk Rating	Current	3	10	0
	2030	6	10	0
	2050	9	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

While exposure to flooding is currently low, it is projected to increase with an associated increase in risk by 2050. The district is completely exposed to salinity with medium risk.

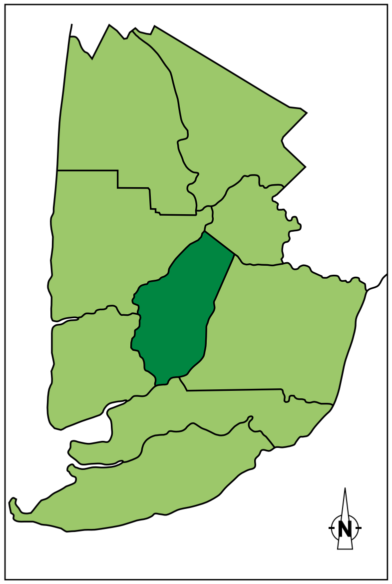
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•	•••	•
Major Industry	•••	••	•
Major Energy	•••	•	•
Urban	••••	•	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements of the salinity control measures for agricultural infrastructure are required in the medium term in the areas of dike strengthening, improvements to sluice gates, and improvements to aquaculture techniques and calendars. Flood protection measures in the energy and industry sectors are required in the medium term, and urban infrastructure requires immediate protection. These are mainly related to raising structures above flood levels and improving water and sanitation.

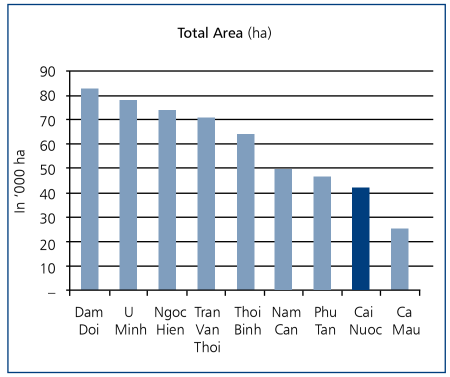
Cai Nuoc

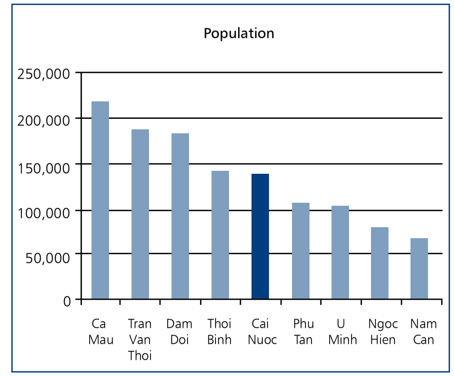


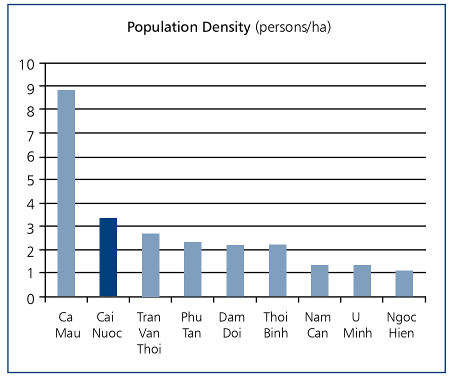
Administrative Center	Cai Nuoc
Land Area (ha)	41,700
Population	137,846
Population Density (persons/ha)	3.31
No. of Households	32,441
Average Family Size	4.25
Average Annual Household Income	D15,399,600
GDP Contribution from Industry (HH)	D398,660
Unemployment Rate	3.2%
Education (teachers/1,000 persons)	11.5
Health (doctors/1,000 persons)	0.68
Ethnicity (% Kinh/non-Kinh)	99.1/0.9

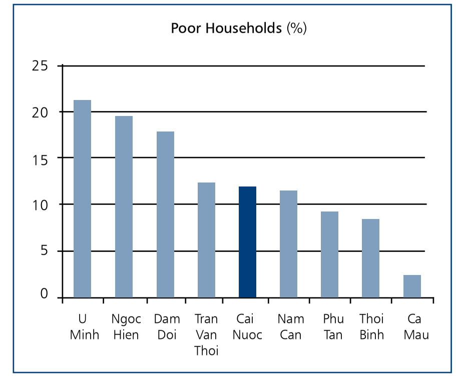
GDP = gross domestic product, ha = hectare, HH = household.

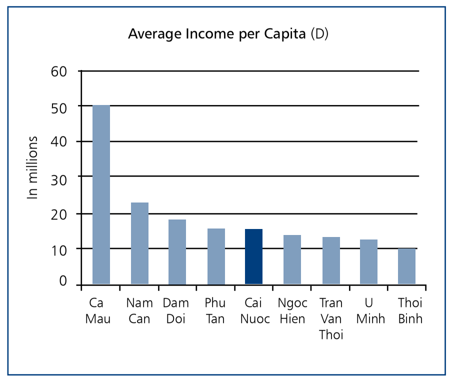
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	Low
	No. of Households	High
	Population at Working Age	Medium
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Medium
	% of Poor Households	Medium
	No. of Teachers	Low
	No. of Doctors	Low
	Agricultural Land per Person	High
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	Low
	No. of Factories	High
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	High
	Urban Households	High
	Urban Area	Medium
	% of Urban Area/Population	High
	Sewer/Septic Tank	Medium
	Water Supply	Medium
	Major Waterways	–
	Major Roads	Medium
	District Roads	Low
	Transport Hubs	Low

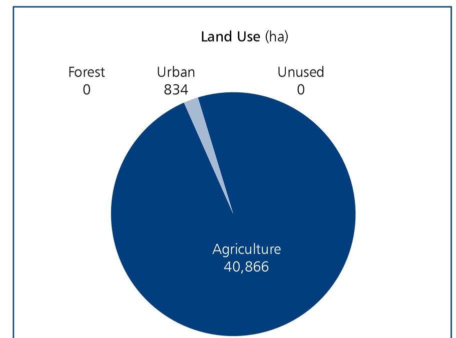








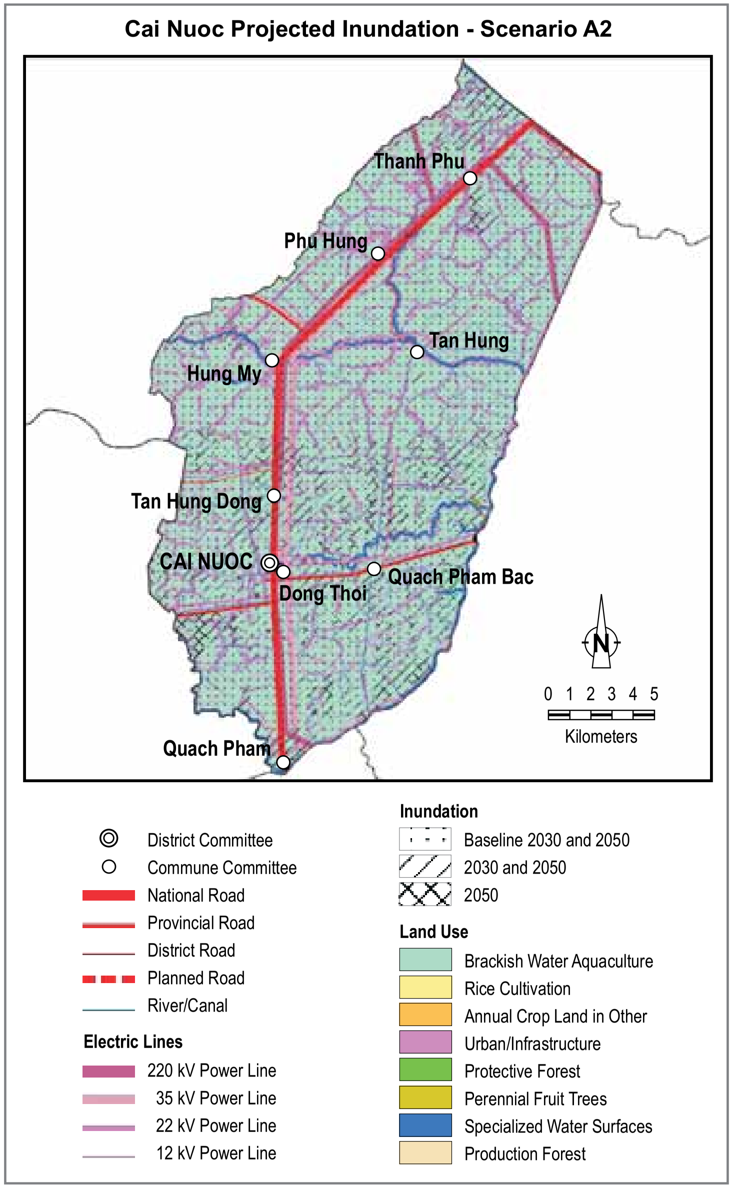




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	73.14	28.26	49.86	62.28
Power (km)	390.26	181.09	273.20	325.30
Agriculture Area (km^2)	86.33	38.58	57.79	68.13
Aquaculture Area (km^2)	305.53	137.14	212.69	249.18
Residential and Commercial Land (km^2)	0.23	0.08	0.15	0.19

km = kilometer, km^2 = square kilometer.



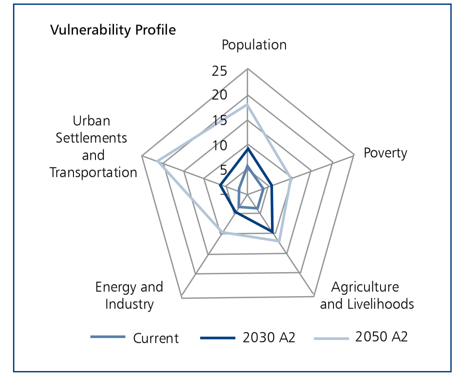
Population: An increasing area of the district will be subject to inundation affecting greater numbers of families in the future.

Poverty: An intermediate percentage of poor households and good access to health and education ameliorates the effects of increased inundation.

Agriculture and Livelihoods: The major increase in the area flooded occurs in 2030, increasing vulnerability.

Energy and Industry: The level of industrialization means there is low vulnerability in this sector.

Urban Settlements and Transportation: A moderate urban population and poor sewage connections lead to high vulnerability that increases with extensive flooding in the future.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	47	100	0
	2030	70	100	0
	2050	82	100	0
Risk Rating	Current	6	10	0
	2030	9	10	0
	2050	9	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

While exposure to flooding is currently moderate, it is projected to increase with an associated increase in risk. The district is completely exposed to salinity with medium risk.

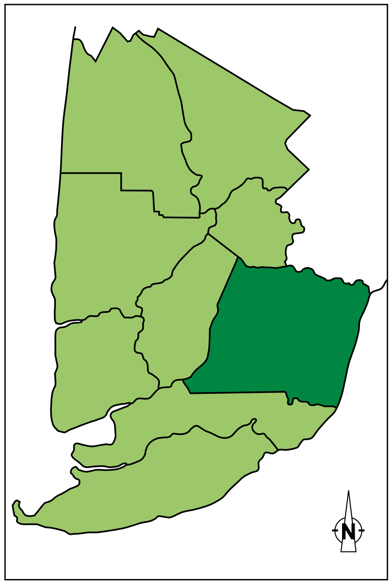
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	•	•
Major Industry	••	•	•
Major Energy	••	•	•
Urban	••	••	•
Transportation	•	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

The overall control measures are good across all of the sectors. Improvements against flooding will be required for most sectors and against salinity in the urban sector in the long term. These are mainly related to dike strengthening and improvements to sluice gates, and improvements in aquaculture techniques and calendars in order to account for climate change, raising structures above flood levels, and improving water and sanitation.

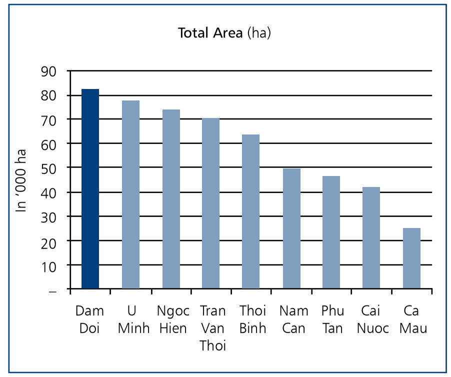
Dam Doi

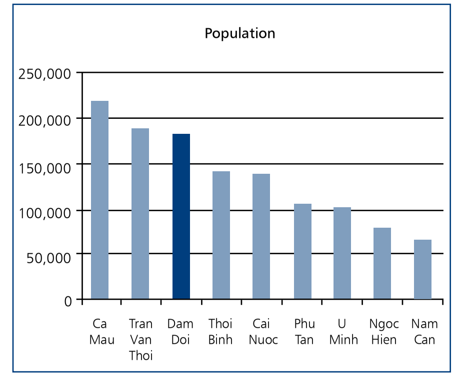


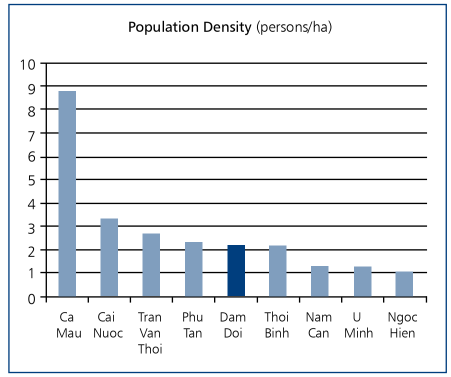
Administrative Center	Dam Doi
Land Area (ha)	82,228
Population	182,332
Population Density (persons/ha)	2.19
No. of Households	39,724
Average Family Size	4.59
Average Annual Household Income	D18,156,000
GDP Contribution from Industry (HH)	D435,111
Unemployment Rate	19.1%
Education (teachers/1,000 persons)	7.1
Health (doctors/1,000 persons)	0.37
Ethnicity (% Kinh/non-Kinh)	96.4/3.6

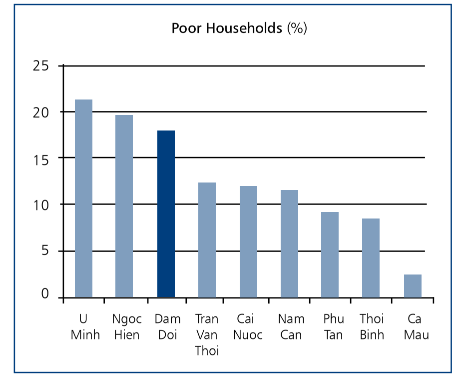
GDP = gross domestic product, ha = hectare, HH = household.

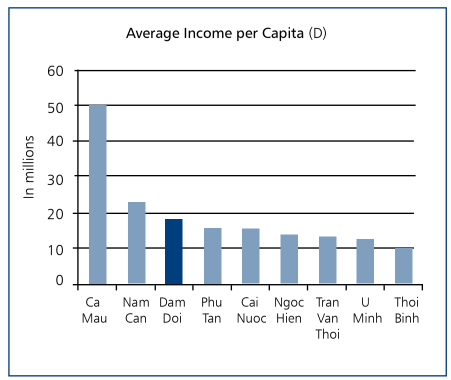
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	Medium
	Average Family Size	High
	No. of Households	Medium
	Population at Working Age	High
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	High
	% of Poor Households	High
	No. of Teachers	High
	No. of Doctors	Medium
	Agricultural Land per Person	Medium
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	Low
	No. of Factories	Low
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	High
	% of Urban Area/Population	Low
	Sewer/Septic Tank	Medium
	Water Supply	Medium
	Major Waterways	–
	Major Roads	Medium
	District Roads	High
	Transport Hubs	High

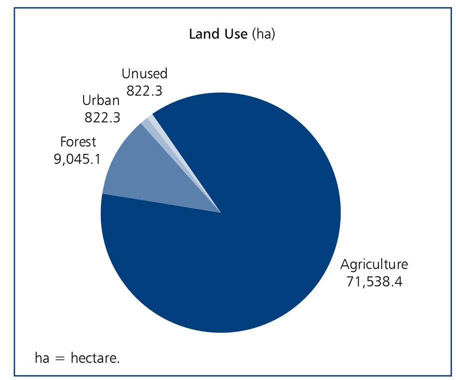






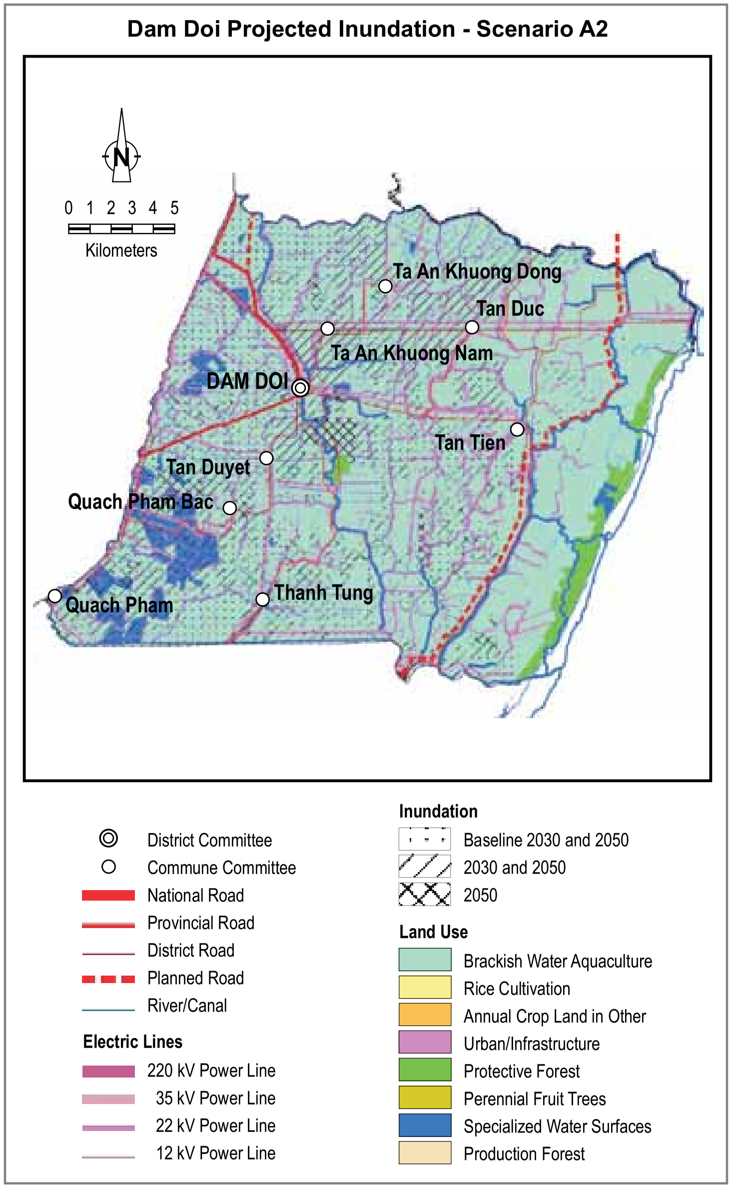






Inundation	Total	2000	2030	2050
Roads (km)	190.10	22.62	45.88	67.98
Power (km)	578.30	84.36	195.82	265.63
Agriculture Area (km²)	110.17	15.33	31.73	41.02
Aquaculture Area (km²)	607.86	57.27	148.94	200.49
Residential and Commercial Land (km²)	111.62	11.34	23.11	38.77

km = kilometer, km² = square kilometer.

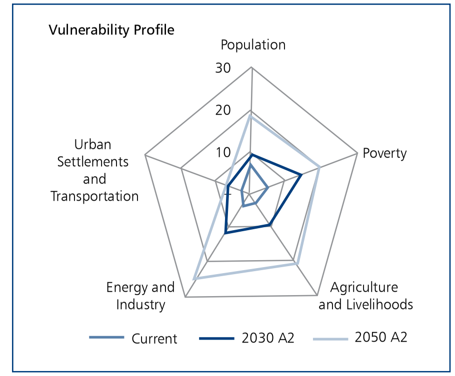


Population: A large family size and a relatively high population mean the initially moderate vulnerability increases in the future due to the increased exposure to inundation and storm surge.

Poverty: A high number of poor household is only slightly ameliorated by moderate access to health and education. Low population growth reduces the effect of increases in inundation by 2050.

Agriculture and Livelihoods: A high number of income streams reduces the current vulnerability, but the large population decreases the availability of land for primary production, thus increasing vulnerability.

Energy and Industry: While industry has a low contribution to the district economy, the large population means that a large number of households are reliant on a few industries. Combined with a poor electrical connection rate but a large amount of electrical infrastructure potentially affected by inundation, salinity, and storm surges, this vulnerability increases in the future.



Urban Settlements and Transportation: A low urban population and protection of the urban center from inundation and storm surges results in little change in vulnerability in the future.

Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	13	100	0
	2030	28	100	0
	2050	36	100	1
Risk Rating	Current	3	10	4
	2030	6	10	4
	2050	6	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

The district has complete exposure to salinity and while exposure to flooding is currently low, it is projected to increase. The risk from saline intrusion is high and the risk from inundation increases in 2030. Exposure to storm surges is projected to increase by 2050. Storm surges along the coast may cause extensive damage. Storm surge risk is low due to it being confined to the coast.

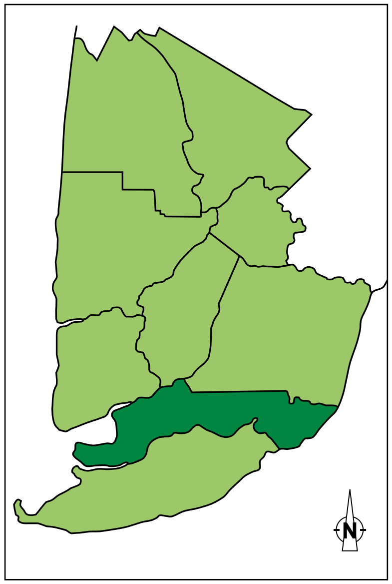
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	•	•••
Major Industry	••	•	•
Major Energy	••	•	••
Urban	••	••	•••
Transportation	•	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

All sectors will require improvements in flooding control measures in the long term. Improvements in the control measures for the agricultural infrastructure are required in the medium to long term to protect from storm surges. Protection measures required are in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in aquaculture techniques and calendars in order to account for climate change. In the urban sector, improvements are required in measures to control storm surges in the medium term and to control flooding and salinity in the long term. Control measures to protect the energy and transport sectors from storm surges will also be required in the long term.

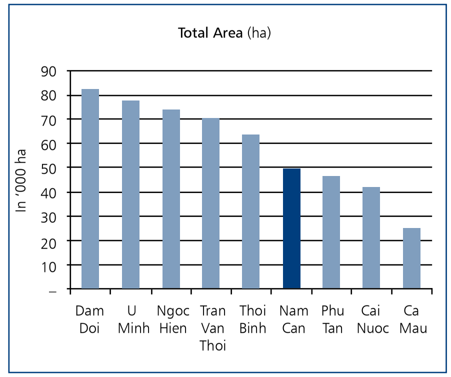
Nam Can

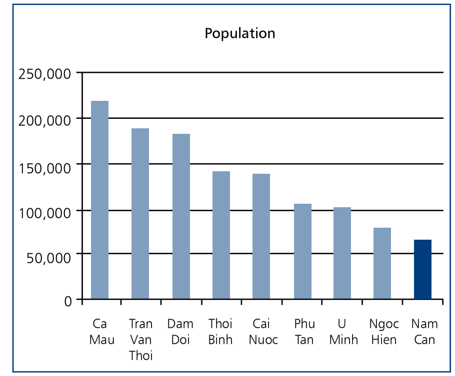


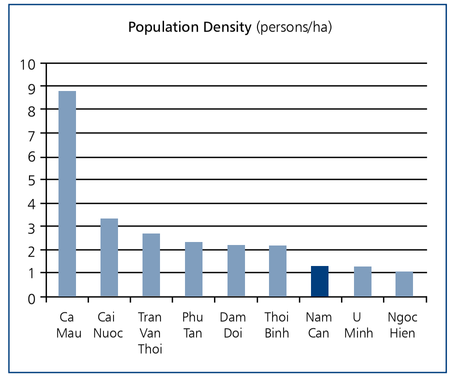
Administrative Center	Nam Can
Land Area (ha)	49,540
Population	66,261
Population Density (persons/ha)	1.30
No. of Households	16,565
Average Family Size	4.00
Average Annual Household Income	D22,656,000
GDP Contribution from Industry (HH)	D175,584
Unemployment Rate	2.5%
Education (teachers/1,000 persons)	8.6
Health (doctors/1,000 persons)	0.54
Ethnicity (% Kinh/non-Kinh)	96.7/3.3

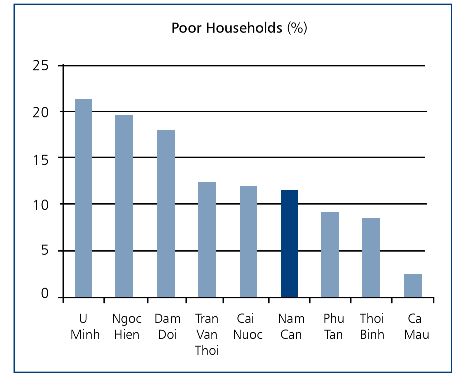
GDP = gross domestic product, ha = hectare, HH = household.

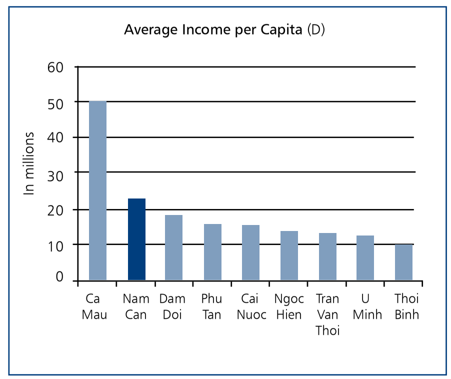
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Low
	% of Poor Households	Medium
	No. of Teachers	Medium
	No. of Doctors	Low
	Agricultural Land per Person	Medium
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Medium
	No. of Different Industries	Medium
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Low
	% of Urban Area/Population	High
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	–
	Major Roads	Low
	District Roads	Medium
	Transport Hubs	Low

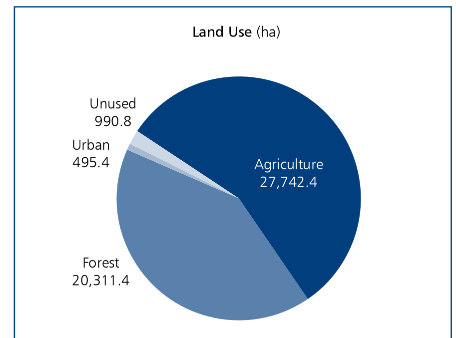








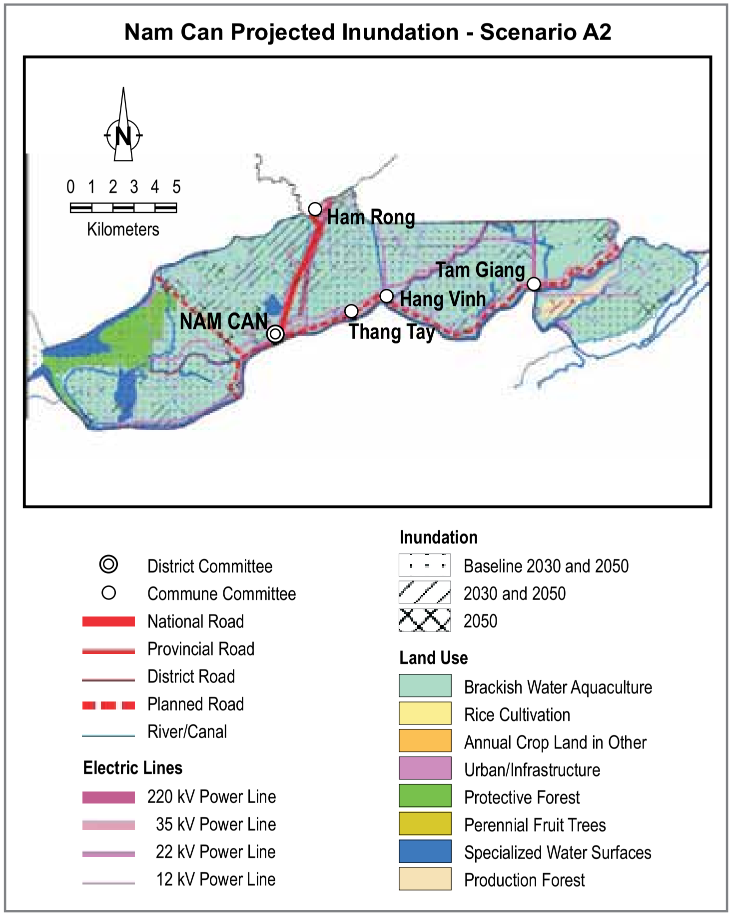




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	63.10	27.09	31.66	33.64
Power (km)	363.67	121.60	159.66	194.35
Agriculture Area (km²)	31.82	14.68	17.69	20.50
Aquaculture Area (km²)	369.02	107.79	153.95	199.67
Residential and Commercial Land (km²)	1.13	0.35	0.55	0.56

km = kilometer, km² = square kilometer.



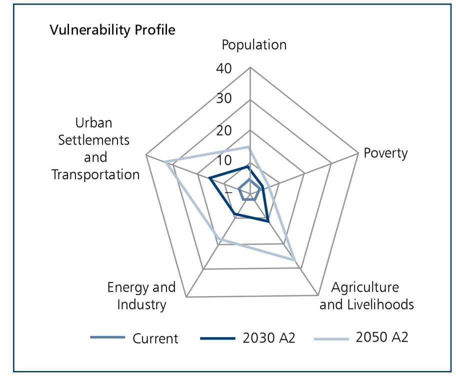
Population: A low population growth rate reduces the vulnerability in this dimension, but an increase in inundation from 36% to 62% and exposure to storm surges increase vulnerability in the future.

Poverty: A low number of poor and ethnic households results in low vulnerability.

Agriculture and Livelihoods: A range of off-farm income sources ameliorates the effects of a high rural population, but vulnerability increases as the area affected by inundation and storm surges increases.

Energy and Industry: A high reliance of household incomes on industry combined with a low rate of connection to the national grid means that vulnerability in this sector also increases.

Urban Settlements and Transportation: A low urban population and protection of the urban center from inundation and storm surges mean that the current vulnerability is low. Vulnerability increases with exposure.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	22	100	60
	2030	29	100	90
	2050	39	100	100
Risk Rating	Current	3	10	8
	2030	6	10	10
	2050	6	10	10

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

The area is completely exposed to salinity, and while exposure to flooding is moderate, it is projected to increase. The risk from saline intrusion is high, and the risk from inundation is projected to increase by 2050. Storm surges along the coast may cause extensive and widespread damage.

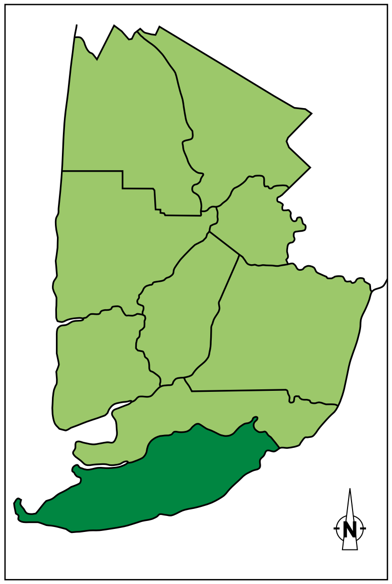
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	••	••••
Major Industry	•	•	••••
Major Energy	••	•	••••
Urban	••	••	••••
Transportation	•	•	••••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

The high exposure to storm surges means improvements in protection are required across all of the sectors in the medium to long term. The agriculture sector will require improvements in the control measures in the medium to long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in aquaculture techniques and calendars in order to account for climate change. The control measures in the urban areas will also require improvements in the long term to protect the town infrastructure from flooding and salinity. The energy infrastructure will also require protection from salinity in the long term.

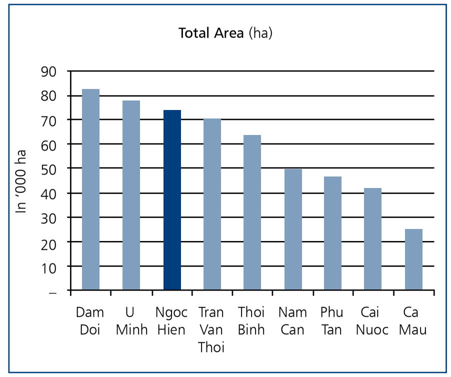
Ngoc Hien

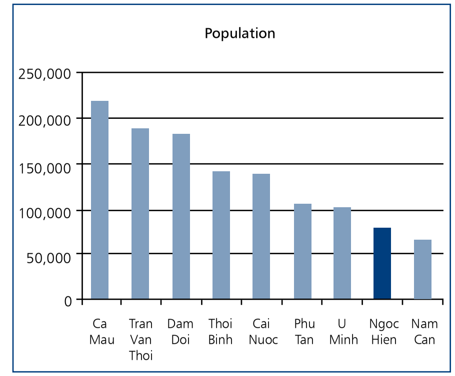


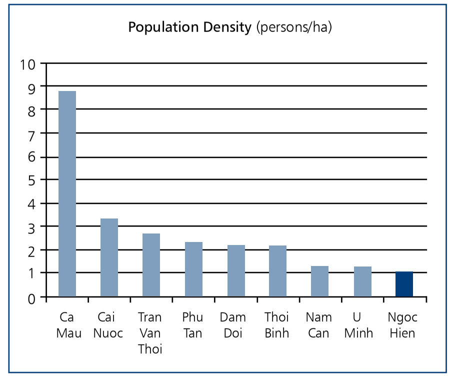
Administrative Center	Viên An Đông
Land Area (ha)	73,517
Population	78,420
Population Density (persons/ha)	1.07
No. of Households	19,221
Average Family Size	4.08
Average Annual Household Income	D13,500,000
GDP Contribution from Industry (HH)	D363,971
Unemployment Rate	4.4%
Education (teachers/1,000 persons)	5.9
Health (doctors/1,000 persons)	0.3
Ethnicity (% Kinh/non-Kinh)	97.3/2.7

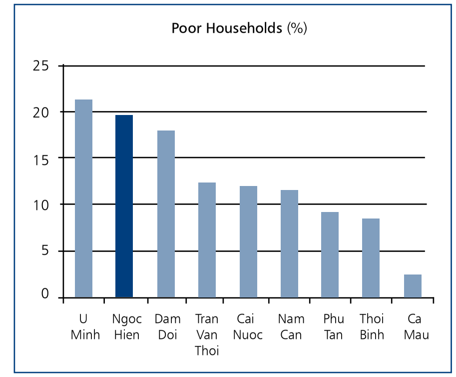
GDP = gross domestic product, ha = hectare, HH = household.

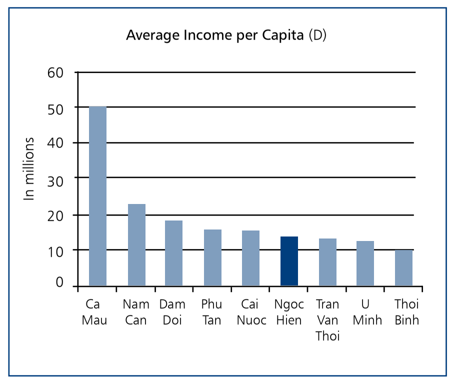
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Medium
	% of Poor Households	High
	No. of Teachers	High
	No. of Doctors	High
	Agricultural Land per Person	Low
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Low
	No. of Different Industries	Medium
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	Low
	% of Urban Area/Population	Low
	Sewer/Septic Tank	Medium
	Water Supply	High
	Major Waterways	–
	Major Roads	Low
	District Roads	High
	Transport Hubs	Medium

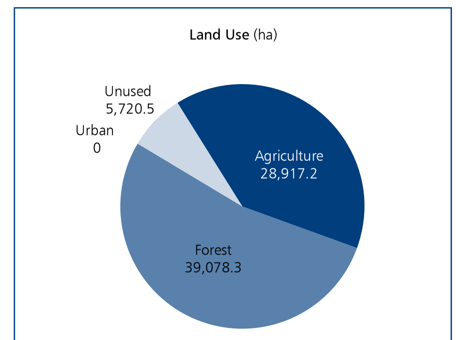










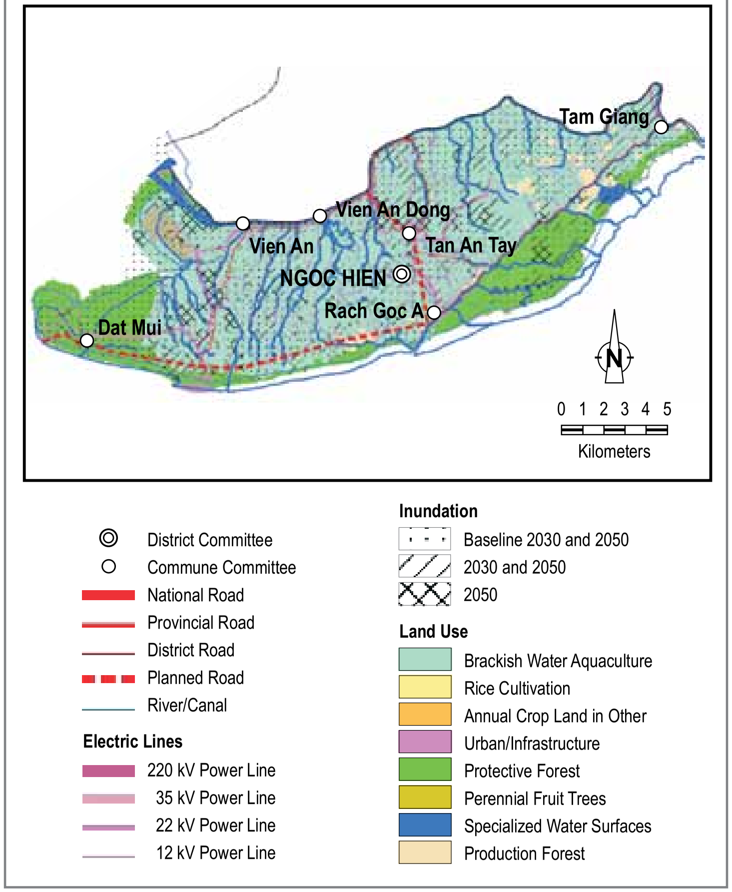


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	72.04	8.35	14.14	25.69
Power (km)	245.48	43.57	55.49	85.97
Agriculture Area (km^2)	0.30	0.20	0.20	0.22
Aquaculture Area (km^2)	421.71	59.82	90.40	136.96
Residential and Commercial Land (km^2)	0.00	0.08	0.09	0.19

km = kilometer, km^2 = square kilometer.

Ngoc Hien Projected Inundation - Scenario A2



All sectors require urgent upgrades to the control measures to protect from storm surges. The overall resilience is low, and some improvement to controls in the agriculture sector for flooding and salinity are required in the long term in the areas of dike strengthening and improvements in aquaculture techniques and calendars in order to account for climate change. As well as protection from storm surges, the urban sector requires improvements in control measures to protect the town infrastructure from flooding and salinity in the long term. Required improvements are mainly related to raising structures above flood levels and improving water and sanitation. Resilience of the industry and transport sectors to salinity and flooding is good, and control measures for these hazards are considered to be adequate.

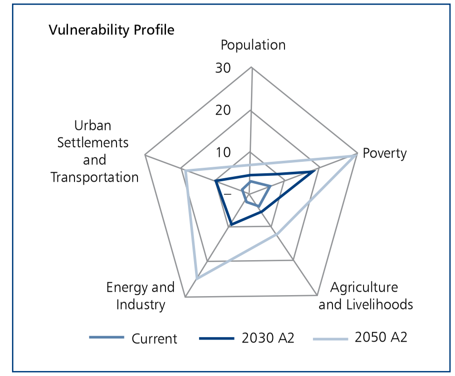
Population: A small, low-density population means low vulnerability despite exposure to salinity and increasing exposure to storm surges.

Poverty: A very low income, high number of poor households, and limited access to health and education lead to increasing vulnerability as exposure to inundation and storm surges increases. The very high population growth increases the effect.

Agriculture and Livelihoods: A range of income streams and availability of land for aquaculture reduce the effect of the high population growth on vulnerability.

Energy and Industry: A moderate reliance on only a few industries increases vulnerability as the population grows and inundation and storm surges increase in the future.

Urban Settlements and Transportation: A small and rural population reduces the increase in vulnerability in the future.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	22	100	60
	2030	29	100	90
	2050	39	100	100
Risk Rating	Current	3	10	8
	2030	6	10	10
	2050	6	10	10

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

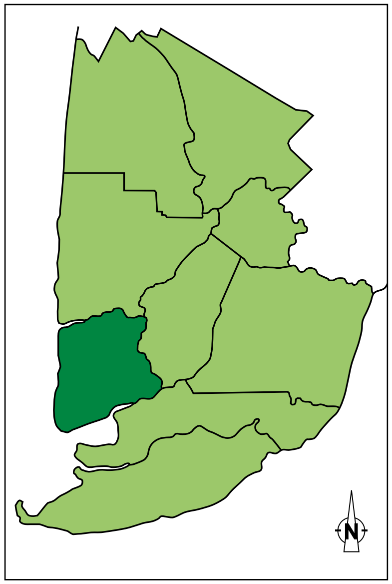
This island district is completely exposed to salinity and has a high exposure to storm surges that is expected to increase to 100%. Exposure to flooding is moderate. The risk from saline intrusion is at the high end of the medium ranking, and the risk from inundation increases in 2030. The low elevation and extensive coastline mean that the exposure to storm surges along the coast may cause extensive and widespread damage, and the risk from storm surges increases in 2030.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	••	••••
Major Industry	•	•	••••
Major Energy	••	•	••••
Urban	••	••	••••
Transportation	•	•	••••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

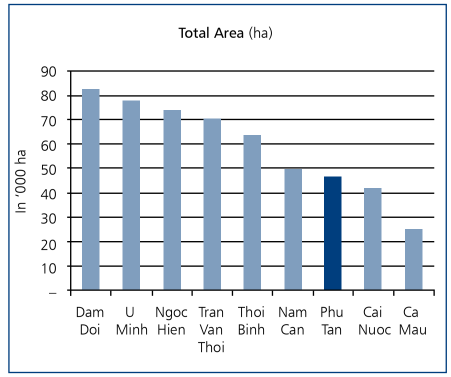
Phu Tan

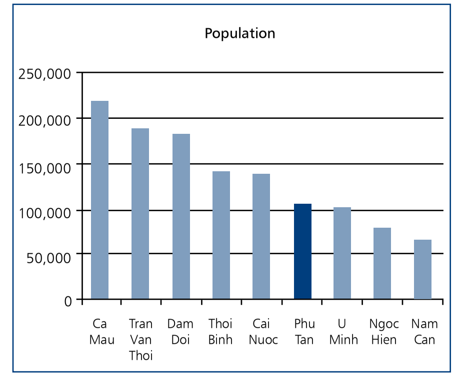


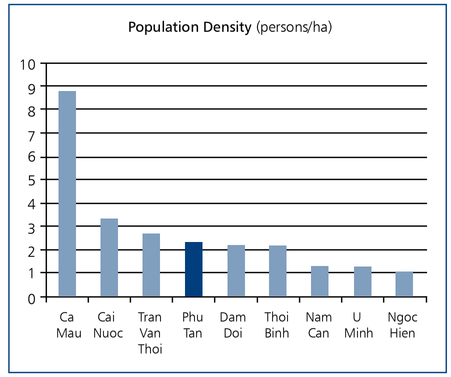
Administrative Center	Cai Doi Vam
Land Area (ha)	46,433
Population	105,599
Population Density (persons/ha)	2.27
No. of Households	23,537
Average Family Size	4.49
Average Annual Household Income	D15,490,000
GDP Contribution from Industry (HH)	D1,572,365
Unemployment Rate	3%
Education (teachers/1,000 persons)	10.4
Health (doctors/1,000 persons)	0.14
Ethnicity (% Kinh/non-Kinh)	95/5

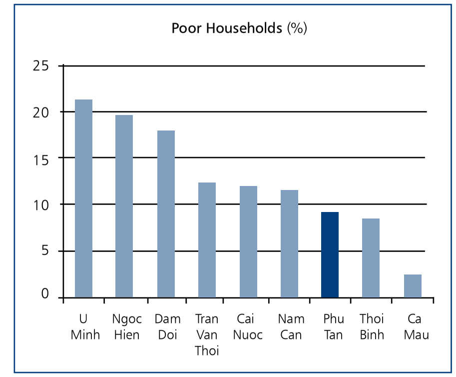
GDP = gross domestic product, ha = hectare, HH = household.

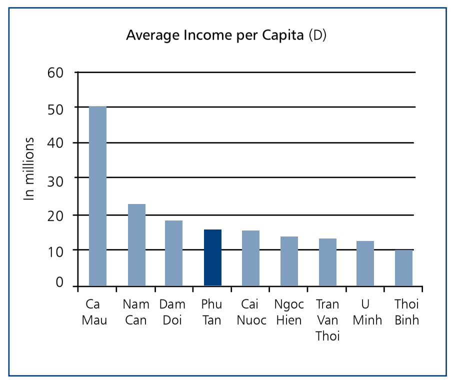
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	High
	No. of Households	Low
	Population at Working Age	Medium
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	Low
	No. of Doctors	High
	Agricultural Land per Person	Medium
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	High
	No. of Factories	High
	No. of Different Industries	Medium
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Low
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	High
	Water Supply	Low
	Major Waterways	–
	Major Roads	Low
	District Roads	Medium
	Transport Hubs	Low

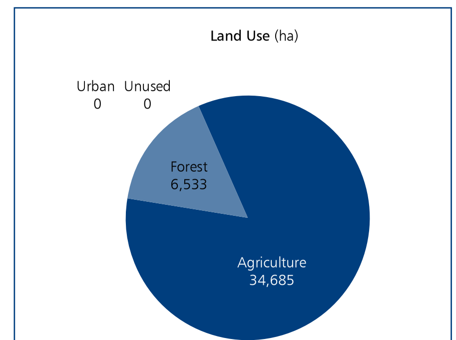








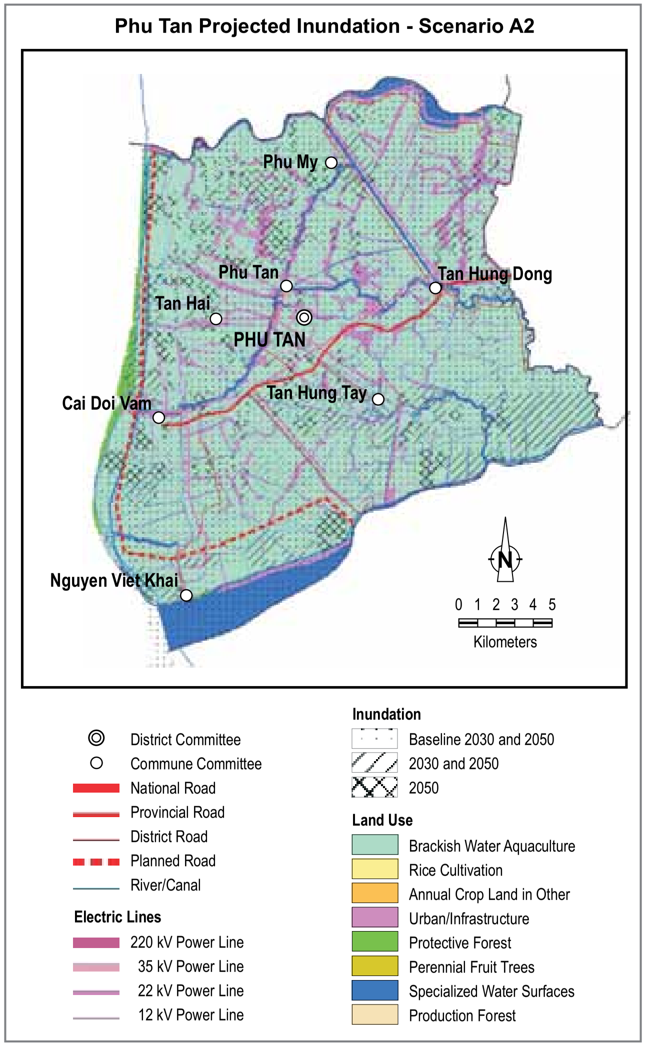




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	80.44	38.41	46.59	61.53
Power (km)	286.89	120.03	147.23	188.60
Agriculture Area (km²)	54.17	21.51	26.72	34.51
Aquaculture Area (km²)	298.62	102.66	136.04	185.93
Residential and Commercial Land (km²)	0.49	0.0948	0.1086	0.1595

km = kilometer, km² = square kilometer.



The district is exposed to storm surges requiring improvements in protection across most of the sectors in the medium to long term. Improvements in the flood control measures for agricultural infrastructure are required in the medium to long term in the areas of dike strengthening and improvements to sluice gates, and improved aquaculture techniques and calendars in order to account for climate change. The overall resilience in the energy and transport sectors is very good with some improvements in control measures for storm surges required in the medium term. In the industry sector, some improvements in control measures for flooding are required in the short term and for storm surges in the medium term. These are mainly related to raising industry structures above flood levels and strengthening sea dikes. Some improvements in control measures for flooding and salinity are required in the medium term and for storm surges in the short term. These are mainly related to raising urban structures above flood levels, improving water and sanitation, improving urban drainage, and strengthening sea dikes.

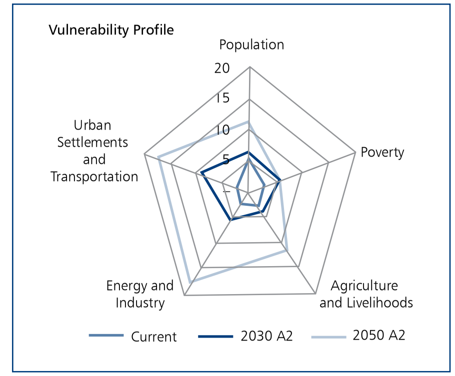
Population: A low population growth rate reduces the vulnerability in this sector, but an increase in inundation from 36% to 62% and exposure to storm surges increase vulnerability in the future.

Poverty: A low number of poor and ethnic households results in low vulnerability.

Agriculture and Livelihoods: A range of off-farm income sources ameliorates the effects of a high rural population, but vulnerability increases as the area affected by inundation and storm surges increases.

Energy and Industry: A high reliance of household incomes on industry combined with a low rate of connection to the national grid means that vulnerability in this sector also increases.

Urban Settlements and Transportation: A low urban population and protection of the urban center from inundation and storm surges mean that current vulnerability is low. Vulnerability increases with exposure.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	36	100	1
	2030	46	100	1
	2050	62	100	2
Risk Rating	Current	6	10	4
	2030	6	10	4
	2050	6	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

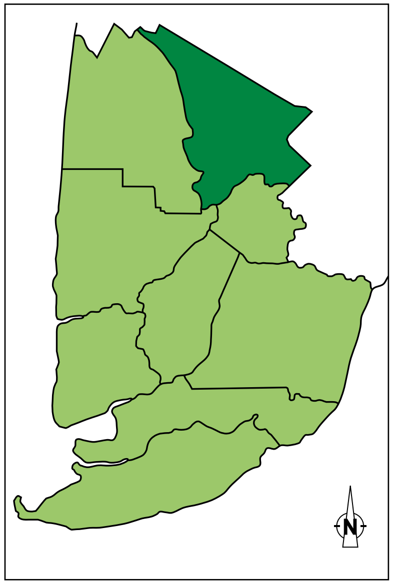
While exposure to flooding is moderate, it is projected to increase, but the risk remains medium. The area is completely exposed to salinity, and the risk is at the high end of the medium ranking. The low elevation and extensive coastline mean that the exposure and risk from storm surges increase.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	•	•••
Major Industry	•••	•	••
Major Energy	•	•	••
Urban	••	••	•••
Transportation	•	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

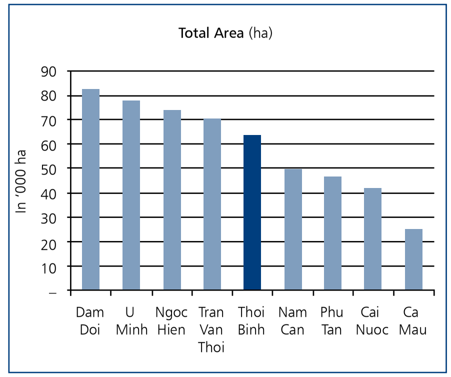
Thoi Binh

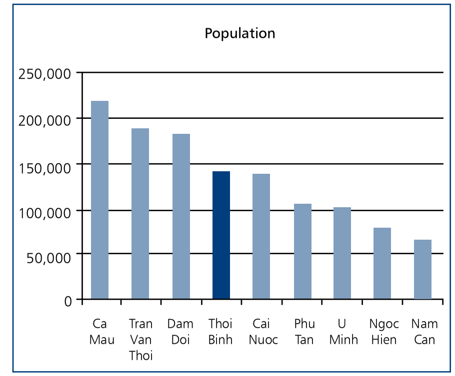


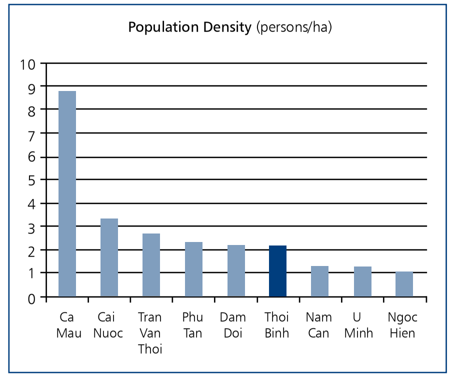
Administrative Center	Thoi Binh
Land Area (ha)	64,131
Population	140,600
Population Density (persons/ha)	2.19
No. of Households	31,885
Average Family Size	4.40
Average Annual Household Income	D10,080,000
GDP Contribution from Industry (HH)	D786,358
Unemployment Rate	9.5%
Education (teachers/1,000 persons)	8.1
Health (doctors/1,000 persons)	0.31
Ethnicity (% Kinh/non-Kinh)	94.1/5.9

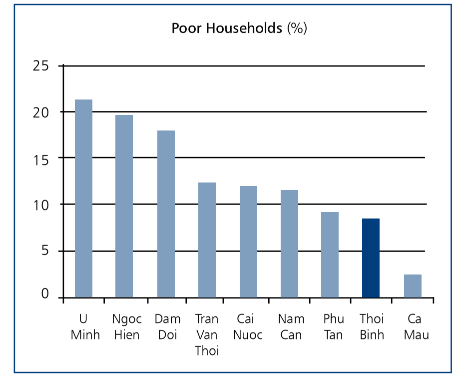
GDP = gross domestic product, ha = hectare, HH = household.

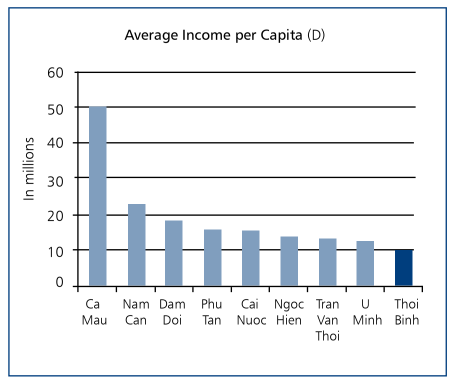
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	High
	No. of Households	Medium
	Population at Working Age	Medium
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	Medium
	% of Poor Households	Low
	No. of Teachers	Medium
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	High
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Medium
	No. of Factories	Low
	No. of Different Industries	Medium
Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Medium
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	High
	Water Supply	Medium
	Major Waterways	–
	Major Roads	High
	District Roads	Low
	Transport Hubs	Low

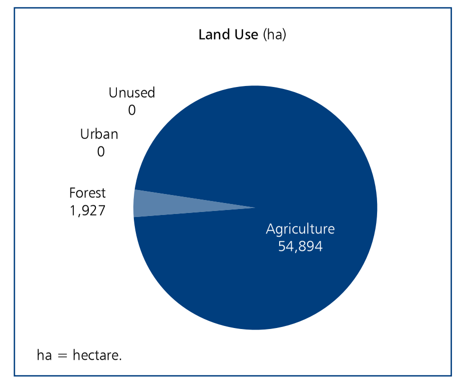






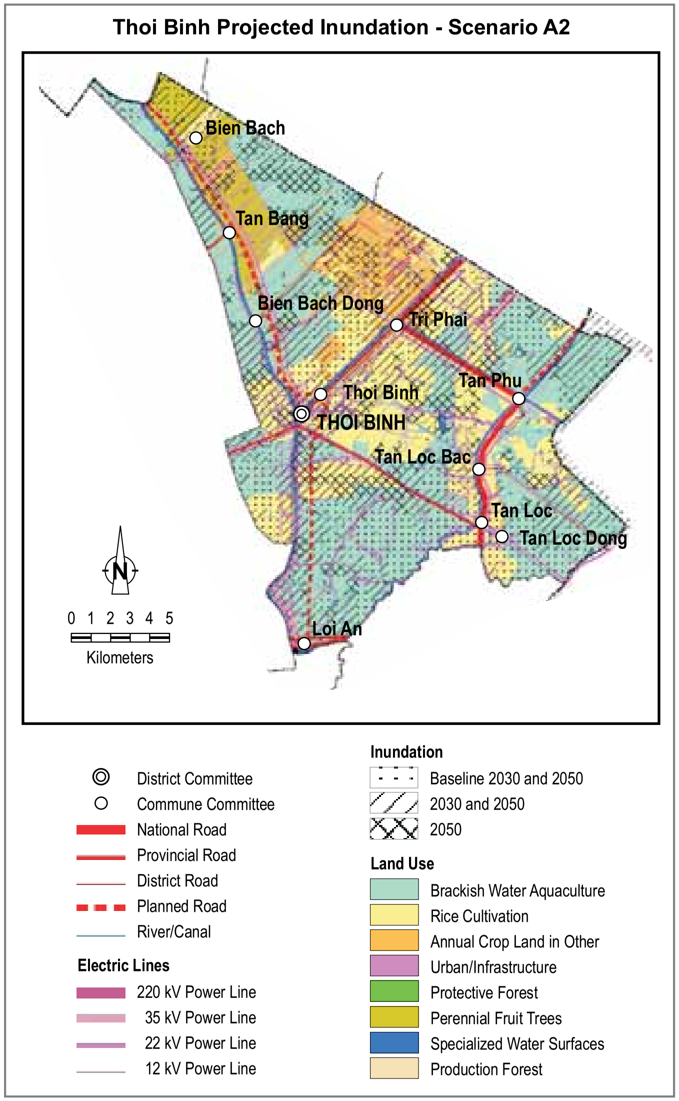






Inundation	Total	2000	2030	2050
Roads (km)	117.17	7.00	20.72	37.36
Power (km)	352.19	28.34	71.09	117.33
Agriculture Area (km²)	257.72	7.97	32.35	72.61
Aquaculture Area (km²)	294.92	19.82	64.28	112.60
Residential and Commercial Land (km²)	4.01	0.09	0.36	1.04

km = kilometer, km² = square kilometer.



Improvements in flood control measures for agriculture and aquaculture infrastructure are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, improvements in rice varieties and cultivation methods, as well as in aquaculture techniques and calendars. The overall resilience in the energy and industry sectors is very good, and control measures are considered adequate. Some improvements in the control measures against flooding are required for the transport sectors in the long term. These are mainly related to raising structures above flood water levels. The urban sector requires improvements in the control measures against flooding and salinity in the medium term. These are raising structures above flood levels, improved urban drainage, and improved water and sanitation.

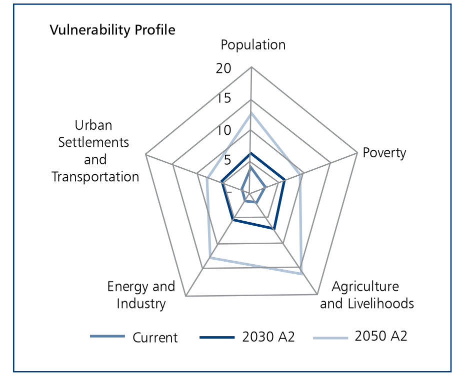
Population: Moderate population density and growth rate combined with low current exposure to inundation result in low vulnerability. An increased exposure to flooding increases vulnerability.

Poverty: A low number of poor households and reasonable access to health and education lead to low vulnerability. A high number of ethnic households increases vulnerability as inundation increases.

Agriculture and Livelihoods: A high number of rural households and low income are offset by a large number of potential income sources and availability of land for aquaculture. A high growth rate and increasing impacts of inundation increase vulnerability in the future.

Energy and Industry: A moderate reliance on industry for income and good connection to the national grid lead to low vulnerability, which increases with exposure to inundation.

Urban Settlements and Transportation: A low urban population, limited infrastructure, and protection of the urban center from inundation and storm surges mean that vulnerability is low.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	6	100	0
	2030	19	100	0
	2050	35	100	0
Risk Rating	Current	3	10	0
	2030	3	10	0
	2050	6	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

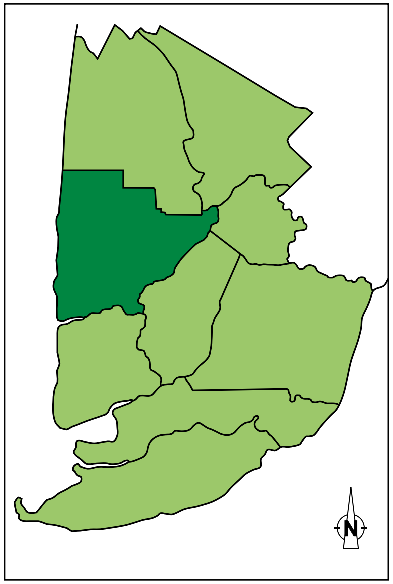
Exposure to flooding is very low, but is projected to increase and the area is completely exposed to salinity. The risk from saline intrusion is at the high end of the medium ranking, and the risk from inundation increases from low to moderate.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	••	•
Major Industry	••	•	•
Major Energy	•	•	•
Urban	••	••	•
Transportation	•	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

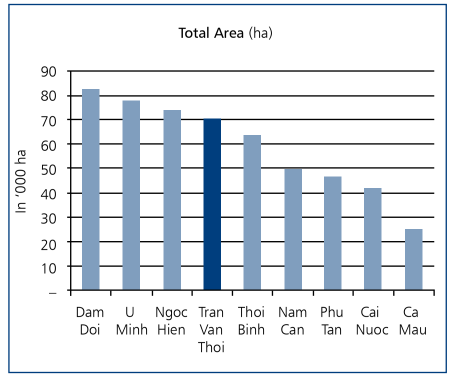
Tran Van Thoi

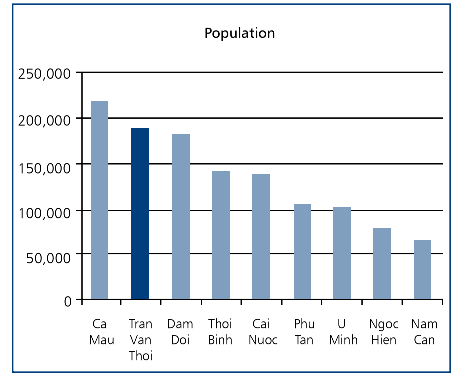


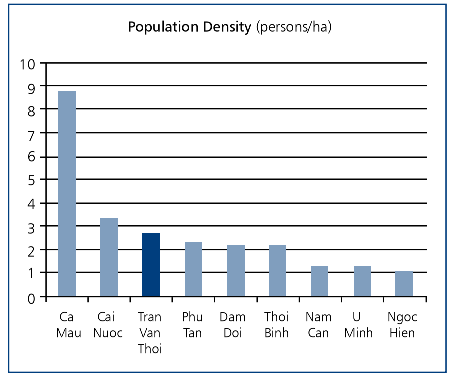
Administrative Center	Tran Van Thoi
Land Area (ha)	70,942
Population	187,132
Population Density (persons/ha)	2.64
No. of Households	44,555
Average Family Size	4.20
Average Annual Household Income	D13,000,000
GDP Contribution from Industry (HH)	D1,750,976
Unemployment Rate	4%
Education (teachers/1,000 persons)	10.9
Health (doctors/1,000 persons)	0.13
Ethnicity (% Kinh/non-Kinh)	95/5

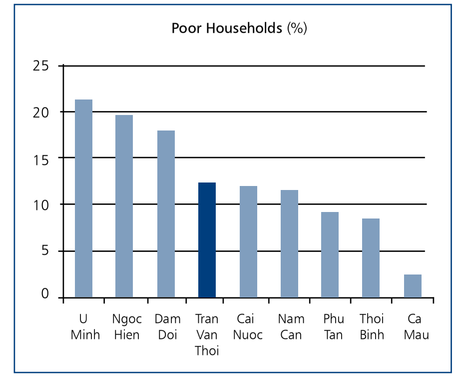
GDP = gross domestic product, ha = hectare, HH = household.

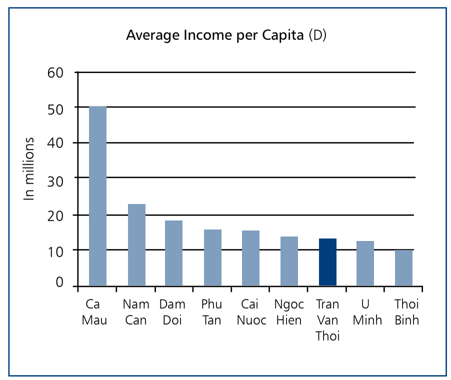
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	Medium
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	Medium
	No. of Teachers	Low
	No. of Doctors	High
	Agricultural Land per Person	High
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	High
	No. of Factories	Low
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	High
	Urban Households	High
	Urban Area	High
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	High
	Water Supply	High
	Major Waterways	–
	Major Roads	High
	District Roads	Medium
	Transport Hubs	Medium

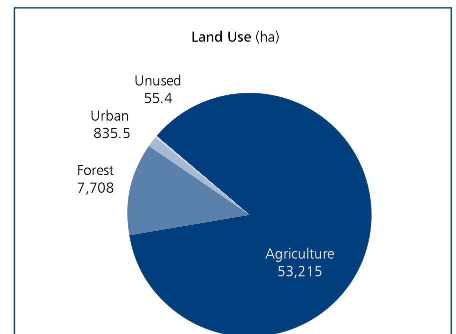








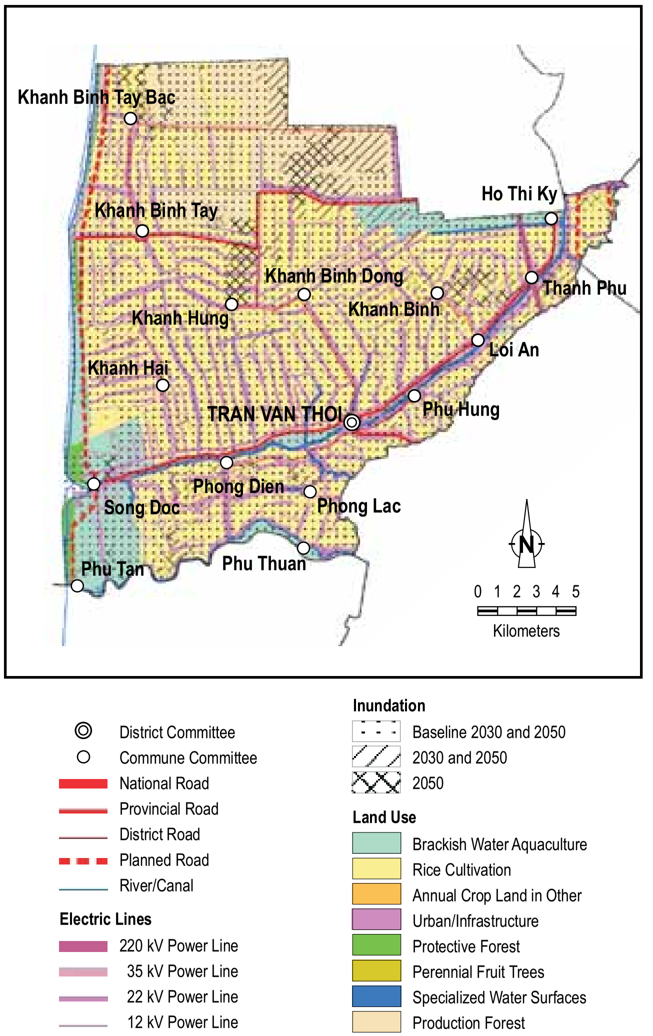




Inundation	Total	2000	2030	2050
Roads (km)	124.21	44.12	64.76	93.06
Power (km)	581.19	278.22	377.52	494.40
Agriculture Area (km^2)	511.32	229.76	230.17	230.27
Aquaculture Area (km^2)	80.71	34.12	101.42	188.74
Residential and Commercial Land (km^2)	0.06	0.01	0.68	1.60

km = kilometer, km^2 = square kilometer.

Tran Van Thoi Projected Inundation - Scenario A2



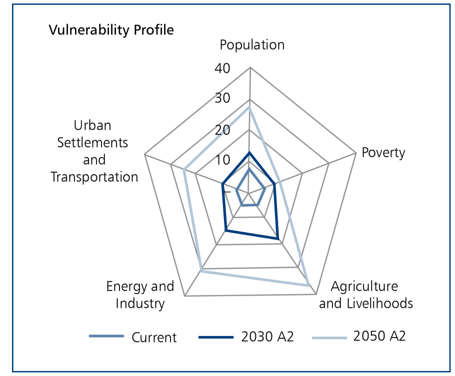
The exposure to storm surges requires improvements in control measures across most of the sectors. The agriculture sector needs improvements in flood and storm surge control measures in the medium to long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in aquaculture techniques and calendars. The control measures in the energy and transport sectors are good with some improvements in storm surge required in the long term. The industry sector requires immediate improvements in storm surge control measures and improvements in flood control measures in the medium term. These are mainly related to raising industry structures above flood levels and strengthening sea dikes. The urban sector needs immediate improvements in control measures for storm surges and in the medium term for flooding and salinity, including strengthening sea dikes and protecting Song Doc town and port, raising urban structures above flood levels, improving water and sanitation, and improving urban drainage.

Population: With a high population and inward migration, a coastal town subject to storm surges and with 46% of the areas subject to inundation, the initial high vulnerability increases as inundation and storm surges affect larger areas.

Poverty: A lower average income, more poor households, and less access to health services compared to other urbanized districts result in high vulnerability. The concentration of households in towns reduces the effect of increased inundation.

Agriculture and Livelihoods: A high number of rural households and a moderate income increase vulnerability as the area impacted by inundation increases to 80% in 2050.

Energy and Industry: A large contribution to gross domestic product from industry and an abundance of energy infrastructure lead to high vulnerability which increases with inundation and storm surges.



Urban Settlements and Transportation: A high urban population in two towns, one of which is on the coast, leads to high vulnerability. Limited infrastructure and protection of the urban center from inundation and storm surges mean that vulnerability is low, which increases as inundation and storm surges affect larger areas.

Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	42	100	1
	2030	58	100	1
	2050	79	100	1
Risk Rating	Current	6	10	4
	2030	6	10	4
	2050	9	10	4

<5 Low risks; 5–12 Medium risks; See Table 13 pg. 32 for detailed descriptions

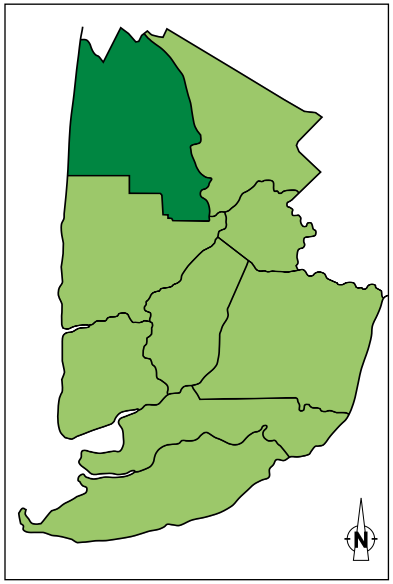
While exposure to flooding is moderate, it is projected to increase. The area is completely exposed to salinity, and exposure to storm surges may cause extensive damage, particularly to industry on the coast. The risk from inundation increases by 2050 and the risk from saline intrusion is at the upper end of the medium ranking. Storm surge risk is low as it is confined to the coast.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	•	•••
Major Industry	•••	•	••••
Major Energy	•	•	••
Urban	••	••	••••
Transportation	•	•	••

• Adequate; •• Change (long term); ••• Improvement (medium term); •••• Rehabilitation urgent

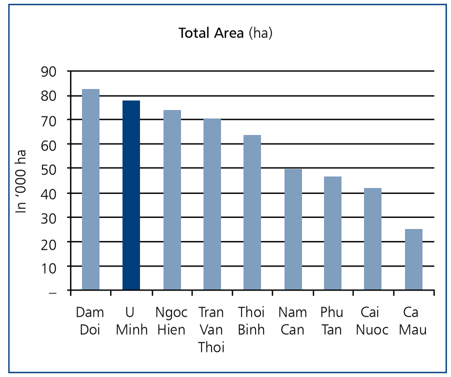
U Minh

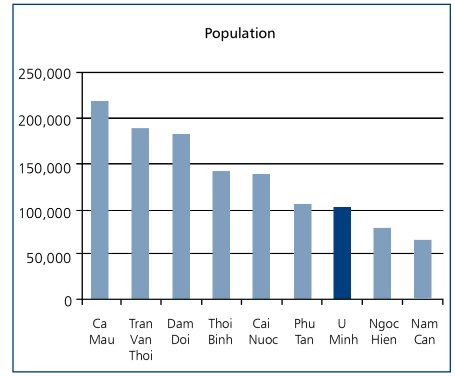


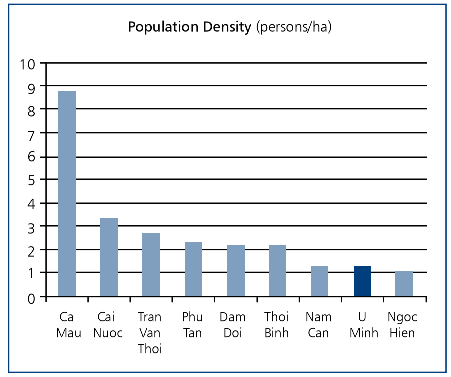
Administrative Center	U Minh
Land Area (ha)	77,462
Population	102,215
Population Density (persons/ha)	1.32
No. of Households	23,771
Average Family Size	4.30
Average Annual Household Income	10,500,000 VND
GDP Contribution from Industry (HH)	256,289 VND
Unemployment Rate	2%
Education (teachers/1,000 persons)	7
Health (doctors/1,000 persons)	0.43
Ethnicity (% Kinh/non-Kinh)	95.4/4.6

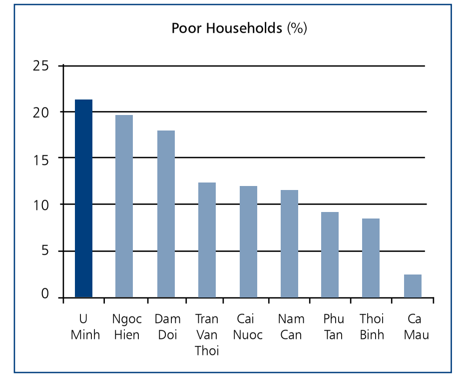
GDP = gross domestic product, ha = hectare, HH = household.

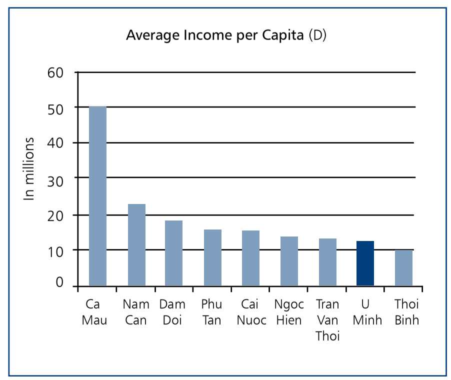
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Medium
	No. of Households	Medium
	Population at Working Age	Low
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	High
	No. of Teachers	High
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	Low
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	Medium
	% of Urban Area/Population	Low
	Sewer/Septic Tank	Low
	Water Supply	Medium
	Major Waterways	–
	Major Roads	High
	District Roads	High
	Transport Hubs	Low

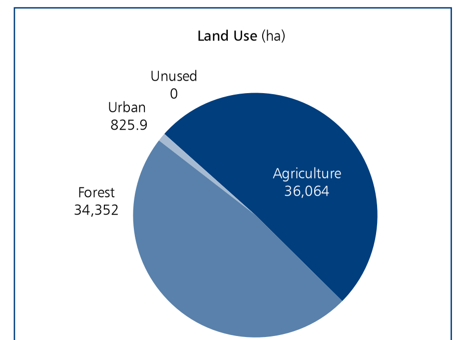








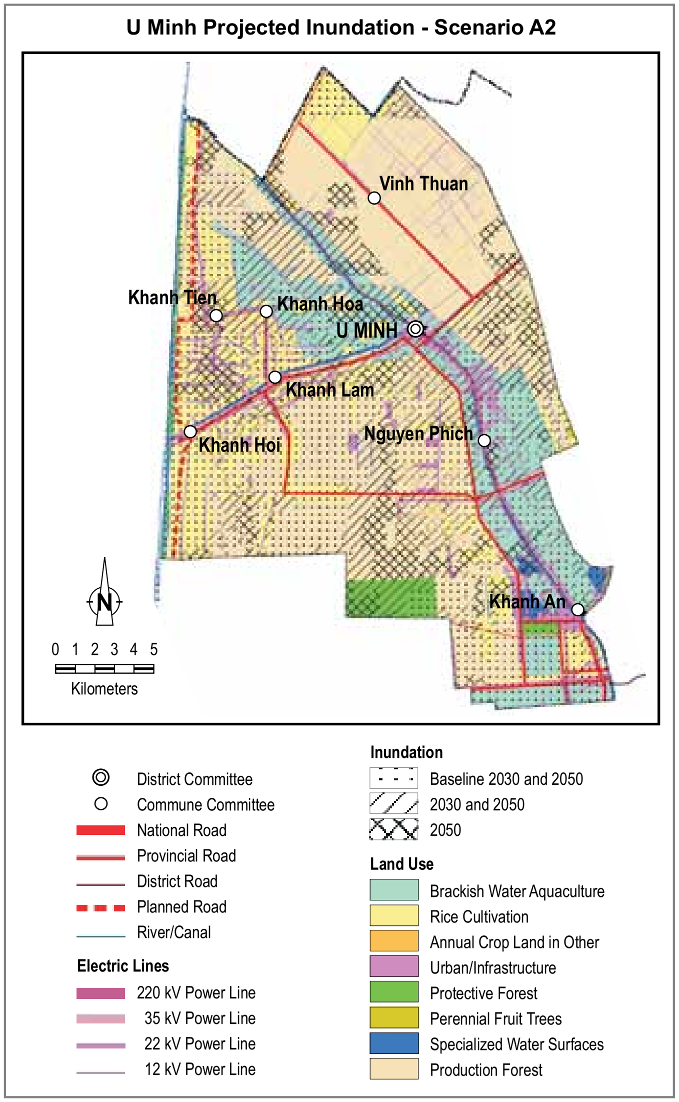




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	176.64	26.84	59.60	90.61
Power (km)	142.51	26.60	53.08	80.68
Agriculture Area (km^2)	180.43	19.58	45.69	87.92
Aquaculture Area (km^2)	126.15	16.19	39.13	70.81
Residential and Commercial Land (km^2)	2.89	0.06	0.44	0.99

km = kilometer, km^2 = square kilometer.



Improvements in the control measures for agricultural infrastructure are required in the medium to long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in aquaculture techniques and calendars. The energy and industry sectors require immediate improvements in control measures for protecting the energy generation and associated infrastructure from flooding. The measures are mainly related to raising structures above flood levels and strengthening sea dikes. The urban sector needs improvements in control measures for storm surge in the medium term and for flooding and salinity in the long term. These are mainly related to strengthening sea dikes, raising urban structures above flood levels, improving water and sanitation, and improving urban drainage. The transport sector has good control measures in place with some improvements for storm surges required in the long term.

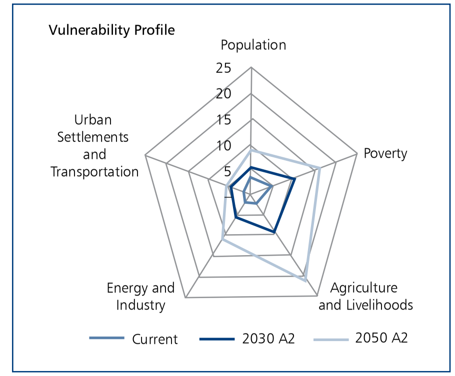
Population: Vulnerability is low due to a low population density and the small area of the current and projected inundation.

Poverty: A high number of poor households and low gross domestic product per head, high number of ethnic households, and poor access to education lead to high vulnerability, which increases due to exposure to inundation and storm surges. The smaller area affected keeps this to fewer than 18 in 2050.

Agriculture and Livelihoods: A high rural population with low incomes is offset by a high number of possible income sources and available land. Exposure to inundation salinity and storm surge leads to high vulnerability in the future.

Energy and Industry: With only a quarter of the population dependent on industry, vulnerability is low. A large amount of energy infrastructure exposed to impacts increases vulnerability in the future.

Urban Settlements and Transportation: A low urban population and only a moderate area affected mean that vulnerability remains low.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	9	100	0
	2030	22	100	1
	2050	42	100	1
Risk Rating	Current	3	10	4
	2030	3	10	4
	2050	6	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding is low and is projected to increase. The area is completely exposed to salinity. Exposure to storm surges along the coast may cause extensive damage. The risk from inundation increases from low to moderate by 2050, and the risk from saline intrusion is at the upper end of the medium ranking. Storm surge risk is low as it is confined to the coast.

Control Measures

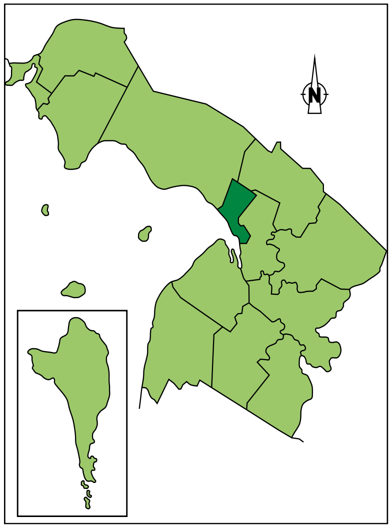
Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	••	•••
Major Industry	••••	•	•
Major Energy	••••	•	••
Urban	••	••	•••
Transportation	•	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Appendix 2

Kien Giang Province District Summaries

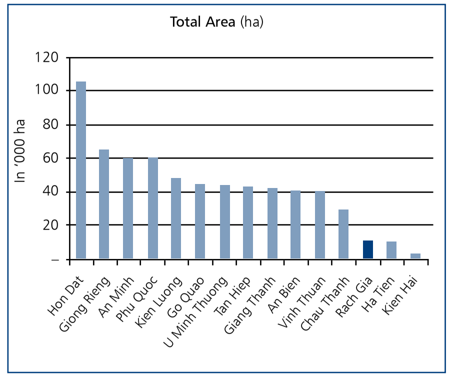
Rach Gia

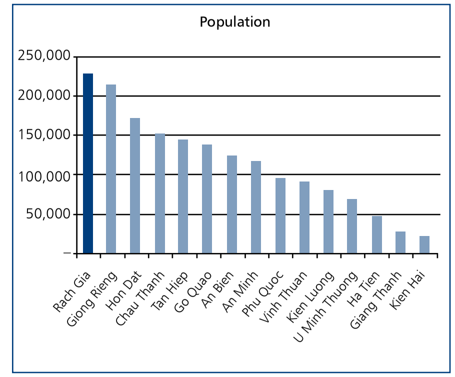


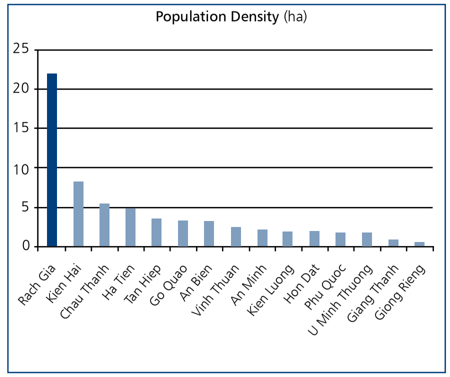
Administrative Center	Provincial Capital
Land Area (ha)	10,364
Population	226,963
Population	21.90
No. of Households	49,453
Average Family Size	4.59
Average Annual Household Income	D30,908,000
GDP Contribution from Industry (HH)	D3,024,354
Unemployment Rate	3.6%
Education (teachers/1,000 persons)	5.83
Health (doctors/1,000 persons)	0.37
Ethnicity (% Kinh/non-Kinh)	88.85/11.15

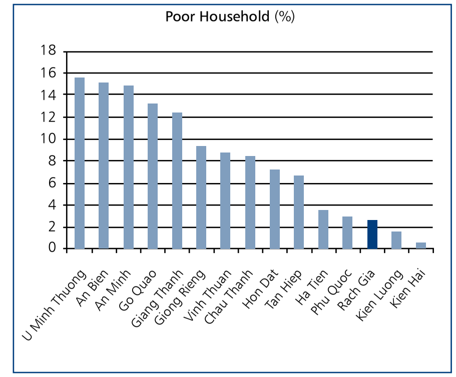
GDP = gross domestic product, ha = hectare, HH = household.

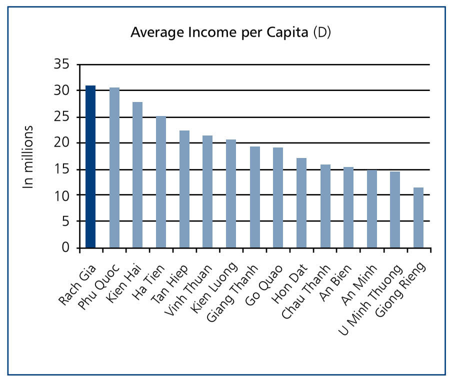
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	High
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Medium
	% of Poor Households	Low
	No. of Teachers	Low
	No. of Doctors	Low
	Agricultural Land per Person	High
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	High
	No. of Factories	High
	No. of Different Industries	Low
Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	High
	% of Urban Area/Population	High
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	Low
	Major Roads	Low
	District Roads	Low
	Transport Hubs	High

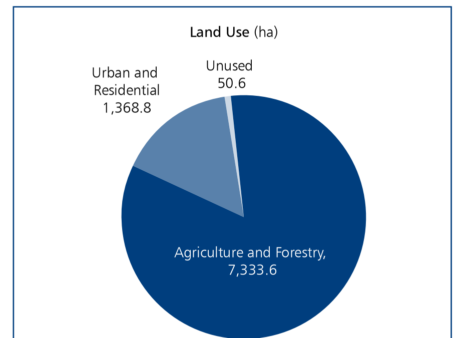








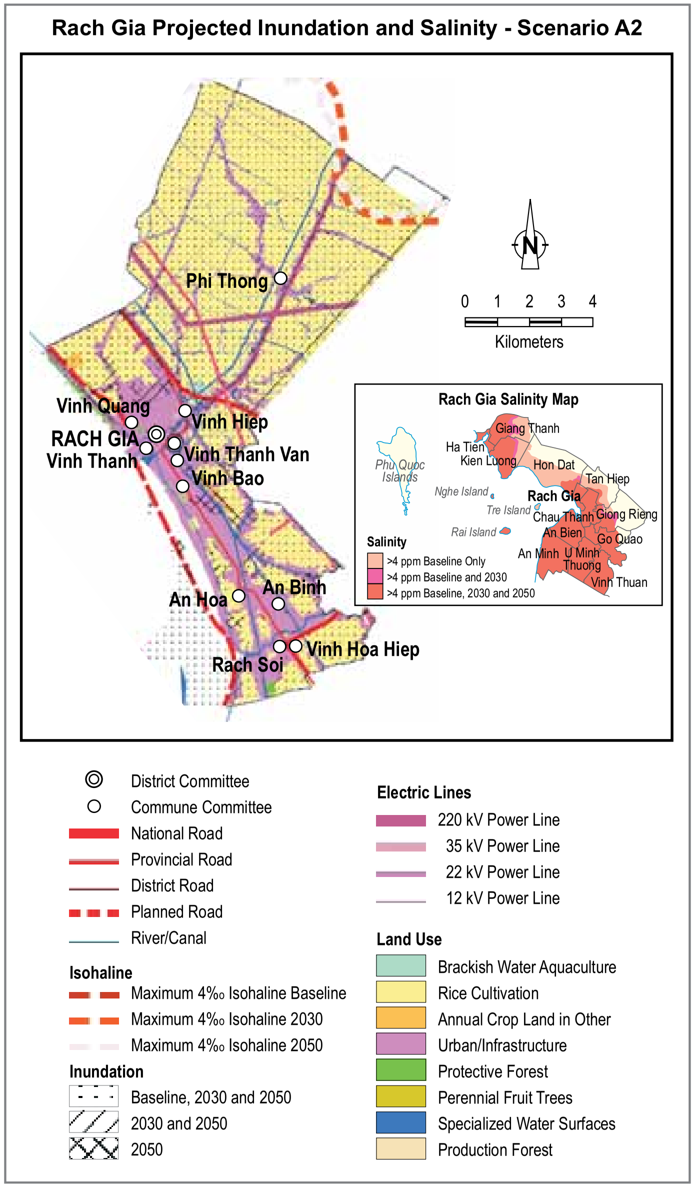




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	47.17	26.11	28.25	31.30
Power (km)	17.52	15.17	15.34	16.42
Agriculture Area (km²)	75.65	63.63	67.10	70.80
Aquaculture Area (km²)	0.4	0.3	0.4	0.4
Residential and Commercial Land (km²)	12.38	1.00	1.34	2.65

km = kilometer, km² = square kilometer.



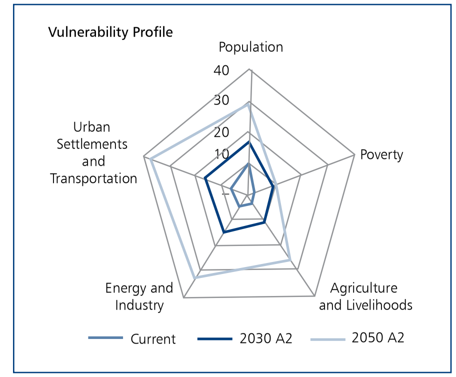
The control measures in the agriculture sector are currently rated as adequate requiring only long term improvements in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing as well as in improvements in rice varieties and cultivation methods. The overall resilience in the energy, transport and industry sectors is medium. Improvements in the control measures for infrastructure in these sectors are required in the medium to long term particularly in terms of flood protection. Required improvements are mainly related to raising structures above flood levels and saline water. Resilience in the urban sectors is very low and improvements to control measures to protect urban infrastructure from flooding and storm surge are required immediately and measures to protect from salinity are required in the medium term. These are mainly related to: raising urban structures above flood levels, improving water and sanitation, improving urban drainage and strengthening sea dikes.

Population: High vulnerability due to a high existing population at high density combined with large inward migration is compounded by exposure to all three impacts and results in high vulnerability.

Poverty: High incomes, a low number of poor households, and good access to health and education facilities lead to low vulnerability in this sector. The combined effect of the three impacts increases the vulnerability over time.

Agriculture and Livelihoods: A low number of rural households keeps the present vulnerability low, but increasing exposure to inundation and saline intrusion increases vulnerability.

Energy and Industry: The aggregation of industry and electricity infrastructure in the city and the reliance of household incomes on industry mean that Rach Gia City is vulnerable. The combined effect of the three impacts increases the vulnerability over time.



Urban Settlements and Transportation: The high population, large urban area, and the concentration of transport hubs increase vulnerability in this sector. In all sectors except poverty, vulnerability increases in the future due to high population growth and inward migration, which emphasize the current susceptibility to all three impacts.

Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	70	95	1
	2030	75	100	2
	2050	81	100	2
Risk Rating	Current	9	10	4
	2030	9	10	4
	2050	9	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

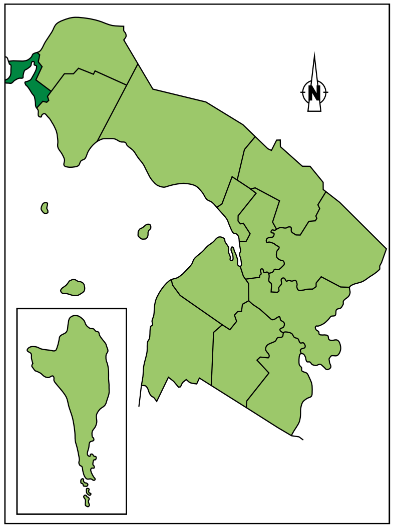
Exposure to flooding is high with a medium risk level and exposure is projected to increase but with no increase in the risk rating. Exposure to salinity is almost complete currently and is projected to be complete by 2030 and the risk rating is at the high end of the medium rank. Exposure to storm surge is also expected to increase as higher sea levels increasingly impact on the coastal infrastructure of the city.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	••	•
Major Industry	•••	••	••
Major Energy	•••	•	••
Urban	••••	••	••••
Transportation	••	•	••••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

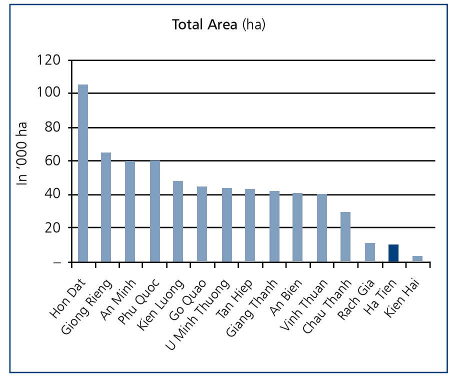
Ha Tien

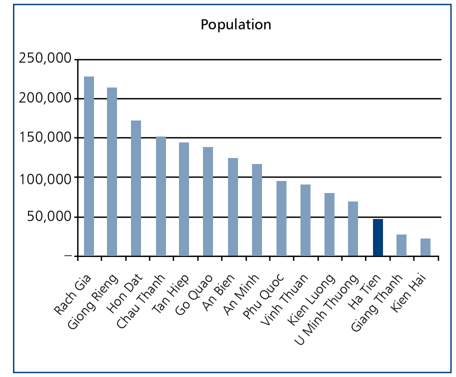


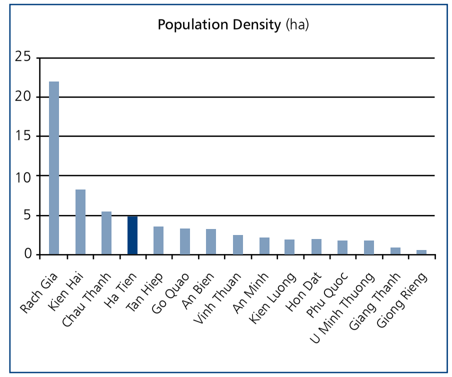
Administrative Center	Ha Tien
Land Area (ha)	9,952
Population	45,810
Population	4.60
No. of Households	11,027
Average Family Size	4.15
Average Annual Household Income	D25,006,000
GDP Contribution from Industry (HH)	D2,617,841
Unemployment Rate	No Data
Education (teachers/1,000 persons)	6.41
Health (doctors/1,000 persons)	0.46
Ethnicity (% Kinh/non-Kinh)	85/15

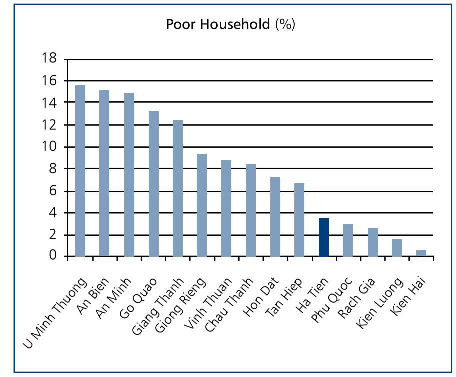
GDP = gross domestic product, ha = hectare, HH = household.

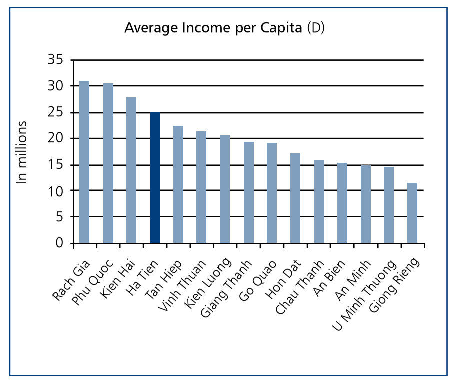
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	High
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	High
	No. of Doctors	Low
	Agricultural Land per Person	High
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	High
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	Low
	% of Urban Area/Population	High
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	Low
	Major Roads	Low
	District Roads	Low
	Transport Hubs	High

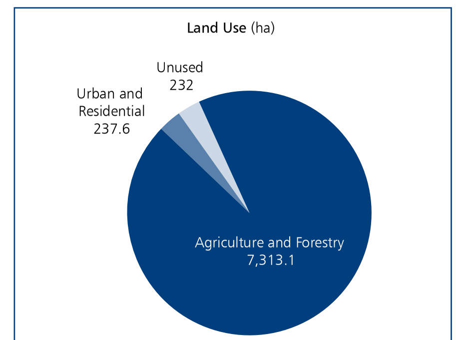










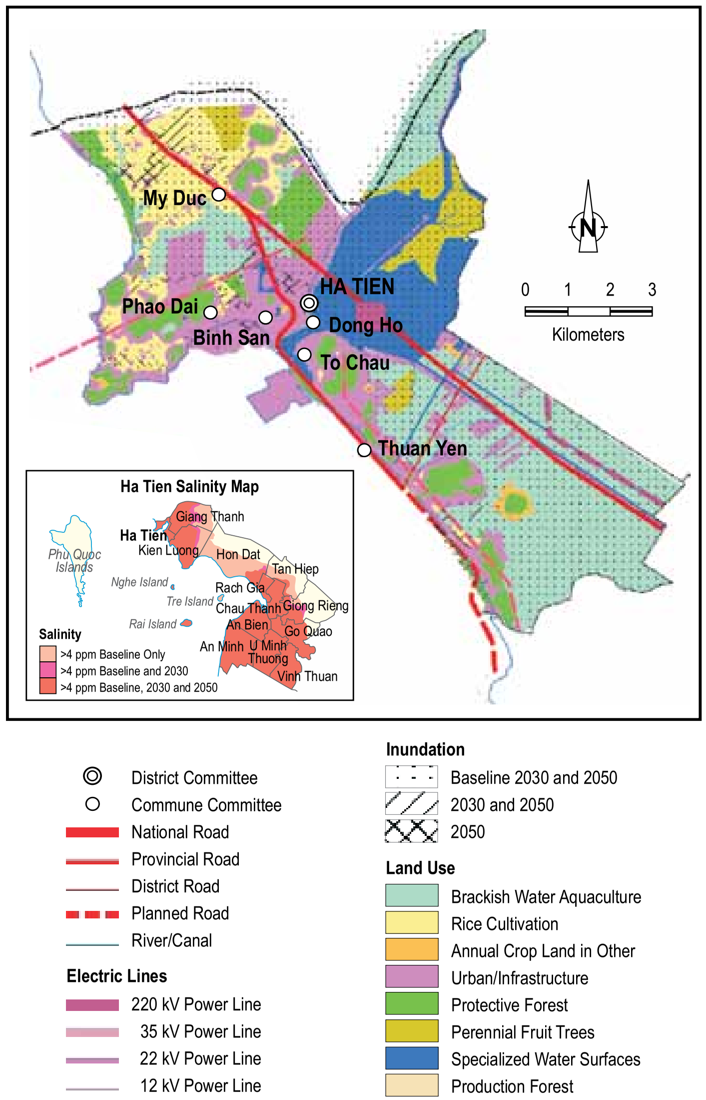


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	46.32	26.65	28.23	29.36
Power (km)	13.40	0.00	0.00	0.00
Agriculture Area (km²)	23.94	9.78	11.16	12.33
Aquaculture Area (km²)	37.1	34.5	35.5	35.8
Residential and Commercial Land (km²)	1.63	0.08	0.17	0.22

km = kilometer, km² = square kilometer.

Ha Tien Projected Inundation and Salinity - Scenario A2



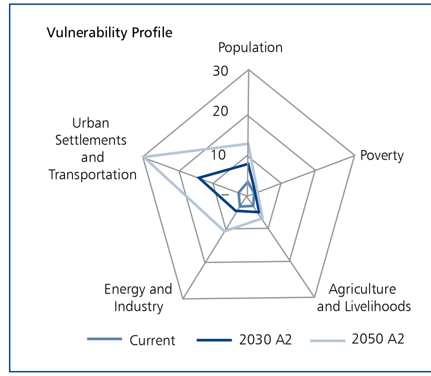
Population: A small population at low density keeps vulnerability moderate despite exposure to all three impacts.

Poverty: High incomes, a low number of poor households and good access to health facilities lead to low vulnerability in this dimension.

Agriculture and Livelihoods: A low number of rural households and good access to other sources of income streams keep vulnerability low.

Energy and Industry: A range of different industries contributing to household income streams leads to low vulnerability. The small area and population minimizes the increase in vulnerability to moderate levels.

Urban Settlements and Transportation: The almost total urbanisation of the population makes the district vulnerable. The urban area is increasingly exposed to all three impacts in the future.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	64	100	6
	2030	67	100	10
	2050	70	100	13
Risk Rating	Current	6	10	4
	2030	6	10	6
	2050	9	10	6

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding is high and is projected to increase with an increase in risk by 2050. The area is completely exposed to salinity. The exposure to storm surges is projected to increase, and the risk from storm surges increases from 2030.

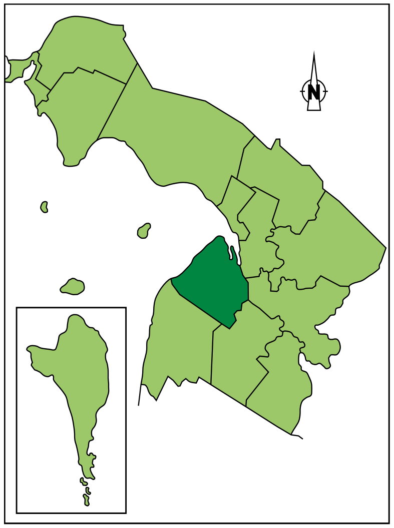
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	•••	•••
Major Industry	•••	••	••••
Major Energy	••	•	•••
Urban	•••	•	••••
Transportation	••	•	••••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

The exposure to storm surge requires immediate improvements in protection across all sectors.The overall resilience in the agriculture sector is low, and improvements in the control measures for agricultural infrastructure are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. Improvements in the control measures for storm surge protection for the industry and urban infrastructure are required immediately and for flood protection in the medium terms. Improvements are mainly related to raising structures above flood levels and improving urban drainage and water and sanitation infrastructure. Exposed transport infrastructure also requires improved protection from storm surge in the near term, while exposed energy infrastructure will require protection in the medium term.

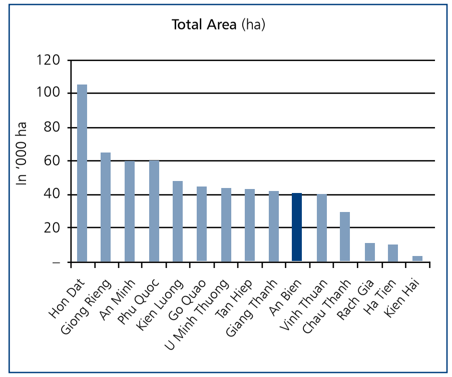
An Bien

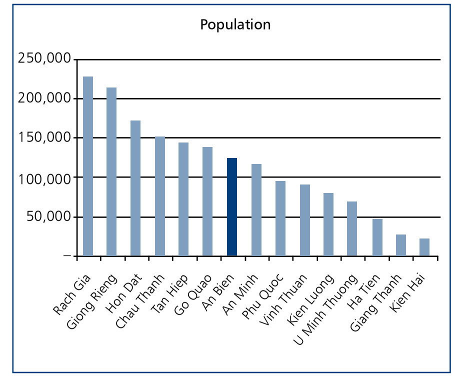


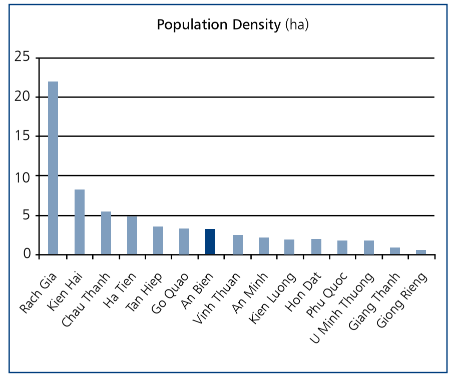
Administrative Center	Thu Ba
Land Area (ha)	40,029
Population	123,077
Population	3.07
No. of Households	28,316
Average Family Size	4.35
Average Annual Household Income	D15,220,000
GDP Contribution from Industry (HH)	D2,590,969
Unemployment Rate	2.1%
Education (teachers/1,000 persons)	15.56
Health (doctors/1,000 persons)	0.23
Ethnicity (% Kinh/non-Kinh)	88.6/11.4

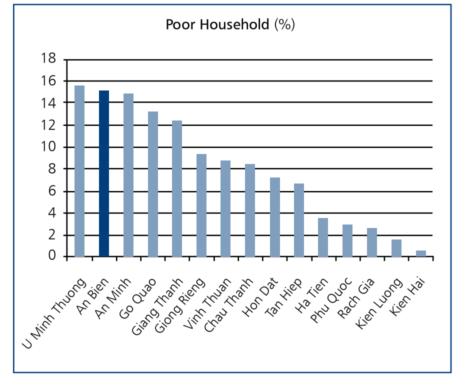
GDP = gross domestic product, ha = hectare, HH = household.

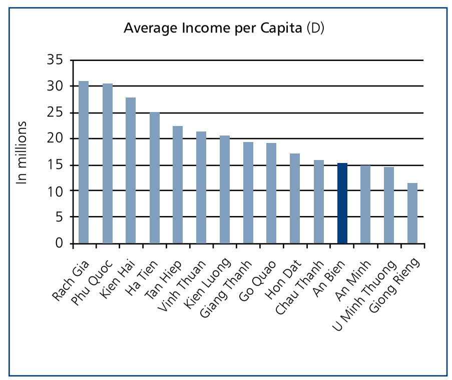
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	Medium
	No. of Households	Medium
	Population at Working Age	Medium
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	High
	No. of Teachers	Low
	No. of Doctors	Medium
	Agricultural Land per Person	Medium
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	High
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	Medium
	No. of Factories	High
	No. of Different Industries	Medium
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Low
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	High
	Water Supply	Medium
	Major Waterways	Medium
	Major Roads	Medium
	District Roads	Low
	Transport Hubs	High

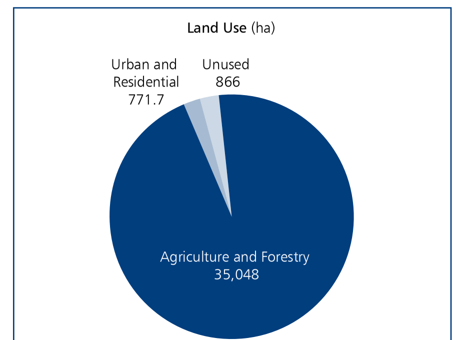










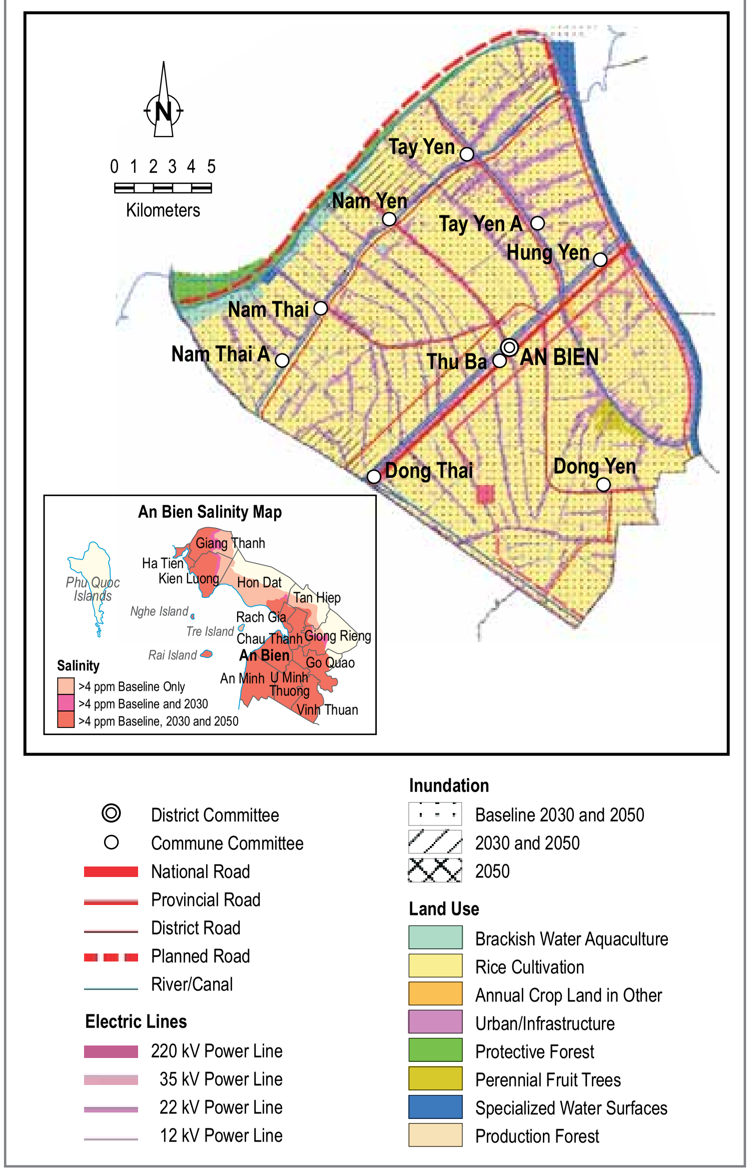


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	148.56	54.99	95.43	113.90
Power (km)	14.38	7.97	11.77	12.14
Agriculture Area (km^2)	341.07	132.57	245.53	287.21
Aquaculture Area (km^2)	5.7	0.1	1.9	3.2
Residential and Commercial Land (km^2)	0.89	0.13	0.22	0.26

km = kilometer, km^2 = square kilometer.

An Bien Projected Inundation and Salinity - Scenario A2



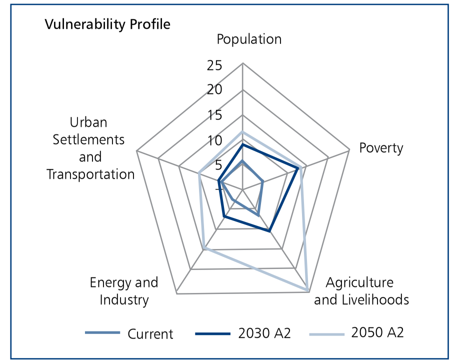
Population: High population at moderate density leads to high vulnerability. A low population growth rate ameliorates future increase despite exposure to all three hazards.

Poverty: A very high number of poor households, low gross domestic product per head, and a moderate number of ethnic households lead to high vulnerability which increases due to exposure to all three hazards. A low population growth rate ameliorates increase after 2030.

Agriculture and Livelihoods: A high rural population with low incomes is offset by available land per head of population. Exposure to all three hazards leads to high vulnerability in the future.

Energy and Industry: A moderate contribution from industry to household income leads to moderate vulnerability. A lack of energy and industrial infrastructure moderates the increase in vulnerability in the future.

Urban Settlements and Transportation: A low urban population and limited transportation infrastructure means that vulnerability remains low.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	38	90	1
	2030	69	100	1
	2050	81	100	2
Risk Rating	Current	6	10	4
	2030	6	10	4
	2050	9	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

While exposure to flooding is currently moderate, it is projected to increase in the future. The district is almost completely exposed to salinity with a medium risk rating. The risk from inundation remains high, and the risk from salinity increases in the future. As storm surges are infrequent and confined to the coast, risk is low. Some planned aquaculture and associated industry and infrastructure on the Ca Lon estuary may be affected by storm surges.

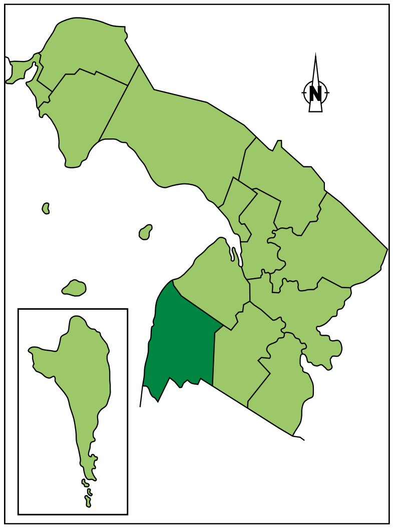
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	••••	•••
Major Industry	•••	••	•••
Major Energy	••	•	••
Urban	••	••	•••
Transportation	•	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure are required in the short to medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. Control measures for both energy and transportation infrastructure are good, and the district is resilient in these sectors. The district requires improvements in control measures in the medium to long term for both the industry and urban infrastructure. These are mainly related to raising structures above flood levels, improving water, sanitation, and drainage, and increasing protection from storm surges.

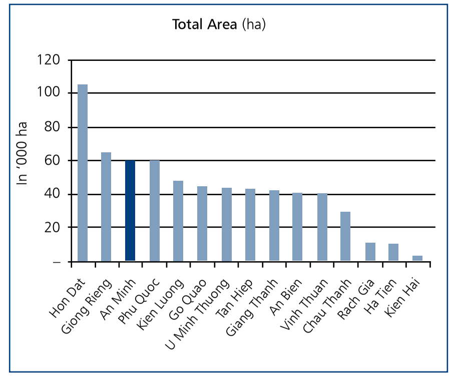
An Minh

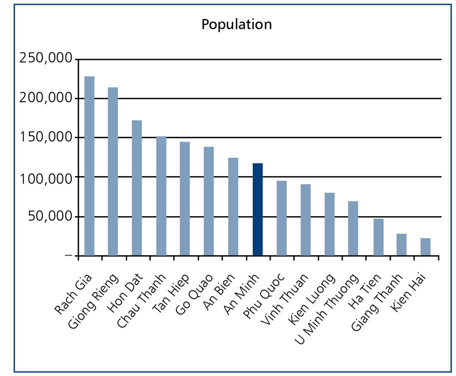


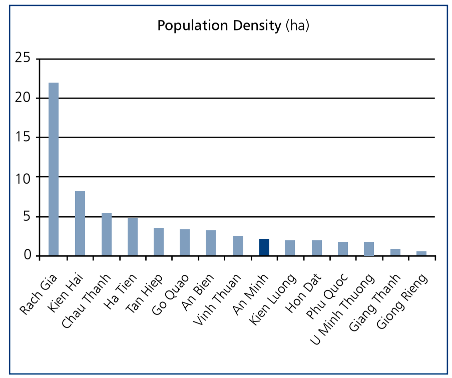
Administrative Center	Thu Muoi Mot
Land Area (ha)	59,050
Population	115,783
Population	1.96
No. of Households	26,767
Average Family Size	4.33
Average Annual Household Income	D14,583,000
GDP Contribution from Industry (HH)	D1,368,219
Unemployment Rate	No Data
Education (teachers/1,000 persons)	7.29
Health (doctors/1,000 persons)	0.2
Ethnicity (% Kinh/non-Kinh)	97.6/2.4

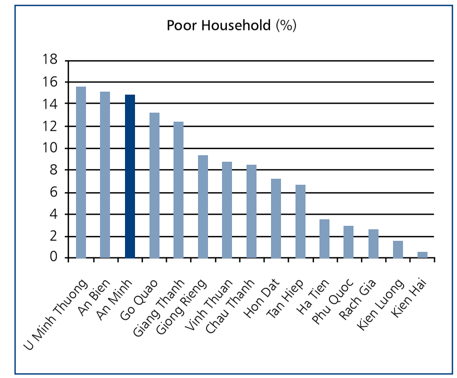
GDP = gross domestic product, ha = hectare, HH = household.

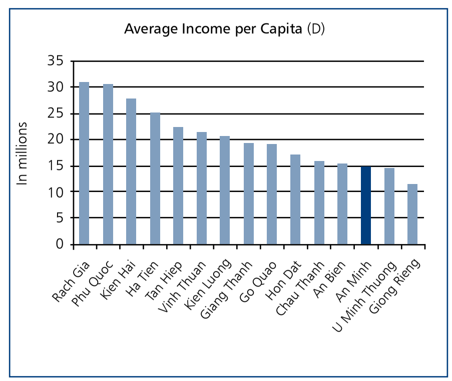
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	Medium
	No. of Households	Medium
	Population at Working Age	Medium
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	High
	No. of Teachers	Medium
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	High
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	High
	Urban Households	High
	Urban Area	Medium
	% of Urban Area/Population	Low
	Sewer/Septic Tank	High
	Water Supply	High
	Major Waterways	High
	Major Roads	High
	District Roads	Medium
	Transport Hubs	Medium

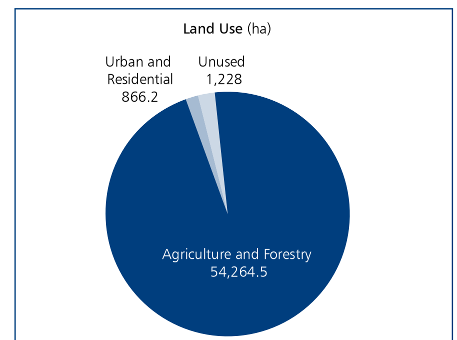










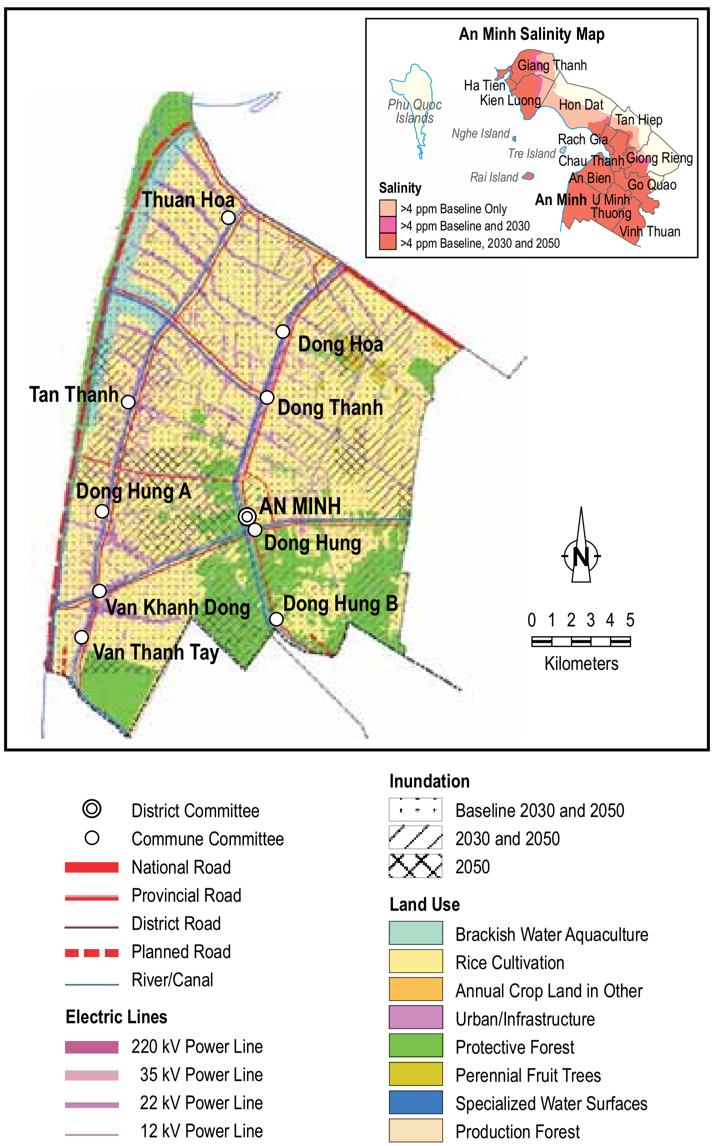


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	167.30	18.55	73.26	115.84
Power (km)	0.00	0.00	0.00	0.00
Agriculture Area (km^2)	408.35	26.82	164.94	278.43
Aquaculture Area (km^2)	17.6	3.6	11.7	14.1
Residential and Commercial Land (km^2)	0.70	0.12	0.23	0.38

km = kilometer, km^2 = square kilometer.

An Minh Projected Inundation and Salinity - Scenario A2



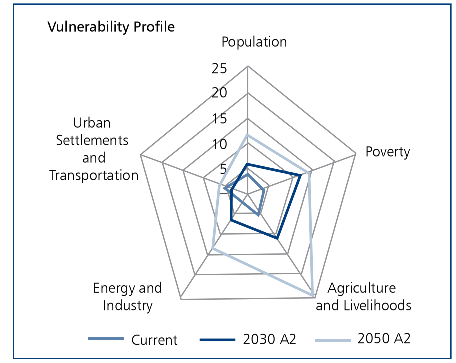
Population: High population at low density and limited present exposure to inundation lead to moderate vulnerability. A low population growth rate ameliorates future increase despite exposure to all three hazards.

Poverty: A high number of poor households and low gross domestic product per head lead to moderate vulnerability, which increases due exposure to all three hazards. A low population growth rate ameliorates increase after 2030.

Agriculture and Livelihoods: A high rural population with low incomes is offset by good availability of land per head of population.

Energy and Industry: A low contribution of input from industry to GDP and a lack of energy and industrial infrastructure lead to very low vulnerability. Exposure to all three hazards increases vulnerability in the future.

Urban Settlements and Transportation: Limited access to water and sanitation for the small urban population leads to moderate vulnerability. The low urban population and limited transportation infrastructure mean that vulnerability is low in the future despite exposure to all three hazards.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	9	99	1
	2030	39	100	1
	2050	64	100	1
Risk Rating	Current	3	10	4
	2030	6	10	4
	2050	6	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

While exposure to flooding is currently low, it is projected to increase considerably with an increase in the risk rating. The district is completely exposed to salinity and at medium risk. Storm surge risk is low due to it being confined to the coast. Some planned industry on the coast may be affected.

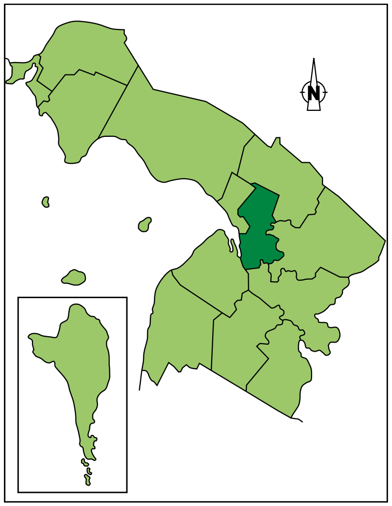
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	••••	•••
Major Industry	••	•	••
Major Energy	•	•	••
Urban	••	••	•••
Transportation	•	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure are required in the short to medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing as well as in improvements in rice varieties and cultivation methods. Control measures for energy, industry and transportation infrastructure are good or very good and the district is resilient in these sectors. Improvements in protection measures for urban infrastructure are required in the medium to long term, particularly for storm surge protection. These are mainly related to raising structures above flood levels and improving water and sanitation.

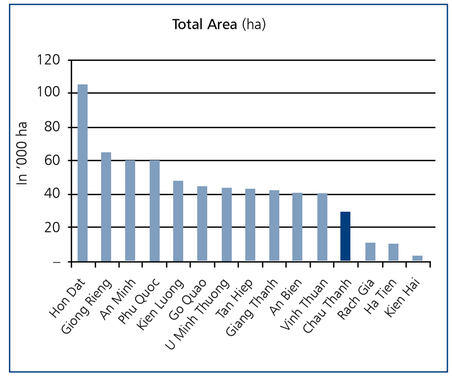
Chau Thanh

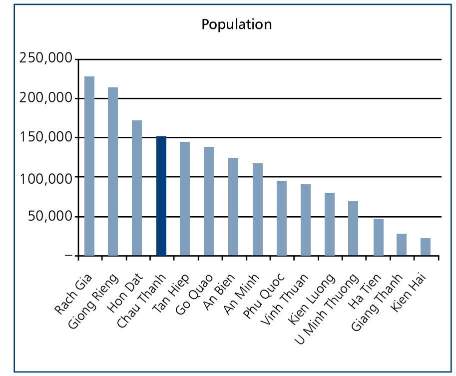


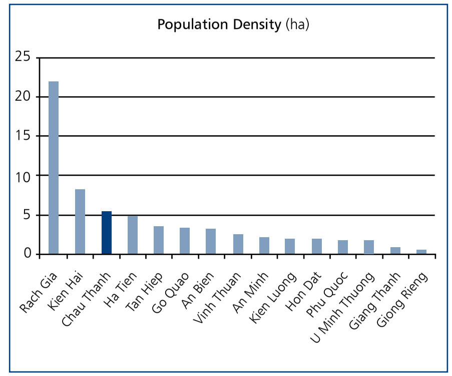
Administrative Center	Minh Luong
Land Area (ha)	28,544
Population	151,250
Population	5.30
No. of Households	34,558
Average Family Size	4.38
Average Annual Household Income	D15,665,000
GDP Contribution from Industry (HH)	D1,849,385
Unemployment Rate	2.3%
Education (teachers/1,000 persons)	7.68
Health (doctors/1,000 persons)	0.19
Ethnicity (% Kinh/non-Kinh)	62.2/37.8

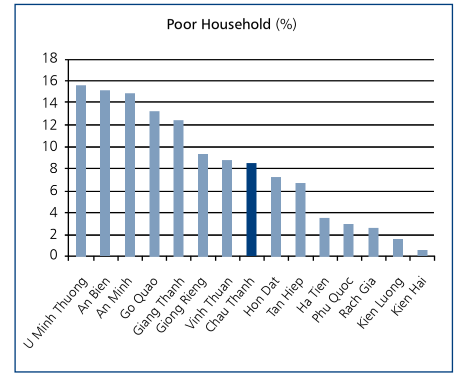
GDP = gross domestic product, ha = hectare, HH = household.

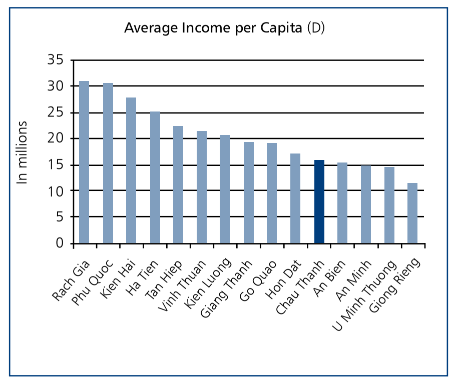
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	High
	No. of Households	High
	Population at Working Age	Medium
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	Medium
	No. of Teachers	Medium
	No. of Doctors	Medium
	Agricultural Land per Person	High
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	High
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	High
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Medium
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	Medium
	Major Roads	Low
	District Roads	Medium
	Transport Hubs	High

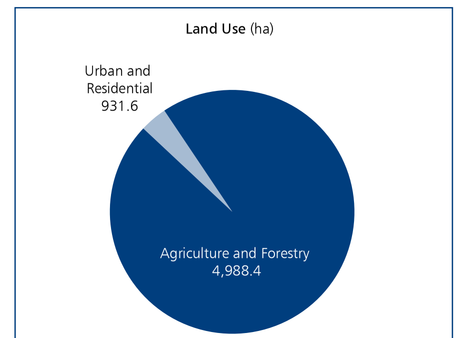










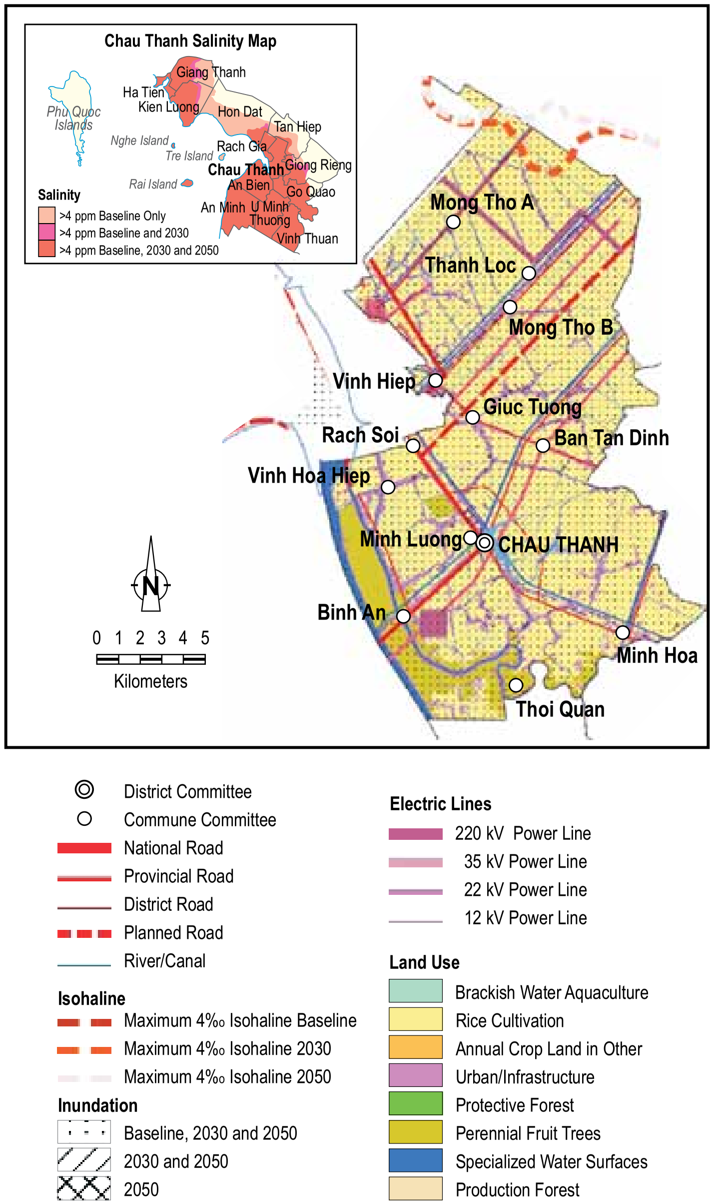


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	139.16	104.81	112.83	118.26
Power (km)	47.34	39.24	41.10	43.23
Agriculture Area (km^2)	250.11	189.42	191.85	201.96
Aquaculture Area (km^2)	0.3	0.2	0.3	0.3
Residential and Commercial Land (km^2)	1.58	0.17	0.18	0.30

km = kilometer, km^2 = square kilometer.

Chau Thanh Projected Inundation and Salinity - Scenario A2

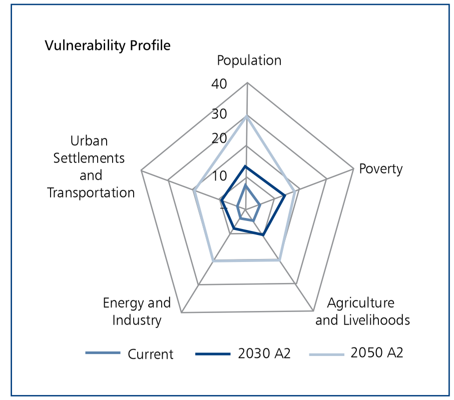


Population: Significant areas already subject to all three impacts and a large population at high density with a high growth rate combine to produce a high vulnerability that increases in the future as a greater area is subject to impacts.

Poverty: High numbers of poor and ethnic households, low income, and limited availability of agricultural land lead to high vulnerability that increases in the future as population increases and a greater area is subject to impacts especially up to 2030.

Agriculture and Livelihoods: High vulnerability due to a high rural population and low annual income is ameliorated by a high number of other income streams. However, vulnerability increases in the future as a greater area of agricultural land is subject to impacts.

Energy and Industry: A high contribution to gross domestic product from industry and the presence of energy infrastructure leads to a high vulnerability. Vulnerability increases in the future as a greater area is subject to impacts.



Urban Settlements and Transportation: Despite a relatively small urban area, the large densely settled population and the presence of transportation infrastructure increase vulnerability in this sector. In all sectors, vulnerability increases in the future due to high population growth, which emphasizes the current susceptibility to all three impacts.

Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	72	100	0
	2030	82	100	1
	2050	87	100	1
Risk Rating	Current	9	10	4
	2030	9	10	4
	2050	9	10	4

<5 Low risks   5–12 Medium risks   See Table 13 pg. 32 for detailed descriptions

Exposure is high across all sectors, and exposure to flooding is projected to increase. The current risk from both inundation and salinity is at the upper end of the medium rank. Some infrastructure on the Ca Lon estuary may be affected by storm surges.

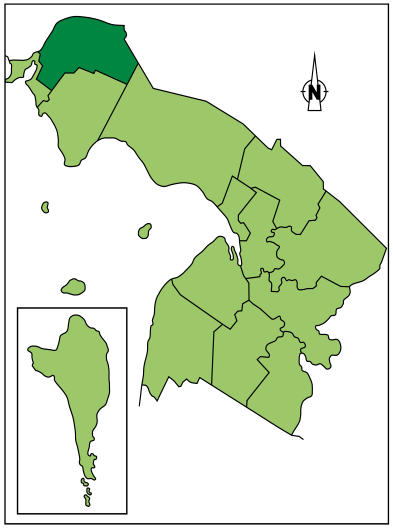
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	•••	••
Major Industry	•••	••	•••
Major Energy	•••	•	••
Urban	••	•	••
Transportation	••	•	••

• Adequate   •• Change (long term)   ••• Improvement (medium term)   •••• Rehabilitation urgent

The control measures in the agriculture sector are adequate at present but improvements are required in the medium to long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall resilience in the energy sector is medium, and resilience in the industry sector is low. Improvements in the control measures for the substantial amount of energy infrastructure and for the industry infrastructure are required particularly in terms of flood protection. Control measures for both urban and transportation infrastructure are good, and the district is resilient in these sectors. Required improvements are mainly related to raising structures above flood levels and improving water and sanitation.

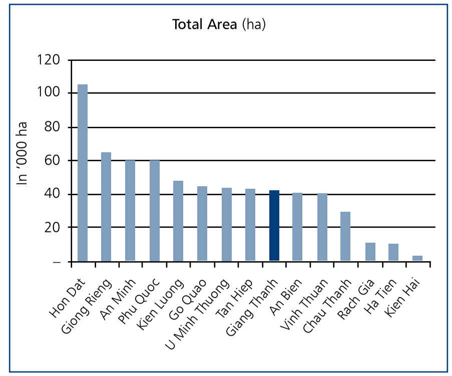
Giang Thanh

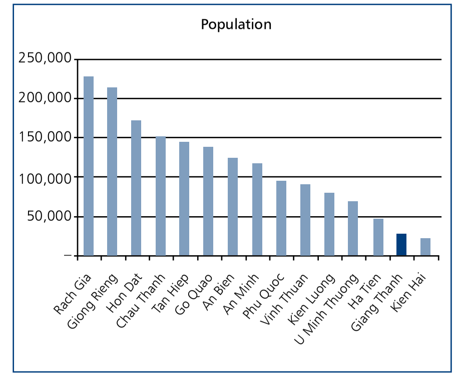


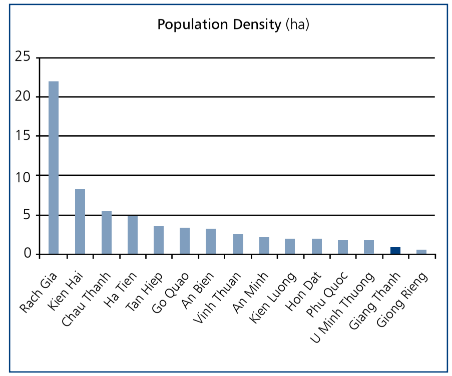
Administrative Center	Tan Khanh Hoa
Land Area (ha)	41,284
Population	27,110
Population	0.66
No. of Households	6,939
Average Family Size	3.91
Average Annual Household Income	D19,270,000
GDP Contribution from Industry (HH)	D687,500
Unemployment Rate	No Data
Education (teachers/1,000 persons)	8.04
Health (doctors/1,000 persons)	0.17
Ethnicity (% Kinh/non-Kinh)	85.7/14.3

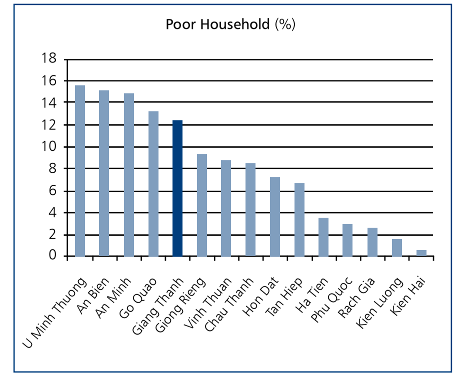
GDP = gross domestic product, ha = hectare, HH = household.

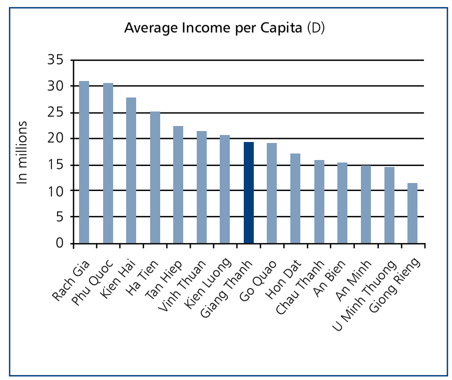
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Low
	% of Poor Households	High
	No. of Teachers	High
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	High
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Low
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	–
	Urban Households	–
	Urban Area	High
	% of Urban Area/Population	Low
	Sewer/Septic Tank	High
	Water Supply	High
	Major Waterways	Medium
	Major Roads	Low
	District Roads	Low
	Transport Hubs	Low

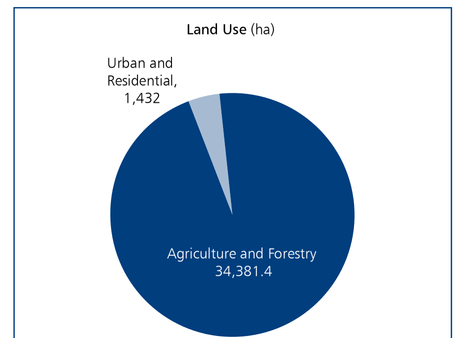








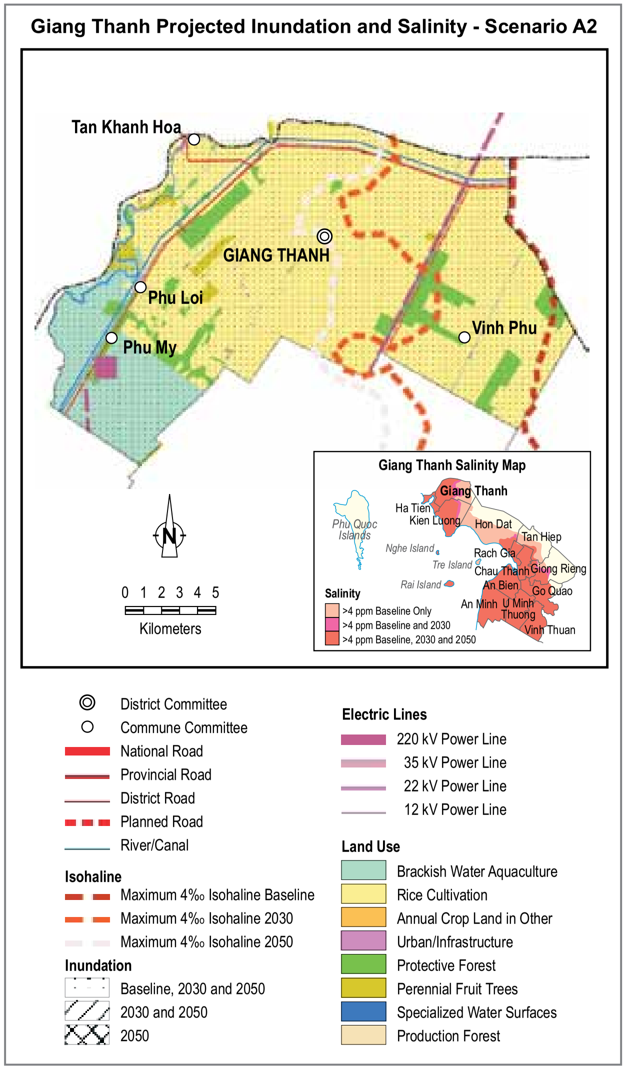




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	55.52	53.76	53.76	53.96
Power (km)	0.00	0.00	0.00	0.00
Agriculture Area (km²)	322.59	315.42	315.57	318.71
Aquaculture Area (km²)	382.13	374.29	374.52	377.92
Residential and Commercial Land (km²)	0.04	0.02	0.02	0.02

km = kilometer, km² = square kilometer.




M. Russell

Rural scene in in Giang Thanh.

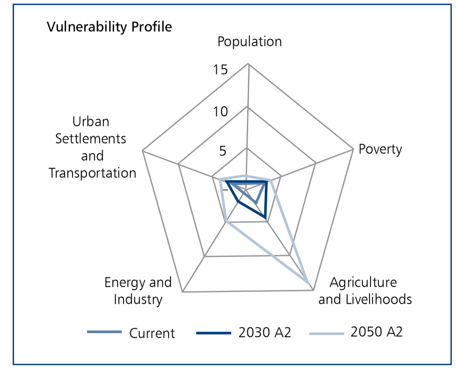
Population: A very small population leads to very low vulnerability despite widespread exposure to inundation and salinity.

Poverty: High percentages of poor and ethnic households and poor access to health and education are offset by the small initial population, which also limits increase in the future.

Agriculture and Livelihoods: A high reliance on agriculture is ameliorated by a moderate gross domestic product and high household access to land. Vulnerability increases in the future due to a high population growth rate and the large size of the area exposed to impacts.

Energy and Industry: A very low reliance on industry for household income and a lack of industrial infrastructure lead to a very low vulnerability.

Urban Settlements and Transportation: Limited access to water and sanitation for the small urban population leads to some vulnerability. The low urban population and limited transportation infrastructure mean that vulnerability is low in the future despite exposure to inundation and salinity.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	98	90	0
	2030	98	100	0
	2050	99	100	0
Risk Rating	Current	9	10	0
	2030	9	10	0
	2050	9	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

The district is completely exposed, and medium associated risk from both inundation and salinity is high.

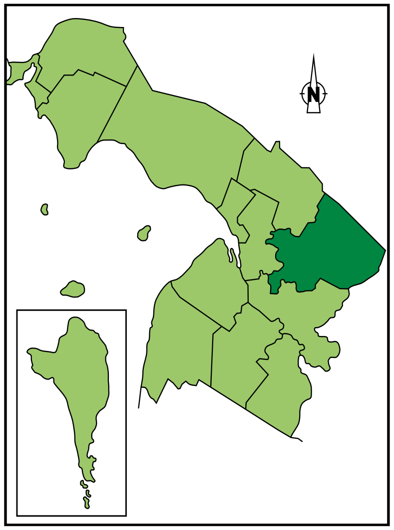
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	••••	••
Major Industry	••	••	•
Major Energy	••	•	•
Urban	••	••	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure are required in the near term to protect against salinity and in the medium to long term for flooding and salinity. Improvements are required in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. In the long term, improvements in the control measures against flooding will be required for most sectors and against salinity for urban and industry infrastructure. These are mainly related to raising structures above flood levels and improving water and sanitation.

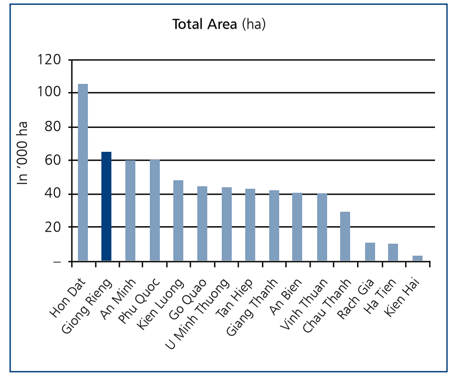
Giong Rieng

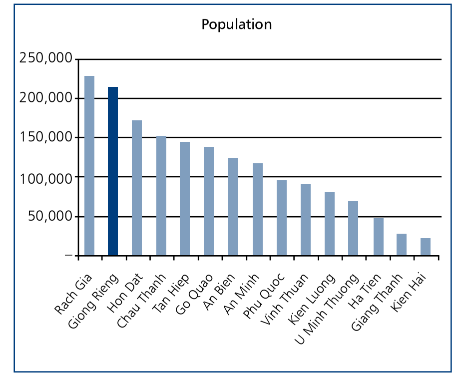


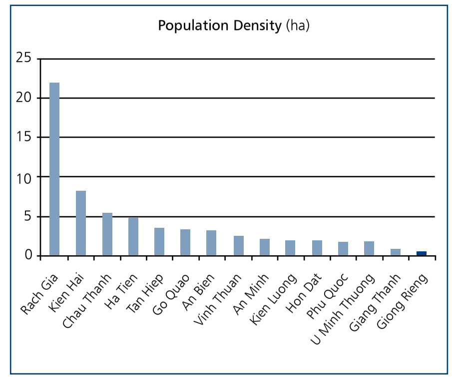
Administrative Center	Giong Rieng
Land Area (ha)	63,929
Population	212,716
Population	3.33
No. of Households	48,885
Average Family Size	4.35
Average Annual Household Income	D11,426,000
GDP Contribution from Industry (HH)	D1,322,965
Unemployment Rate	1.8%
Education (teachers/1,000 persons)	8.71
Health (doctors/1,000 persons)	0.01
Ethnicity (% Kinh/non-Kinh)	97.2/2.8

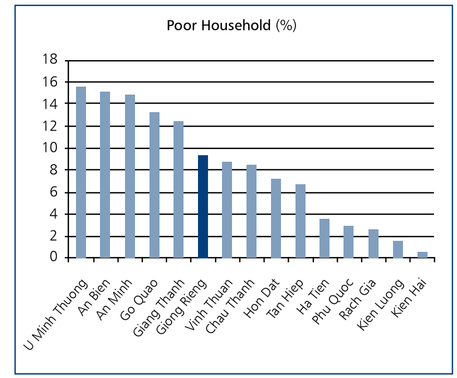
GDP = gross domestic product, ha = hectare, HH = household.

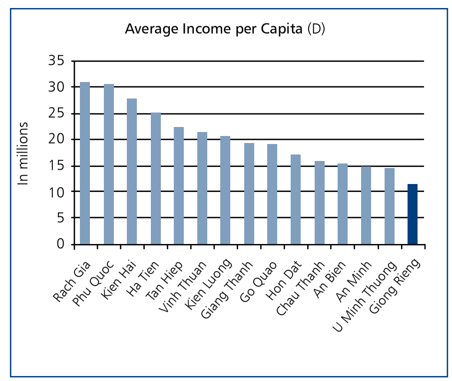
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	Medium
	Average Family Size	High
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	High
	% of Poor Households	Medium
	No. of Teachers	Low
	No. of Doctors	High
	Agricultural Land per Person	Medium
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	Medium
	Average Annual GDP per Household	High
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	Low
	No. of Factories	Medium
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Medium
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	Medium
	Water Supply	High
	Major Waterways	High
	Major Roads	High
	District Roads	Medium
	Transport Hubs	Low

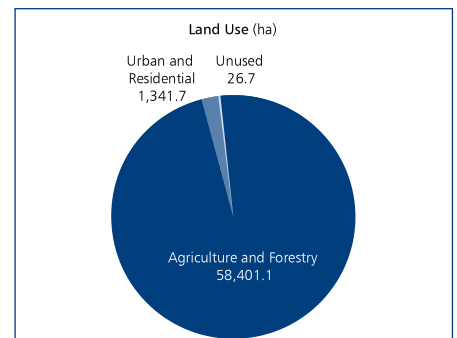










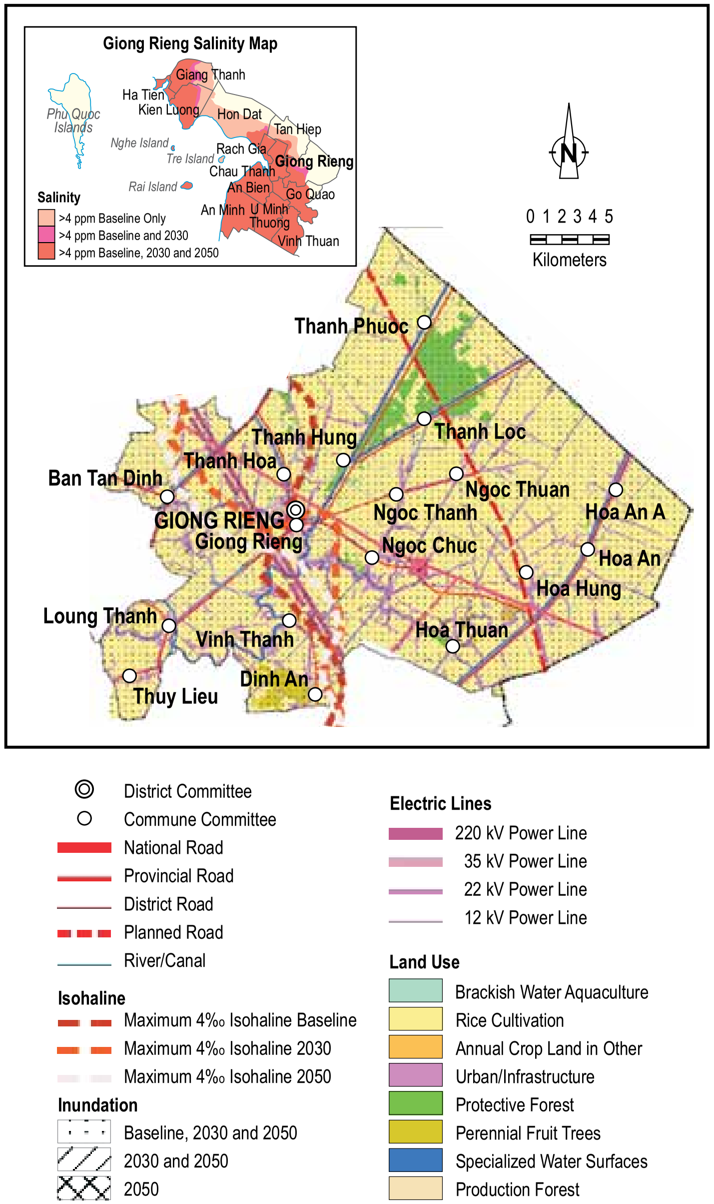


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	187.79	146.36	159.04	168.14
Power (km)	50.18	42.33	43.68	47.02
Agriculture Area (km^2)	547.75	470.82	475.15	498.23
Aquaculture Area (km^2)	0.0	0.0	0.0	0.0
Residential and Commercial Land (km^2)	1.75	0.28	0.44	0.79

km = kilometer, km^2 = square kilometer.

Giong Rieng Projected Inundation and Salinity - Scenario A2



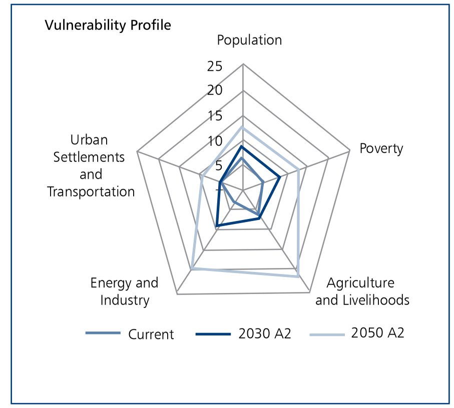
Population: A large population at a moderate density that is currently affected by inundation results in increasing vulnerability in the future as population and exposure increase.

Poverty: A low average annual income and a large number of poor and ethnic households lead to a high vulnerability that increases in the future due to moderate population growth.

Agriculture and Livelihoods: A very large rural population with low annual income is exposed to inundation and salinity, leading to high vulnerability as both population and the area exposed to inundation increase.

Energy and Industry: The large population means that a large number of households are reliant on industry, increasing vulnerability in the future as population and exposure increase.

Urban Settlements and Transportation: Poor access to water and sewage and current exposure of a large amount of transportation infrastructure to inundation increase vulnerability. The small percentage of the population that lives in urban areas and small increase in the area exposed reduce future increases.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	83	25	0
	2030	89	20	0
	2050	94	20	0
Risk Rating	Current	9	5	0
	2030	9	5	0
	2050	9	5	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding is high and is projected to increase while exposure to salinity is moderate and is projected to decrease. The risk from inundation is relatively high but from salinity remains at the low end of the medium rank.

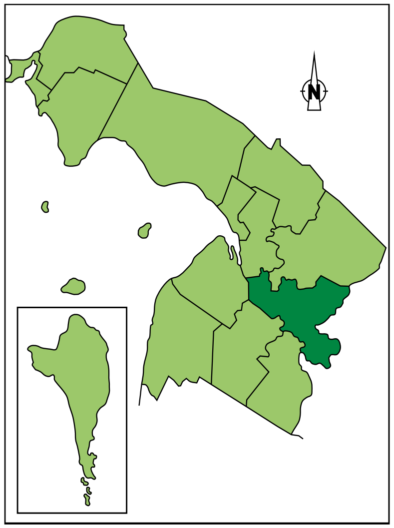
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	••	•
Major Industry	••	•	•
Major Energy	••	•	•
Urban	••	•	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure are required in the medium to long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall resilience in the other sectors is very good with some improvements in the control measures against flooding required for most sectors in the long term. These are mainly related to raising structures above flood levels, improved urban drainage, and improved water and sanitation.

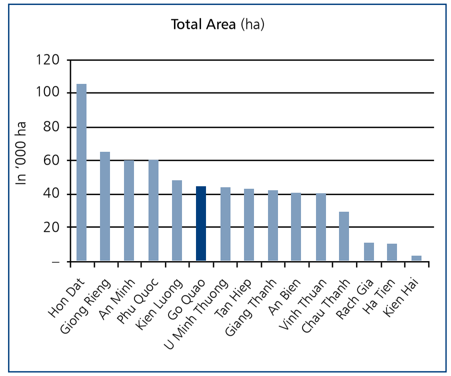
Go Quao

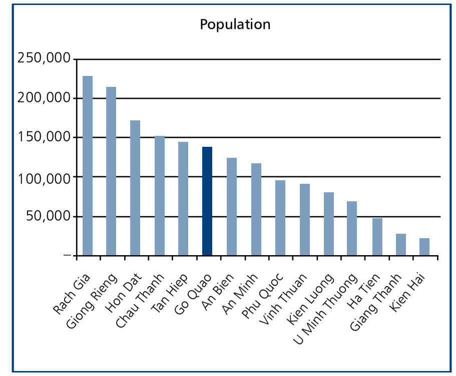


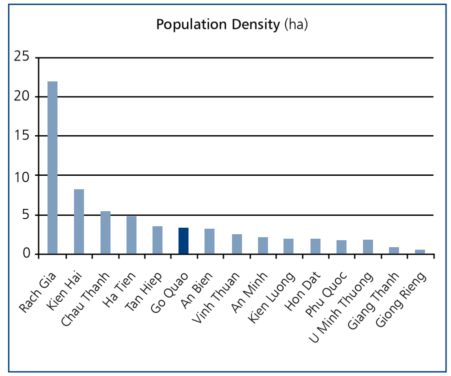
Administrative Center	Go Quao
Land Area (ha)	43,951
Population	137,250
Population	3.12
No. of Households	32,630
Average Family Size	4.21
Average Annual Household Income	D19,000,000
GDP Contribution from Industry (HH)	D3,077,822
Unemployment Rate	1.8%
Education (teachers/1,000 persons)	8.52
Health (doctors/1,000 persons)	0.25
Ethnicity (% Kinh/non-Kinh)	66.6/33.4

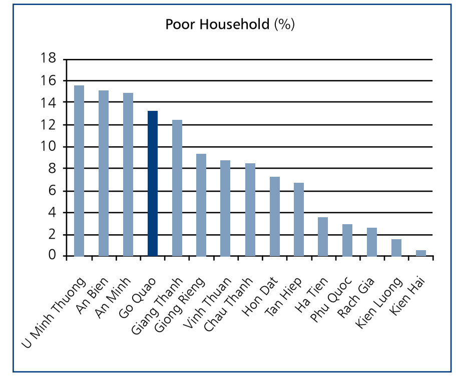
GDP = gross domestic product, ha = hectare, HH = household.

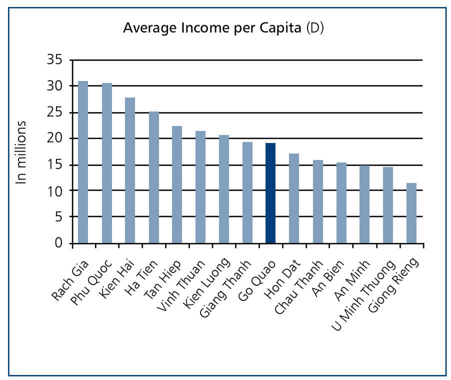
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	Medium
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	Low
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	High
	% of Poor Households	High
	No. of Teachers	Medium
	No. of Doctors	Low
	Agricultural Land per Person	Medium
	% Ethnic Households	High
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	High
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Medium
	No. of Factories	Medium
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	High
	Urban Households	High
	Urban Area	High
	% of Urban Area/Population	Low
	Sewer/Septic Tank	Medium
	Water Supply	High
	Major Waterways	Low
	Major Roads	Medium
	District Roads	Medium
	Transport Hubs	Low

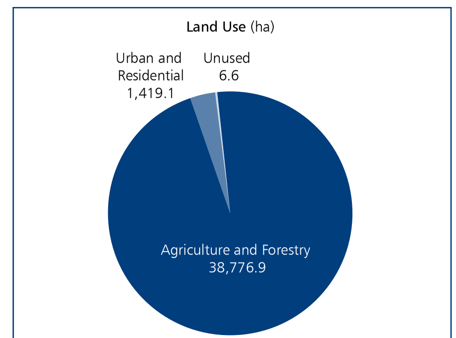








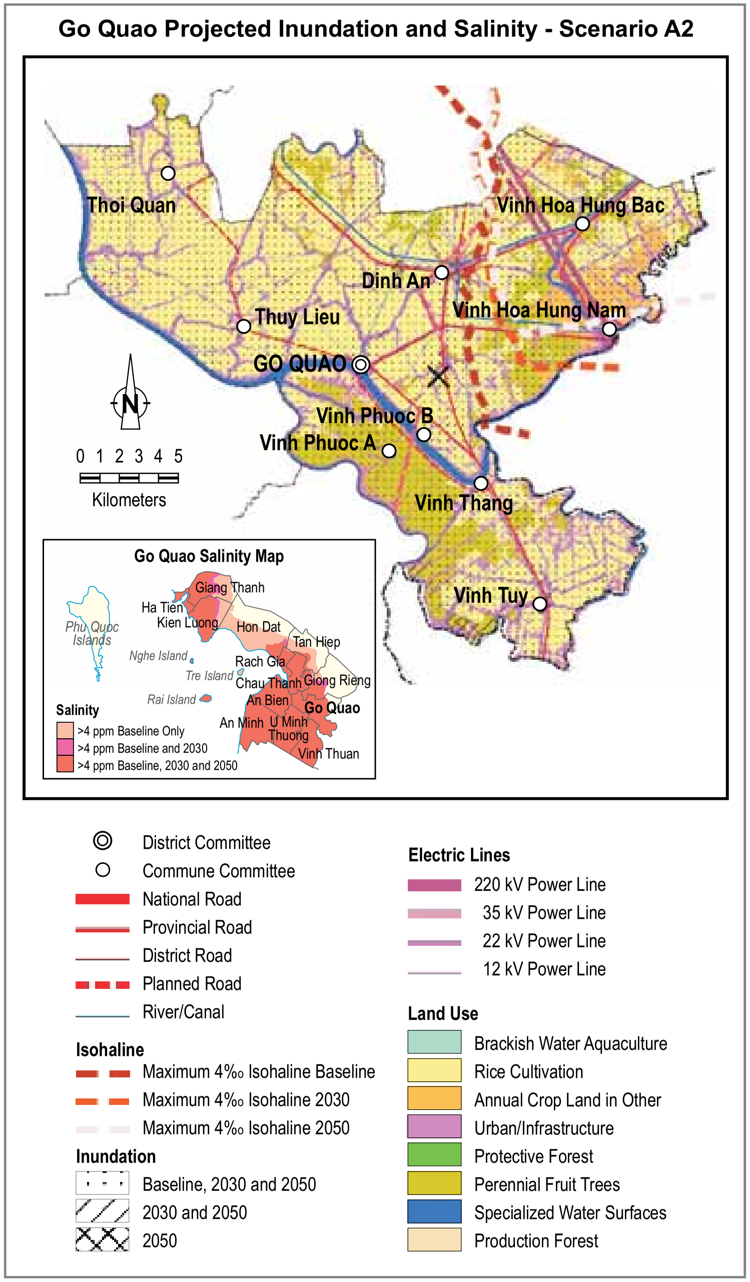




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	121.21	79.77	104.31	112.49
Power (km)	11.44	6.76	8.61	10.46
Agriculture Area (km²)	383.34	236.44	241.15	263.84
Aquaculture Area (km²)	0.1	0.0	0.0	0.0
Residential and Commercial Land (km²)	1.42	0.07	6.01	6.21

km = kilometer, km² = square kilometer.



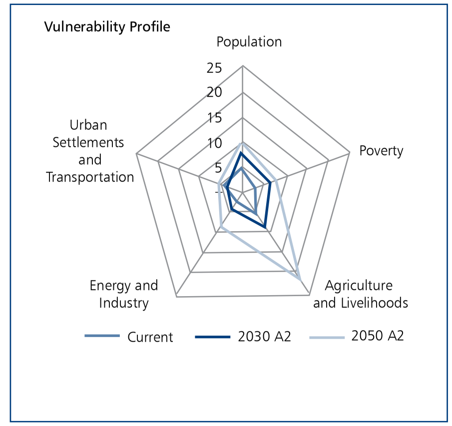
Population: A moderate population at medium density is exposed to inundation and salinity. A moderate population growth and increased exposure increase vulnerability in the future.

Poverty: Very high numbers of poor and ethnic households are offset by moderate values of other indicators. Expansion of the area subject to inundation increases vulnerability in the future.

Agriculture and Livelihoods: A high reliance on agriculture is ameliorated by a moderate gross domestic product and household access to land. Vulnerability increases in the future due to a gradual increase in the area affected by inundation and salinity.

Energy and Industry: A very low reliance on industry for household income and a lack of industrial infrastructure lead to a very low vulnerability despite increased exposure to impacts.

Urban Settlements and Transportation: A very small urban population and relatively limited access to water and sanitation lead to some vulnerability. The moderate population growth and increase in exposure mean that future vulnerability is low compared to other districts.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	61	70	0
	2030	86	80	0
	2050	92	85	0
Risk Rating	Current	6	5	0
	2030	9	10	0
	2050	9	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding and salinity is high and both are projected to increase.The risk from both inundation and salinity increase from 2030.

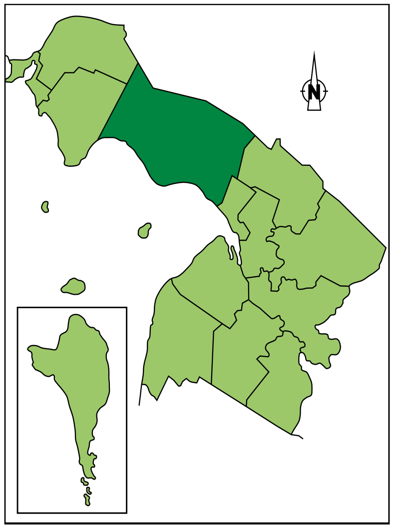
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	•••	•
Major Industry	••	••	•
Major Energy	•	•	•
Urban	••	••	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure to protect against flooding and salinity are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall resilience in the other sectors is good with improvements in the control measures against flooding and salinity only required for most sectors in the long term. These are mainly related to raising structures above flood levels, improved urban drainage, and improved water and sanitation.

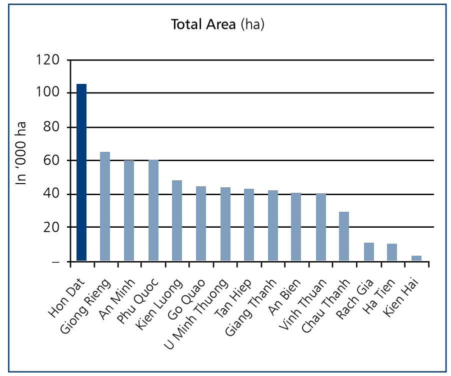
Hon Dat

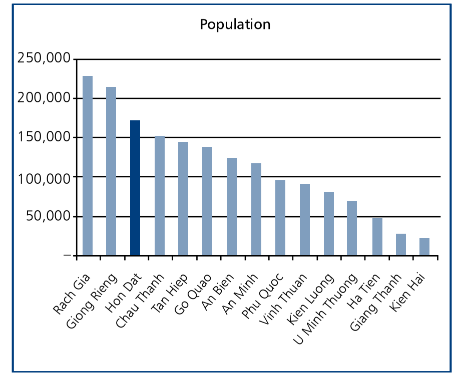


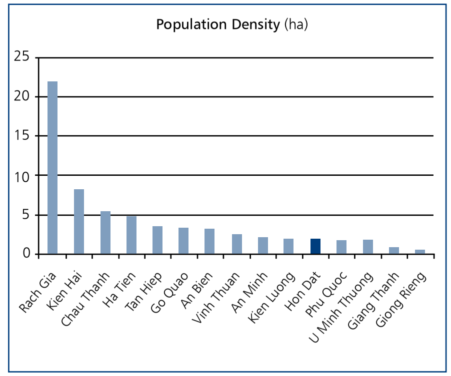
Administrative Center	Hon Dat
Land Area (ha)	103,863
Population	171,000
Population	1.65
No. of Households	38,589
Average Family Size	4.43
Average Annual Household Income	D16,885,000
GDP Contribution from Industry (HH)	D1,497,001
Unemployment Rate	3.3%
Education (teachers/1,000 persons)	7.85
Health (doctors/1,000 persons)	0.18
Ethnicity (% Kinh/non-Kinh)	86.14/13.86

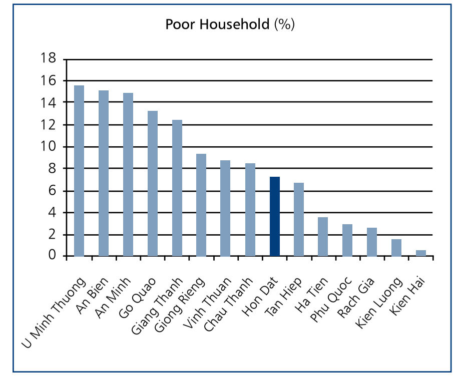
GDP = gross domestic product, ha = hectare, HH = household.

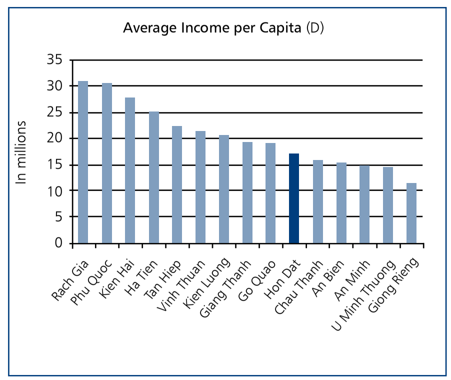
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	Low
	Average Family Size	High
	No. of Households	High
	Population at Working Age	High
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Medium
	% of Poor Households	Medium
	No. of Teachers	Low
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Low
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	High
	% of Urban Area/Population	High
	Sewer/Septic Tank	Medium
	Water Supply	Low
	Major Waterways	High
	Major Roads	High
	District Roads	High
	Transport Hubs	Medium

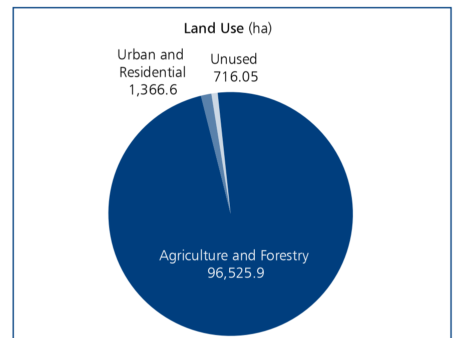








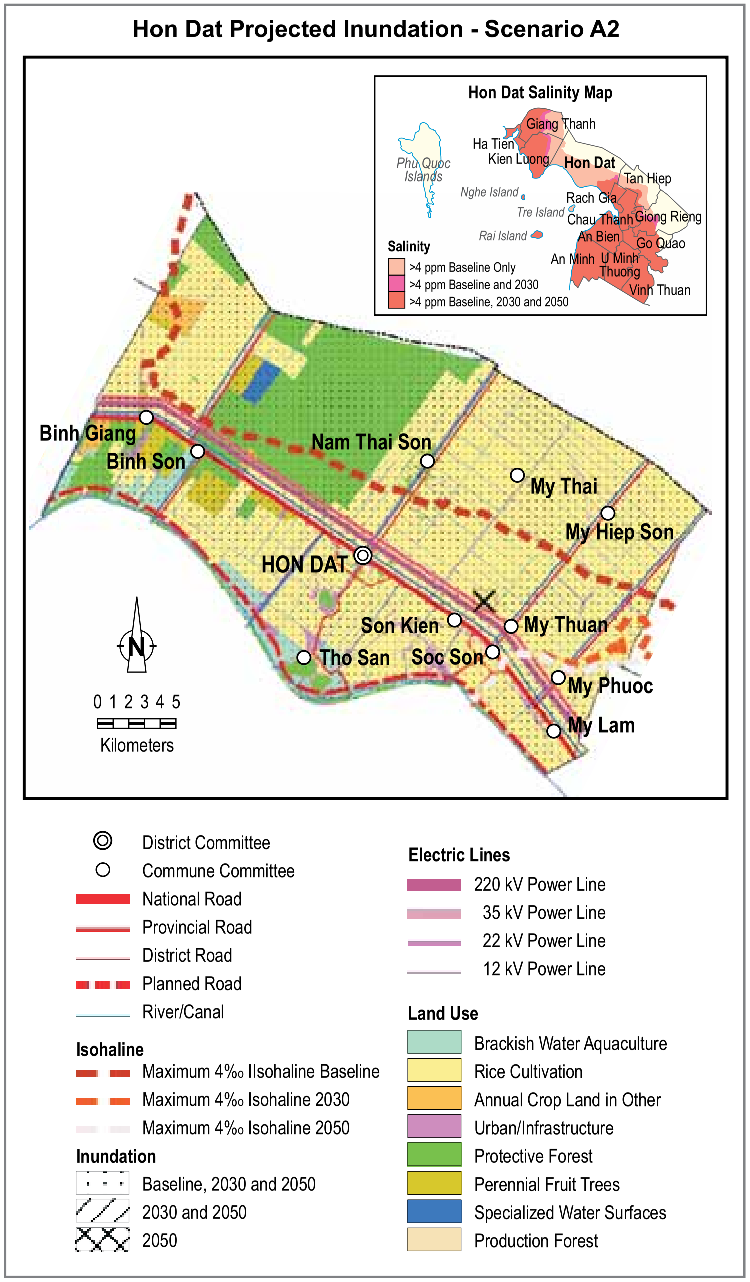




ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	243.72	223.03	224.88	235.77
Power (km)	91.54	89.86	90.10	91.14
Agriculture Area (km^2)	727.82	712.52	713.29	721.31
Aquaculture Area (km^2)	36.3	32.6	32.6	33.3
Residential and Commercial Land (km^2)	1.84	1.38	1.39	1.75

km = kilometer, km^2 = square kilometer.



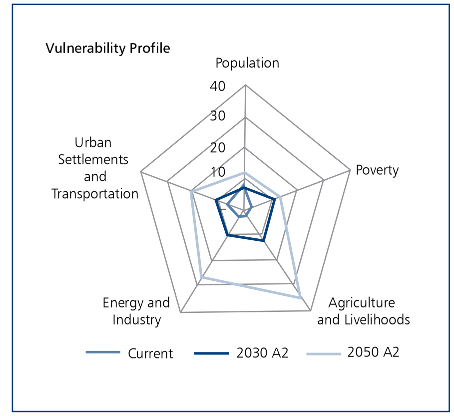
Population: A very large population with a high growth rate and large family size is currently affected by extensive inundation and salinity. A reduction in the area exposed to salinity leads to a small increase in the future.

Poverty: A low average annual income and a large number of poor and ethnic households lead to a high vulnerability that increases in the future due to high population growth.

Agriculture and Livelihoods: Low population density and good access to agricultural land lead to low initial vulnerability. A high growth rate of the mostly rural population and an increase in exposure to inundation and storm surges increase vulnerability in the future.

Energy and Industry: The large population means that a large number of households is reliant on industry, increasing vulnerability in the future as population and exposure of the extensive power infrastructure increase.

Urban Settlements and Transportation: The two large towns, poor access to sewage, and current exposure of a large amount of transport infrastructure to inundation lead to vulnerability, which increases in the future as population and exposure increase.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	96	50	0
	2030	97	20	1
	2050	98	20	1
Risk Rating	Current	9	10	4
	2030	9	5	4
	2050	9	5	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding and salinity is high, and exposure to storm surges is projected to increase; however, modeling suggests that the exposure and associated risk from salinity decrease from 2030. Storm surge risk is low as it is confined to the coast.

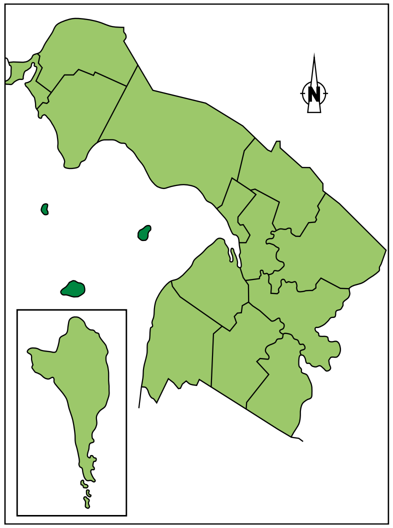
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••••	•••	••
Major Industry	•••	••	••
Major Energy	••	•	••
Urban	••	••	•••
Transportation	••	•	••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

The exposure to storm surge will require improvements in protection across all sectors in the long term. The overall resilience in the agriculture sector is low and improvements in the control measures for agricultural infrastructure are required immediately to protect from flooding, and in the medium term to protect from salinity. Measures required are in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing as well as in improvements in rice varieties and cultivation methods. Improvements in control measures are required in the medium to long term to protect industry infrastructure from flooding and the town infrastructure from storm surge. Improvements in the control measures are required in the long term to protect the town energy and transportation infrastructure. Required improvements are mainly related to raising structures above flood levels and strengthening against storm surge.

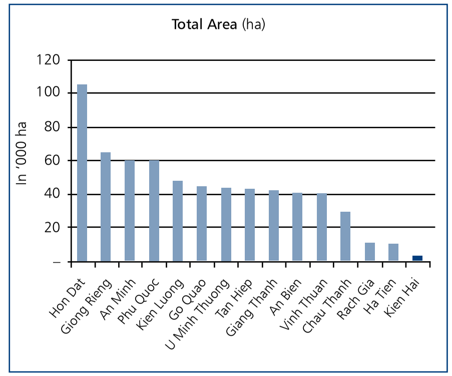
Kien Hai

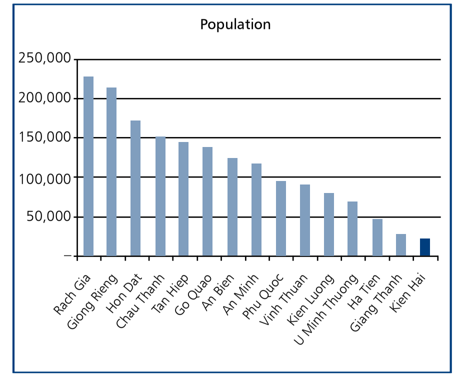


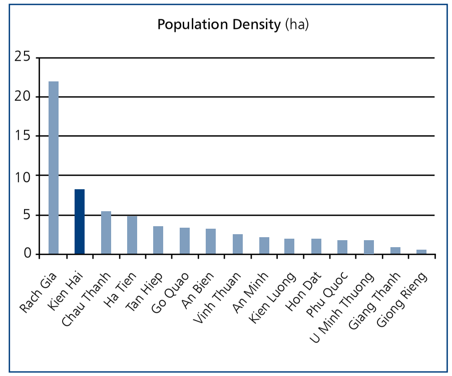
Administrative Center	Bai Nha
Land Area (ha)	2,558
Population	21,272
Population	8.32
No. of Households	5,214
Average Family Size	4.08
Average Annual Household Income	D27,640,000
GDP Contribution from Industry (HH)	D3,846,660
Unemployment Rate	6.0%
Education (teachers/1,000 persons)	6.2
Health (doctors/1,000 persons)	0.05
Ethnicity (% Kinh/non-Kinh)	98.1/1.9

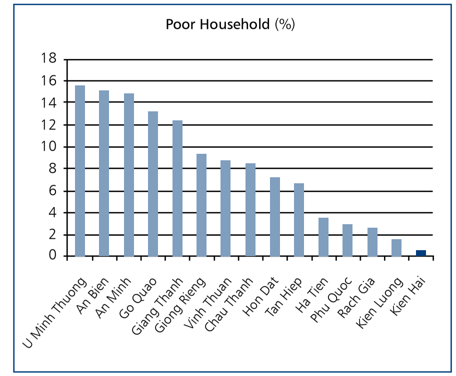
GDP = gross domestic product, ha = hectare, HH = household.

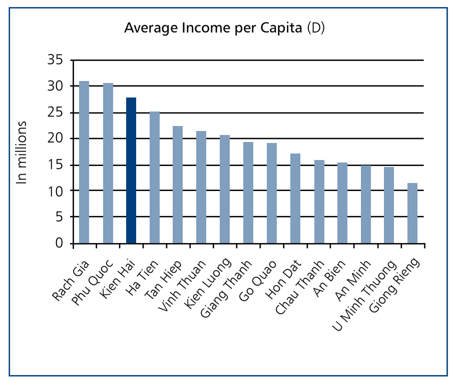
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	High
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	High
	No. of Doctors	High
	Agricultural Land per Person	High
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	High
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	Medium
	No. of Factories	Low
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	–
	Urban Households	–
	Urban Area	Low
	% of Urban Area/Population	Low
	Sewer/Septic Tank	Medium
	Water Supply	High
	Major Waterways	–
	Major Roads	–
	District Roads	Low
	Transport Hubs	High

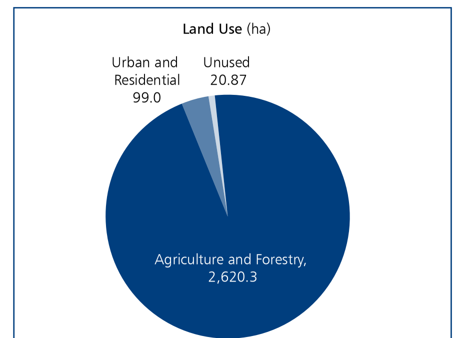






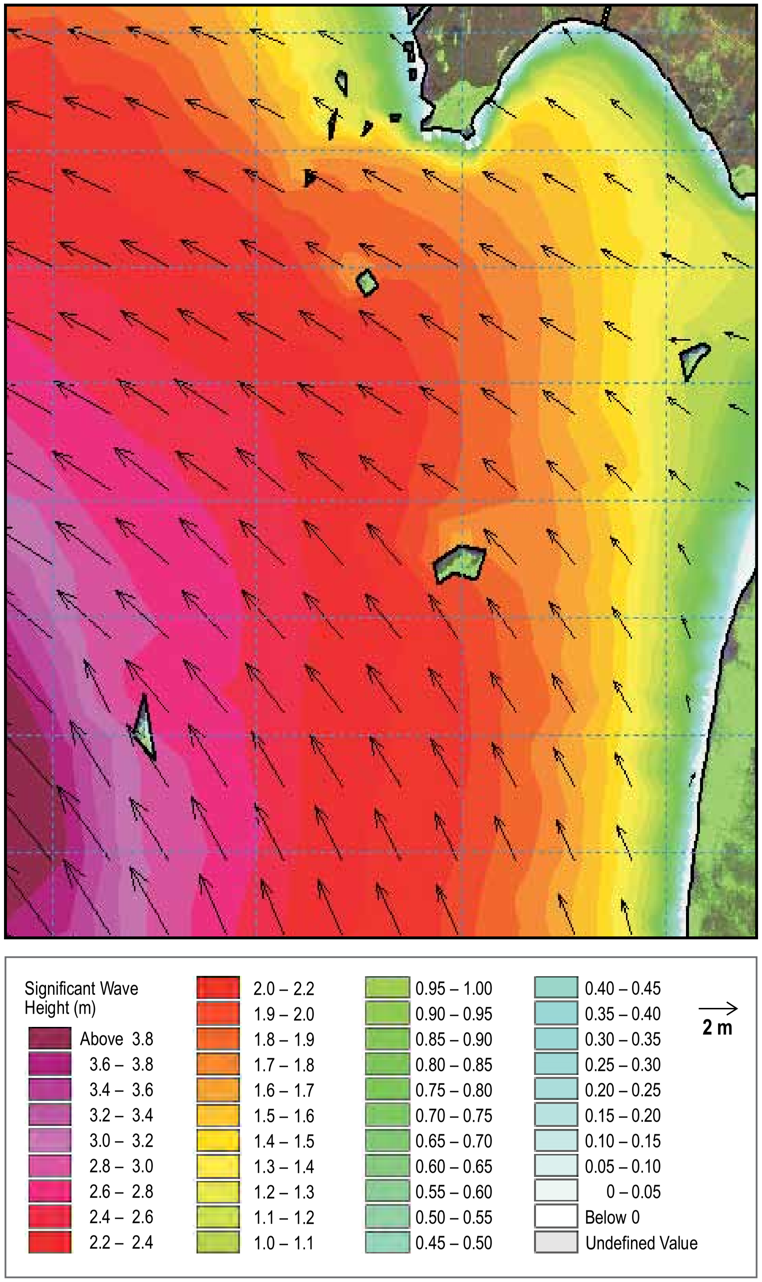






ha = hectare.

Kien Hai Wave Height in Typhoon



Modeled significant wave height in the sea surrounding Kien Hai during Typhoon Linda that passed over the district in September 1997 causing considerable damage.

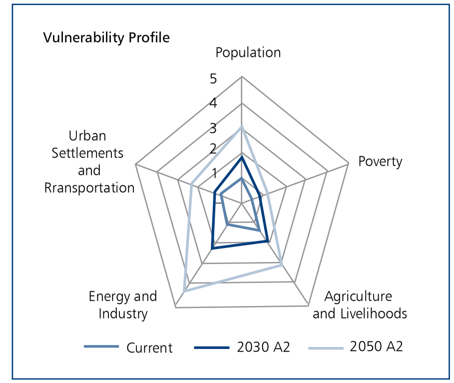
Population: A very small population and no exposure to flooding lead to very low vulnerability despite a high exposure to storm surges.

Poverty: A high gross domestic product per household and low numbers of poor and ethnic households offset the vulnerability due to poor access to health and education.

Agriculture and Livelihoods: The high gross domestic product per household and wide range of income sources ameliorate the potential vulnerability of a 100% rural population.

Energy and Industry: The small population reduces the effects of the reliance of the district on industry. The high exposure of households and energy and industrial infrastructure to storm surge increases vulnerability.

Urban Settlements and Transportation: Limited access to water and sanitation and increasing exposure of marine transport hubs to storm surge increase vulnerability.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	0	0	12
	2030	0	0	15
	2050	0	0	18
Risk Rating	Current	0	0	6
	2030	0	0	6
	2050	0	0	6

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

This island district has little exposure to flooding and salinity but is very exposed to storm surge. While the risk from inundation and salinity are low due to the steep terrain of the islands, the risk from storm surge is moderate due to the exposure of housing and boats along the shore.

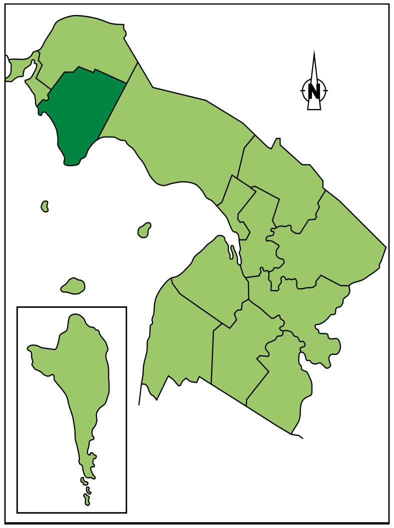
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•	•	•
Major Industry	•	•	••••
Major Energy	•	•	•••
Urban	•	•	••••
Transportation	•	•	•••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

There is very little agriculture infrastructure so it is very resilient in this sector. The exposure to storm surge which may cause extensive and widespread damage requires immediate improvements in protection across all of the other sectors. These are in the form of protection from wind damage, inundation due to storm surge and damage by waves. Structures at risk include urban structures, the power generating and distribution system, and the ferry and fishing villages and boats.

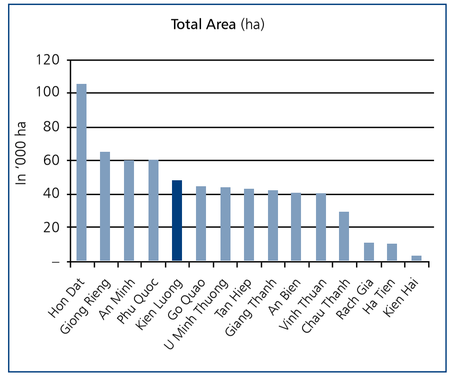
Kien Luong

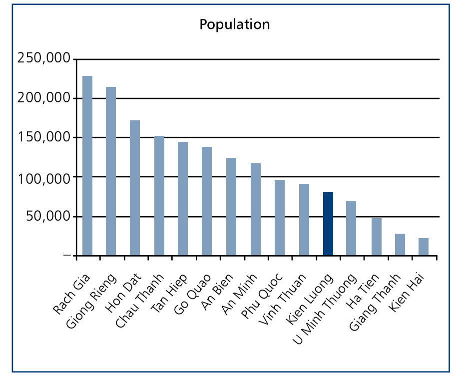


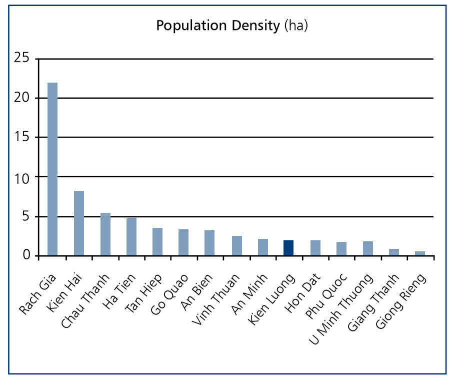
Administrative Center	Kien Luong
Land Area (ha)	47,285
Population	79,236
Population	1.68
No. of Households	19,322
Average Family Size	4.10
Average Annual Household Income	D20,463,000
GDP Contribution from Industry (HH)	D2,455,398
Unemployment Rate	2.5%
Education (teachers/1,000 persons)	7.87
Health (doctors/1,000 persons)	0.37
Ethnicity (% Kinh/non-Kinh)	85.44/14.56

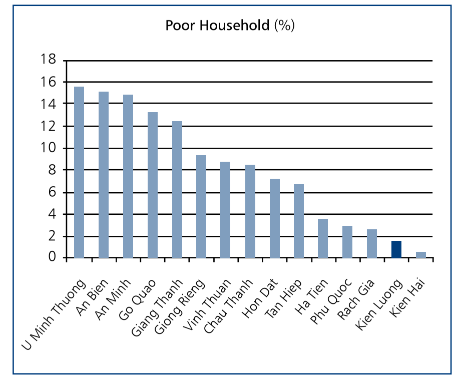
GDP = gross domestic product, ha = hectare, HH = household.

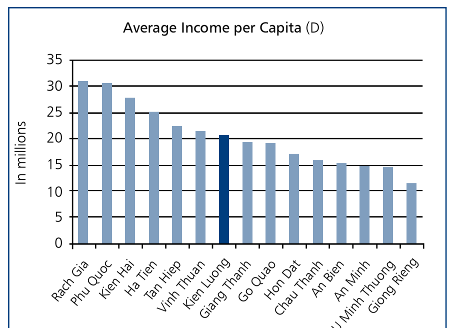
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Low
	No. of Households	Low
	Population at Working Age	Medium
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	High
	No. of Doctors	Medium
	Agricultural Land per Person	Low
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	High
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	Medium
	% of Urban Area/Population	High
	Sewer/Septic Tank	Medium
	Water Supply	Medium
	Major Waterways	Medium
	Major Roads	Low
	District Roads	Low
	Transport Hubs	Medium

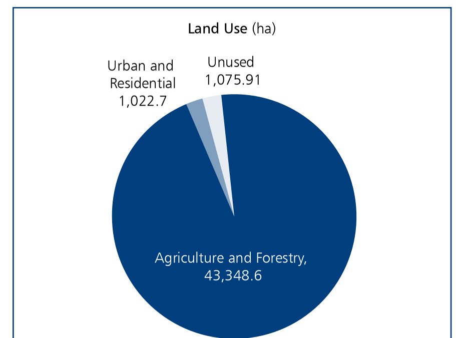










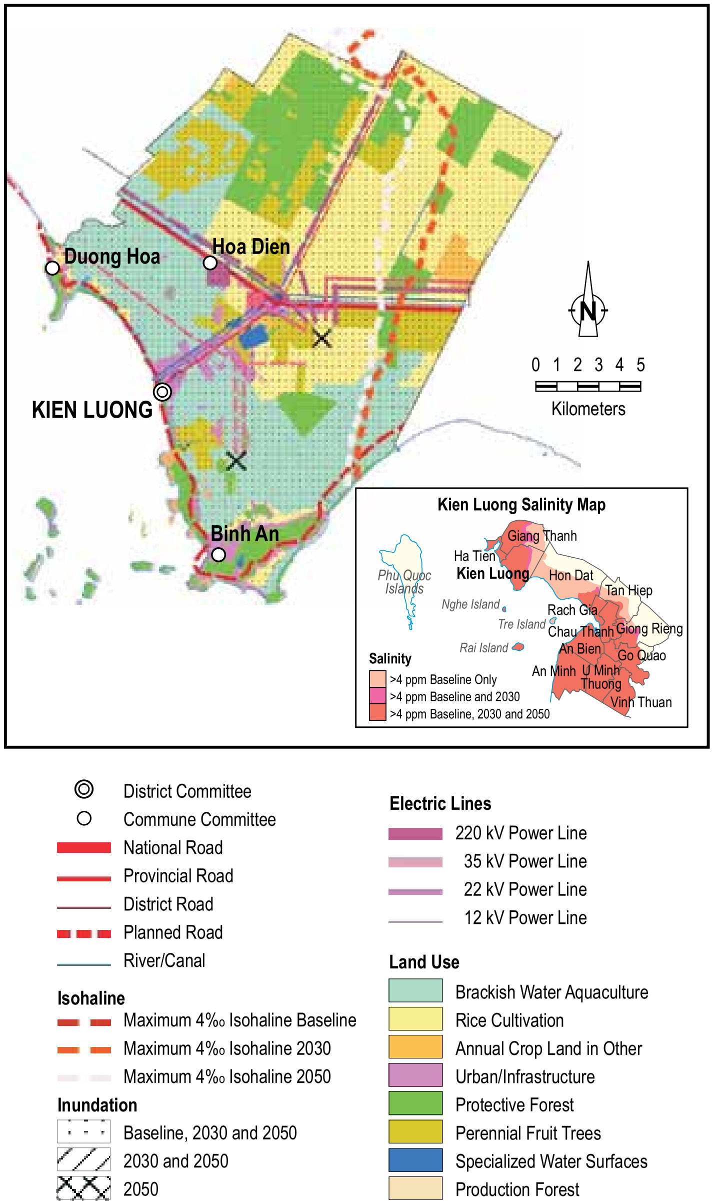


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	89.32	68.12	71.88	77.58
Power (km)	23.65	21.12	22.44	23.15
Agriculture Area (km²)	179.08	165.50	166.82	170.61
Aquaculture Area (km²)	133.6	128.4	129.1	131.2
Residential and Commercial Land (km²)	2.76	0.76	1.49	1.91

km = kilometer, km² = square kilometer.

Kien Luong Projected Inundation and Salinity - Scenario A2



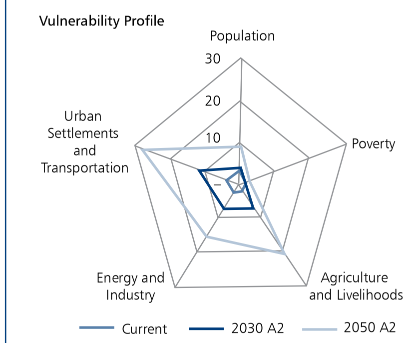
Population: A small population at low density reduces vulnerability. A moderate population growth rate ameliorates future increase despite exposure to all three hazards.

Poverty: A low number of poor households, moderate gross domestic product per head, and good access to agricultural land reduce vulnerability despite exposure to all three hazards.

Agriculture and Livelihoods: A low number of rural households with high incomes leads to low vulnerability. A moderate population growth rate increases vulnerability in the future.

Energy and Industry: A reliance on industry and extensive electrical infrastructure lead to vulnerability that increases as the population grows and exposure to storm surges increases.

Urban Settlements and Transportation: Moderate urbanization and poor access to water and sanitation lead to increased vulnerability in the future.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	89	100	1
	2030	89	75	2
	2050	91	75	2
Risk Rating	Current	9	10	4
	2030	9	10	4
	2050	9	10	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding is high and while the current exposure to salinity is 100% it is projected to decrease by 2030. The risk from inundation and salinity are high. Storm surge exposure is moderate but the risk is low as it is confined to the coast.

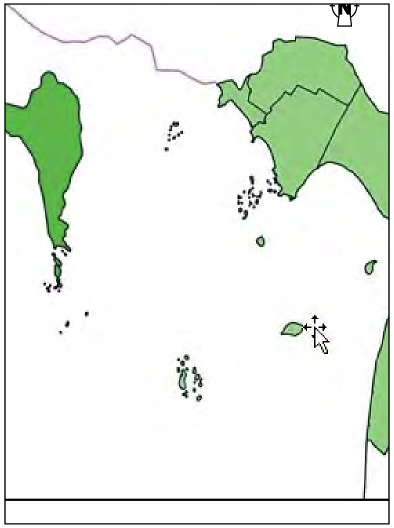
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	•••	•••
Major Industry	••	••	••••
Major Energy	•••	•	•••
Urban	••	••	•••
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

The district is exposed to storm surge requiring improvements in protection across most of the sectors in the short term. The overall resilience in the agriculture sector is low and improvements in the control measures for agricultural infrastructure are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, improvements in rice varieties and cultivation methods as well as in aquaculture techniques and calendars in order to account for climate change. Improvements in the control measures for the infrastructure in the industry and urban sectors are required in the long term particularly in terms of storm surge protection. The major energy infrastructure requires improved control measures to protect from flooding and storm surge. Required improvements are mainly related to raising structures above flood levels, improving coastal barriers and improving urban drainage and water and sanitation infrastructure. The transportation sector has a high resilience and only requires improvements in control measures in the long term.

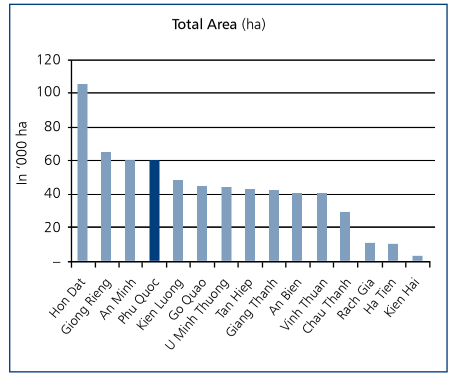
Phu Quoc

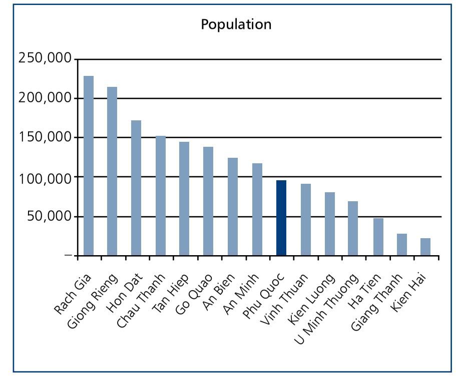


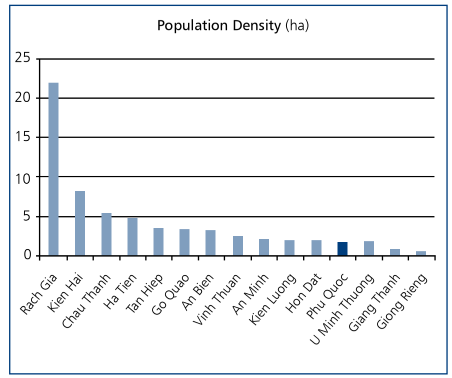
Administrative Center	Duong Đông
Land Area (ha)	58,891
Population	93,654
Population	1.59
No. of Households	23,363
Average Family Size	4.01
Average Annual Household Income	D30,414,000
GDP Contribution from Industry (HH)	D2,845,897
Unemployment Rate	No Data
Education (teachers/1,000 persons)	9.65
Health (doctors/1,000 persons)	0.14
Ethnicity (% Kinh/non-Kinh)	97.12/2.78

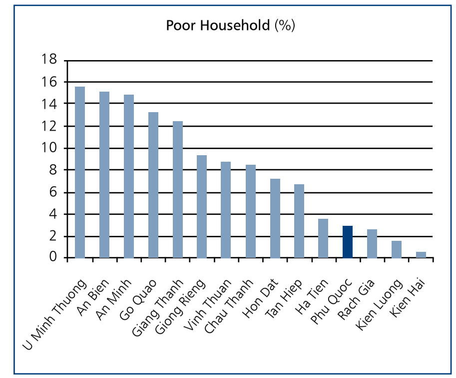
GDP = gross domestic product, ha = hectare, HH = household.

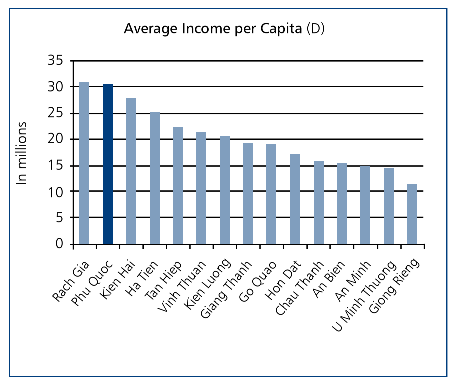
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Low
	Average Family Size	Low
	No. of Households	Medium
	Population at Working Age	Medium
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Low
	% of Poor Households	Low
	No. of Teachers	Medium
	No. of Doctors	High
	Agricultural Land per Person	High
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Low
	No. of Livelihood Streams	Low
	Streams Employing > 10,000 or Producing > D250 Billion	Low
	Average Annual GDP per Household	Low
	Rice Crop Land per Person	High
	Aquaculture Land per Person	High
Energy and Industry	Households Reliant on Industry	High
	Average Annual GDP per Household Contributed by Industry	High
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	High
	% Off-Farm Income	High
	No. of Factories	High
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	Low
	Urban Households	Low
	Urban Area	Low
	% of Urban Area/Population	High
	Sewer/Septic Tank	Low
	Water Supply	Medium
	Major Waterways	–
	Major Roads	–
	District Roads	High
	Transport Hubs	High

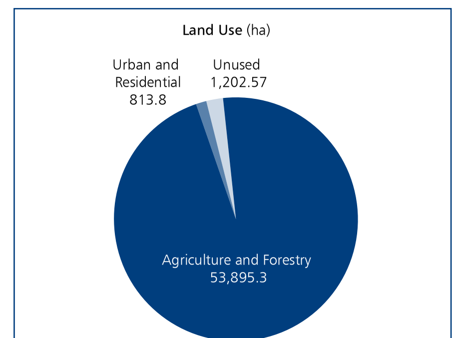






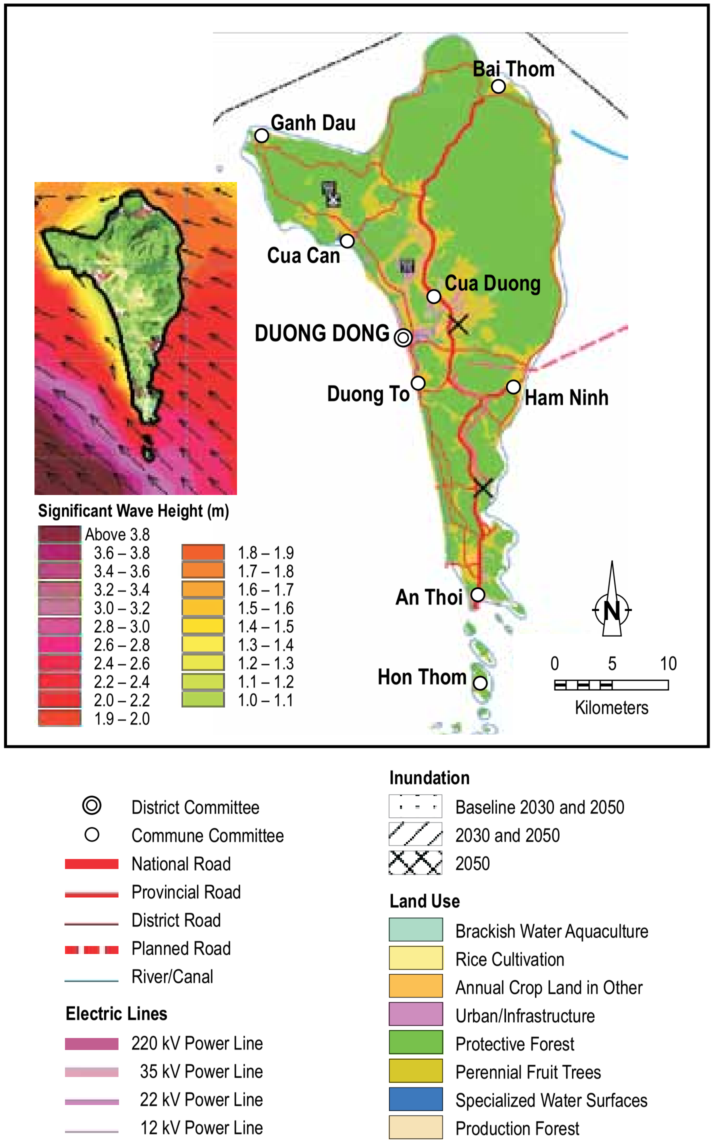






ha = hectare.

Phu Quoc Projected Inundation - Scenario A2



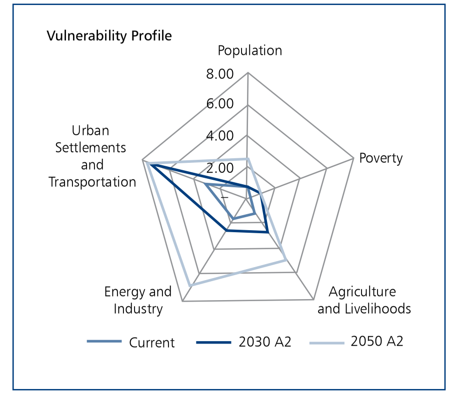
Population: The low density of the moderate population and limited exposure to flooding and salinity keep vulnerability at very low levels.

Poverty: A very high gross domestic product per household and low numbers of poor and ethnic households keep vulnerability at very low levels.

Agriculture and Livelihoods: The very high gross domestic product per household and wide range of income sources ameliorate the potential vulnerability of a 50% rural population with low access to agricultural land.

Energy and Industry: The limited exposure to flooding and salinity reduces the effects of the high reliance of households on industry. The high exposure of households and energy and industrial infrastructure to storm surges increases vulnerability in the future.

Urban Settlements and Transportation: Exposure of the moderate urban population in two towns and the marine transport hubs to storm surge increase vulnerability.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	0	0	1
	2030	0	0	1
	2050	0	0	1
Risk Rating	Current	3	0	4
	2030	3	0	4
	2050	3	0	4

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

As a result of the hilly terrain, inundation is confined to localized short-term flooding so exposure and risk are low and saline intrusion does not extend inland. Storm surges along the coast may cause extensive and widespread damage to urban and port infrastructure but risk is low due to it being confined to the coast.

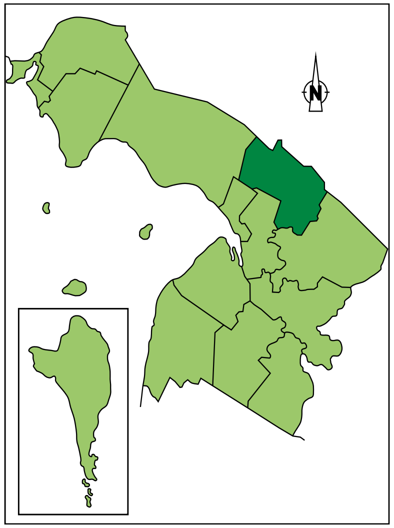
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•	•	••
Major Industry	•	•	••••
Major Energy	•	•	••
Urban	•	•	••••
Transportation	••	•	•••

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Some improvements to infrastructure will be required in the long term to deal with localized flooding and saline intrusion into the estuaries, particularly Duong Dong town. The island has very high exposure to storm surges, and immediate improvements are required for the control measures for the industry, transportation, and urban infrastructure. These are in the form of protection from wind damage, inundation due to storm surges, and damage by waves. Structures at risk include urban and tourist facilities, the power generating and distribution system, and the ferry and fishing ports.

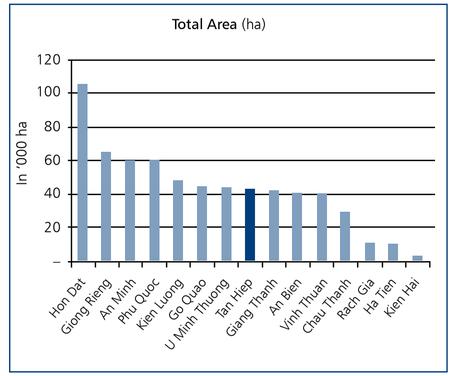
Tan Hiep

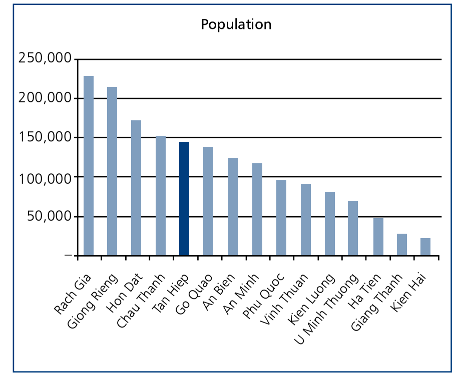


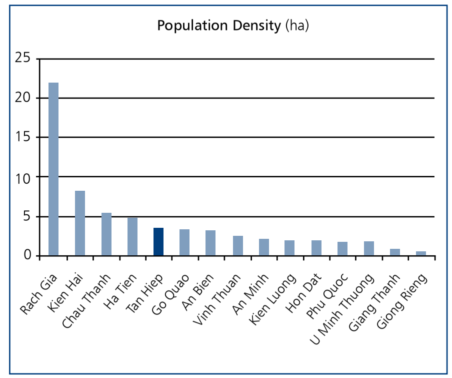
Administrative Center	Tan Hiep
Land Area (ha)	42,288
Population	143,439
Population	3.39
No. of Households	31,724
Average Family Size	4.52
Average Annual Household Income	D22,204,000
GDP Contribution from Industry (HH)	D1,741,494
Unemployment Rate	No Data
Education (teachers/1,000 persons)	11.54
Health (doctors/1,000 persons)	0.07
Ethnicity (% Kinh/non-Kinh)	96.36/3.64

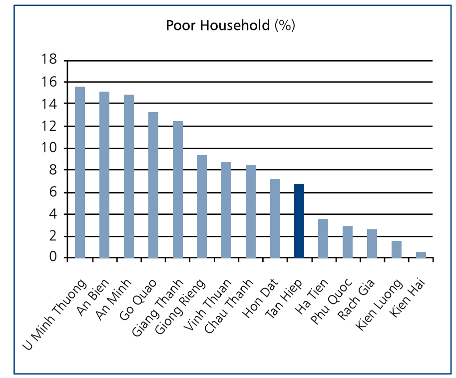
GDP = gross domestic product, ha = hectare, HH = household.

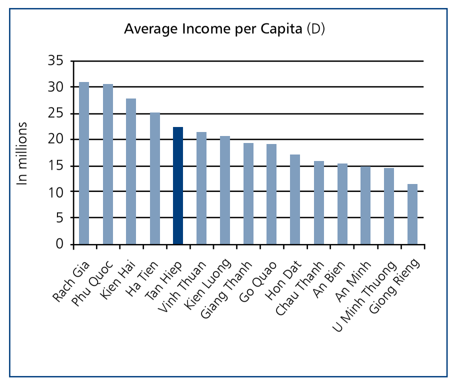
	Vulnerability Index	Ranking
Population	Total Population	High
	Population Density	High
	Average Family Size	High
	No. of Households	Medium
	Population at Working Age	High
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	Low
	No. of Poor Households	Medium
	% of Poor Households	Medium
	No. of Teachers	Low
	No. of Doctors	High
	Agricultural Land per Person	Medium
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	High
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	High
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Medium
	Average Annual GDP per Household Contributed by Industry	Medium
	Households Connected to National Grid	High
	Length of High/Medium-Voltage Power Lines	High
	No. of Power Plants/High-Voltage Substations	Medium
	% Off-Farm Income	Medium
	No. of Factories	Medium
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Medium
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	High
	Water Supply	Medium
	Major Waterways	Medium
	Major Roads	Medium
	District Roads	High
	Transport Hubs	Low

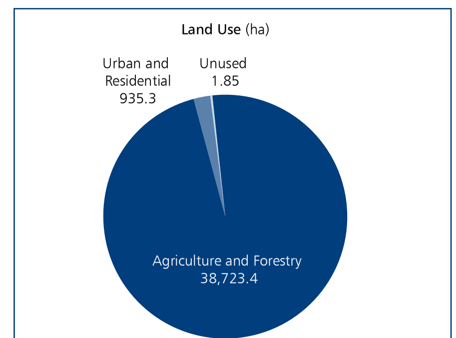










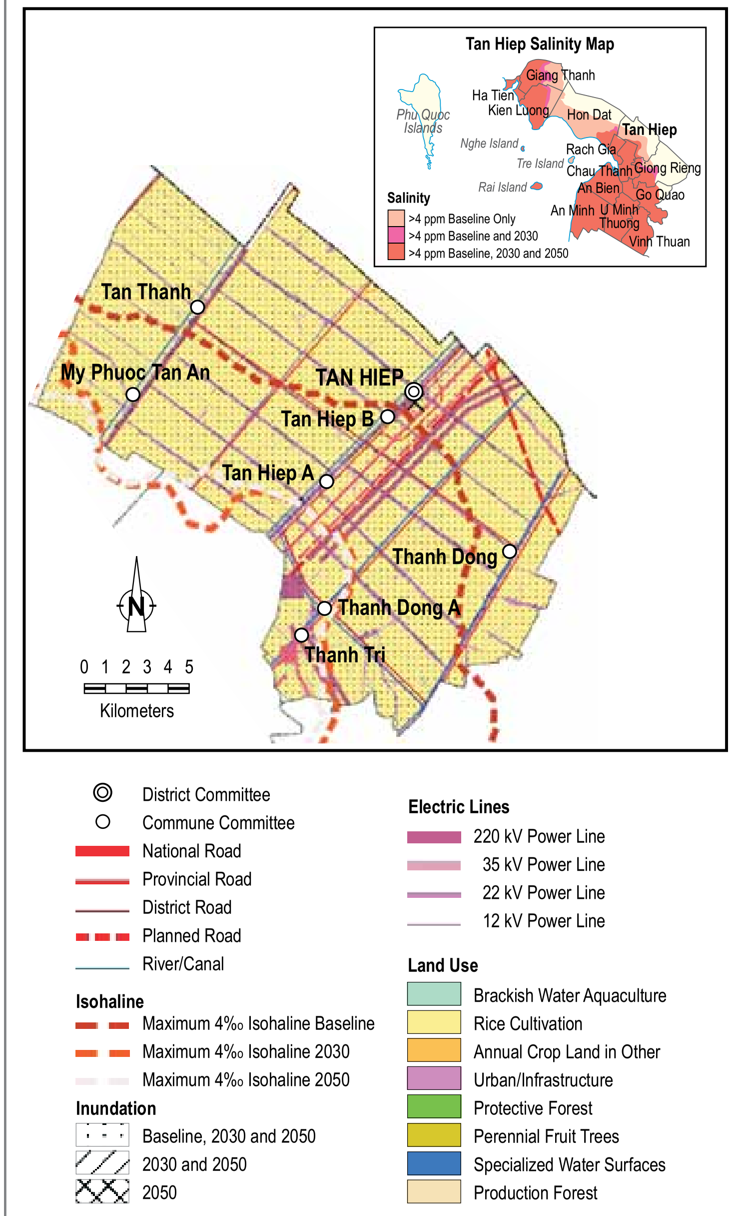


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	159.80	146.42	147.61	157.27
Power (km)	52.13	47.36	48.20	51.66
Agriculture Area (km^2)	385.99	371.33	373.31	384.00
Aquaculture Area (km^2)	0.3	0.1	0.1	0.2
Residential and Commercial Land (km^2)	0.34	0.03	0.07	0.26

km = kilometer, km^2 = square kilometer.

Tan Hiep Projected Inundation and Salinity - Scenario A2



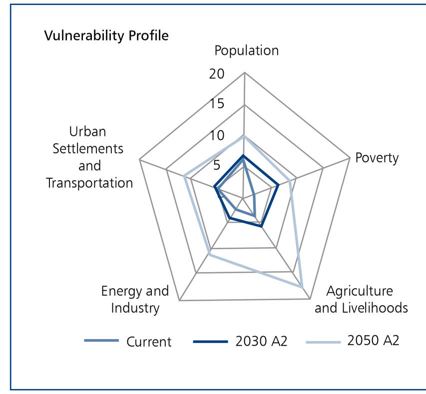
Population: A large population and large family size combined with a high exposure to inundation lead to high vulnerability, but a moderate growth rate and a reduction in exposure to salinity lead to a small increase in vulnerability in the future.

Poverty: A low number of ethnic households and good access to agricultural land result in low vulnerability that increases with population growth.

Agriculture and Livelihoods: A small number of alternative income streams and moderate values for other indicators lead to vulnerability that increases with population in the future.

Energy and Industry: A moderate contribution from industry to household income leads to moderate vulnerability. A lack of energy and industrial infrastructure moderates the increases in vulnerability in the future.

Urban Settlements and Transportation: Poor access to water and sanitation leads to vulnerability despite the low urban population.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	91	60	0
	2030	92	20	0
	2050	98	20	0
Risk Rating	Current	9	10	0
	2030	9	5	0
	2050	9	5	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

Exposure to flooding is very high and is projected to increase to almost 100%. Exposure to salinity is moderate and is projected to decrease. The risk from inundation remains at the high end of the medium rank, but the risk from saline intrusion decreases.

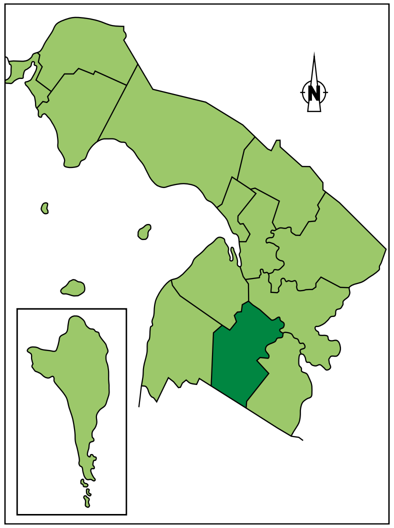
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	••	••	•
Major Industry	••	••	•
Major Energy	••	•	•
Urban	••	••	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Overall, the status of the control measures in place across all sectors is good. In the agriculture sector, improvements in the control measures for agricultural infrastructure are required in the long term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall status in the energy and transportation sectors is very good with some improvements in the control measures against flooding required in the long term. These are mainly related to raising structures above flood levels. The overall status in the industry and urban sectors is good with some improvements in the control measures against flooding and salinity required in the long term. These are mainly related to raising structures above flood and saline water levels, improved urban drainage, and improved water and sanitation.

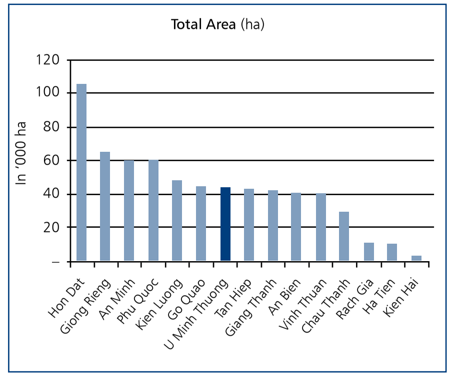
U Minh Thuong

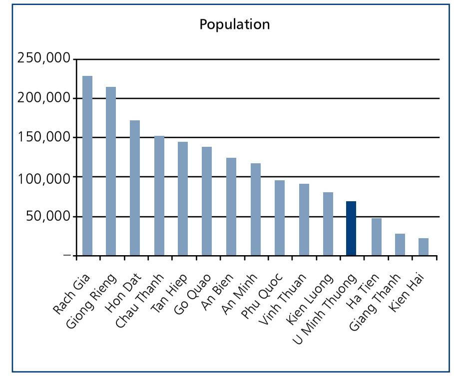


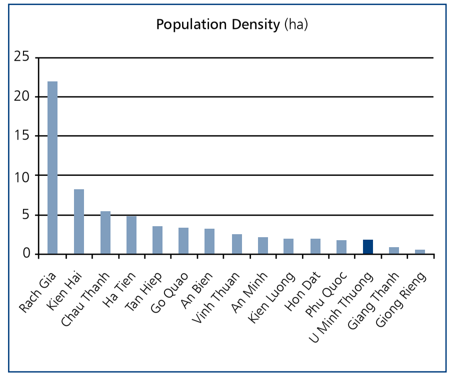
Administrative Center	U Minh Thuong
Land Area (ha)	43,270
Population	67,698
Population	1.56
No. of Households	16,025
Average Family Size	4.22
Average Annual Household Income	D14,400,000
GDP Contribution from Industry (HH)	No Data
Unemployment Rate	No Data
Education (teachers/1,000 persons)	12.18
Health (doctors/1,000 persons)	0.06
Ethnicity (% Kinh/non-Kinh)	90.85/9.15

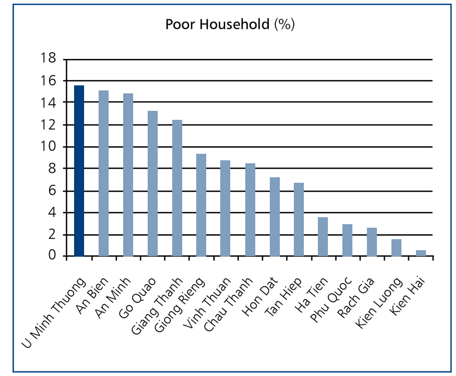
GDP = gross domestic product, ha = hectare, HH = household.

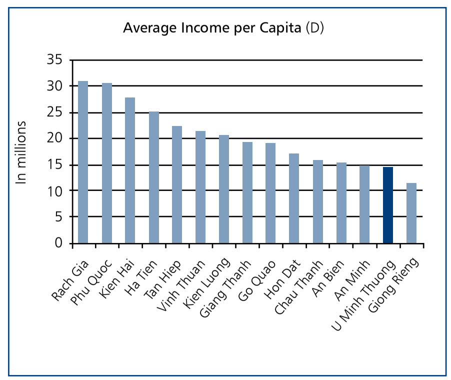
	Vulnerability Index	Ranking
Population	Total Population	Low
	Population Density	Low
	Average Family Size	Medium
	No. of Households	Low
	Population at Working Age	Low
	Average Natural Population Growth Rate	High
Poverty	Annual Average Income per Capita	High
	No. of Poor Households	Medium
	% of Poor Households	High
	No. of Teachers	High
	No. of Doctors	High
	Agricultural Land per Person	Low
	% Ethnic Households	Medium
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	High
	Streams Employing > 10,000 or Producing > D250 Billion	High
	Average Annual GDP per Household	High
	Rice Crop Land per Person	Low
	Aquaculture Land per Person	Medium
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Low
	Length of High/Medium-Voltage Power Lines	Low
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Medium
	No. of Factories	Low
	No. of Different Industries	High
Urban Settlements and Transportation	Urban Population	–
	Urban Households	–
	Urban Area	High
	% of Urban Area/Population	Low
	Sewer/Septic Tank	High
	Water Supply	Medium
	Major Waterways	Low
	Major Roads	Medium
	District Roads	Medium
	Transport Hubs	Medium

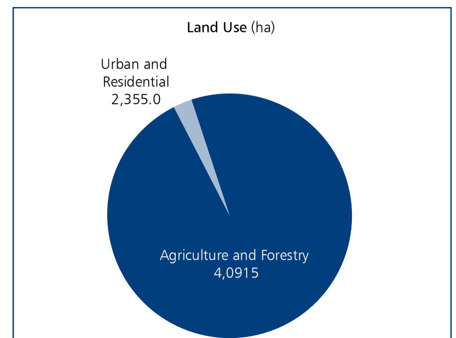










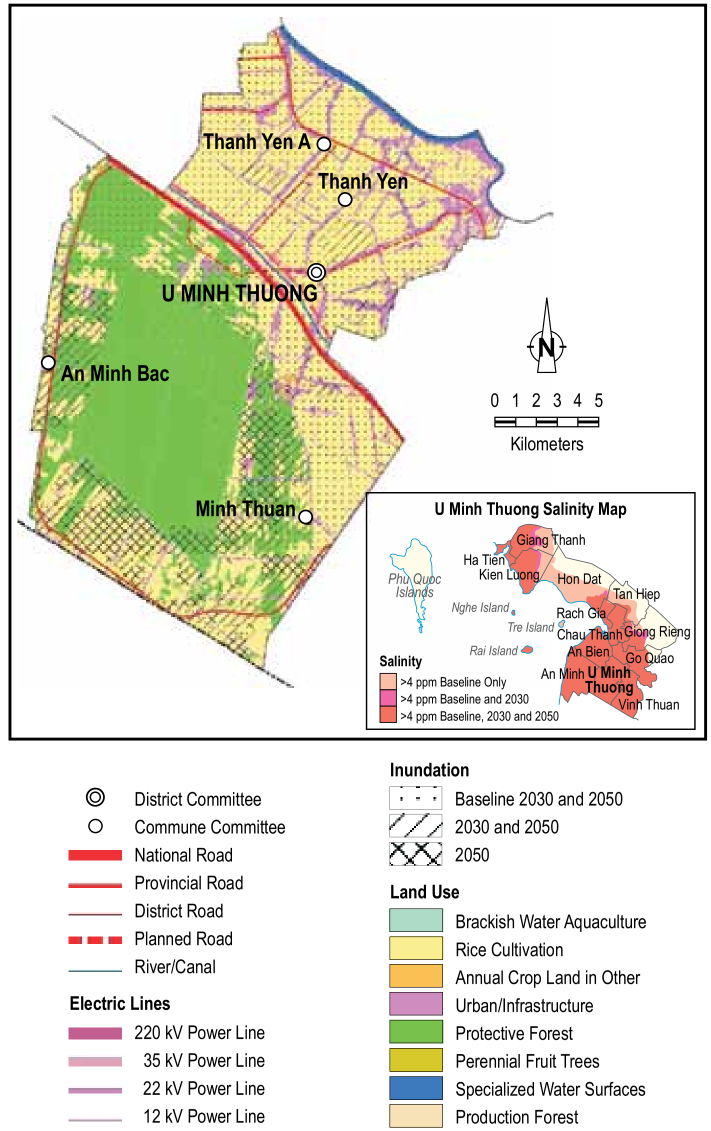


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	99.87	22.30	44.43	67.93
Power (km)	0.00	0.00	0.00	0.00
Agriculture Area (km²)	259.04	46.40	114.52	179.28
Aquaculture Area (km²)	0.1	0.0	0.1	0.1
Residential and Commercial Land (km²)	–	–	–	–

– = no data, km = kilometer, km² = square kilometer.

U Minh Thuong Projected Inundation and Salinity - Scenario A2



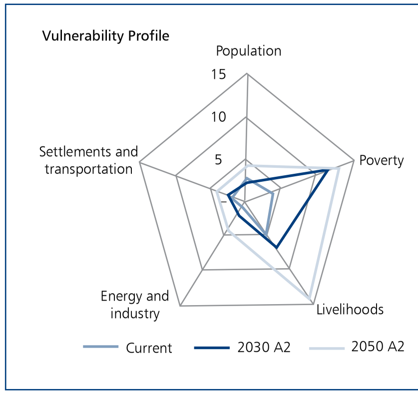
Population: A small population at low density and a low exposure to inundation lead to low vulnerability.

Poverty: A high number of poor households, low gross domestic product per head, and a moderate number of ethnic households lead to high vulnerability, which increases due to exposure to inundation in the future.

Livelihoods: An entirely rural population with low incomes is offset by available land per head of population. An increase in exposure to inundation leads to high vulnerability in the future.

Energy and Industry: A very low amount of industry keeps vulnerability low.

Settlements and Transportation: A lack of urban centers and limited transportation infrastructure mean that vulnerability remains low.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	17	100	0
	2030	34	100	0
	2050	52	100	0
Risk Rating	Current	3	10	0
	2030	6	10	0
	2050	6	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

The area is completely exposed to salinity, and while exposure to flooding is currently low, it is projected to increase. Risk from saline intrusion is high, and the risk of inundation increases by 2030.

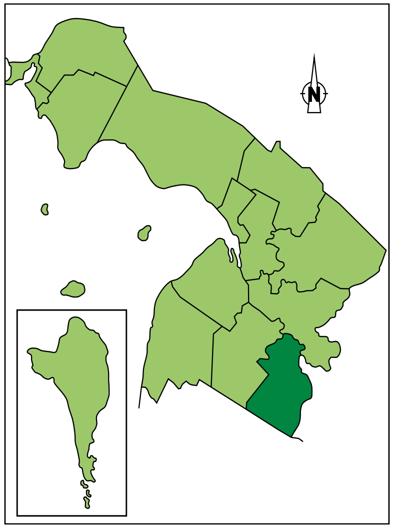
Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	•••	•
Major Industry	•	••	•
Major Energy	•	•	•
Urban	••	••	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

In the agriculture sector, improvements in the control measures are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall status of the control measures in the energy, industry, and transportation sectors is very good with some improvements in the control measures against flooding and salinity required for most sectors in the long term. These are mainly related to raising structures above flood and saline water levels. The urban sector requires improvements in the control measures to protect the town infrastructure from flooding and salinity in the long term. Required improvements are mainly related to raising structures above flood levels, improving urban drainage, and improving water and sanitation.

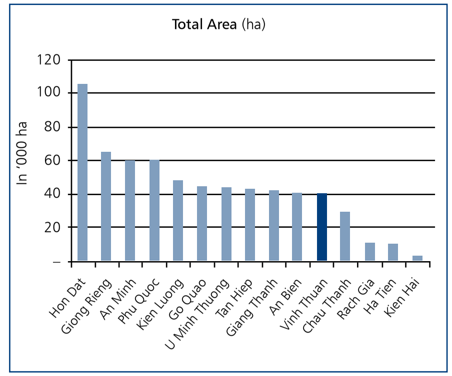
Vinh Thuan

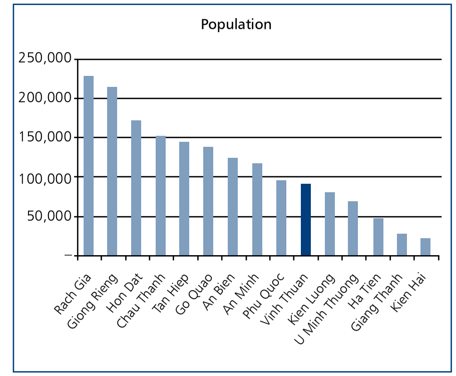


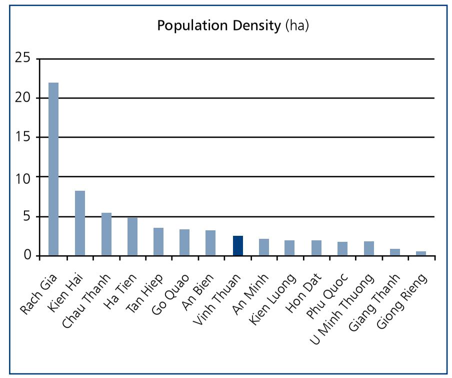
Administrative Center	Vinh Thuan
Land Area (ha)	39,483
Population	89,814
Population	2.27
No. of Households	20,980
Average Family Size	4.28
Average Annual Household Income	D21,325,000
GDP Contribution from Industry (HH)	No Data
Unemployment Rate	No Data
Education (teachers/1,000 persons)	9.31
Health (doctors/1,000 persons)	0.62
Ethnicity (% Kinh/non-Kinh)	91.15/8.15

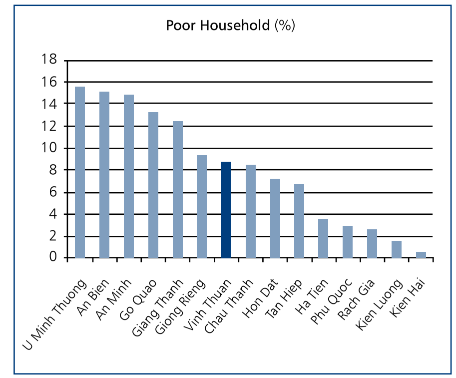
GDP = gross domestic product, ha = hectare, HH = household.

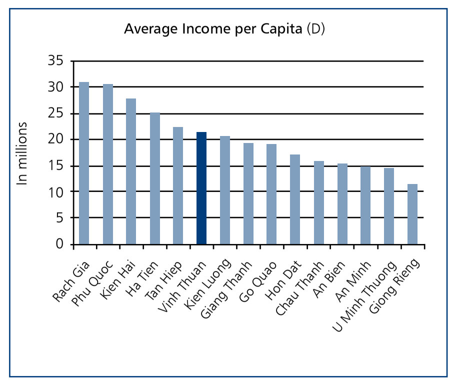
	Vulnerability Index	Ranking
Population	Total Population	Medium
	Population Density	Medium
	Average Family Size	Medium
	No. of Households	Medium
	Population at Working Age	Low
	Average Natural Population Growth Rate	Medium
Poverty	Annual Average Income per Capita	Medium
	No. of Poor Households	Medium
	% of Poor Households	Medium
	No. of Teachers	Medium
	No. of Doctors	Low
	Agricultural Land per Person	Medium
	% Ethnic Households	Low
Agriculture and Livelihoods	No. of Rural Households	Medium
	No. of Livelihood Streams	Medium
	Streams Employing > 10,000 or Producing > D250 Billion	High
	Average Annual GDP per Household	Medium
	Rice Crop Land per Person	Medium
	Aquaculture Land per Person	Low
Energy and Industry	Households Reliant on Industry	Low
	Average Annual GDP per Household Contributed by Industry	Low
	Households Connected to National Grid	Medium
	Length of High/Medium-Voltage Power Lines	Medium
	No. of Power Plants/High-Voltage Substations	Low
	% Off-Farm Income	Low
	No. of Factories	Low
	No. of Different Industries	Low
Urban Settlements and Transportation	Urban Population	Medium
	Urban Households	Medium
	Urban Area	Low
	% of Urban Area/Population	Medium
	Sewer/Septic Tank	Low
	Water Supply	Low
	Major Waterways	Low
	Major Roads	Low
	District Roads	Low
	Transport Hubs	Low

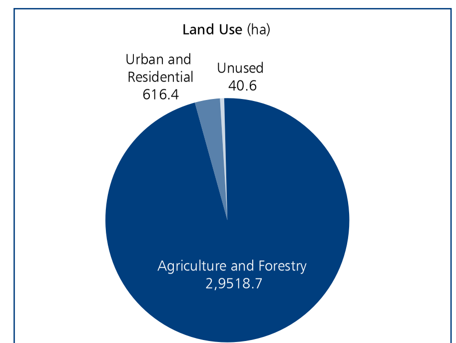










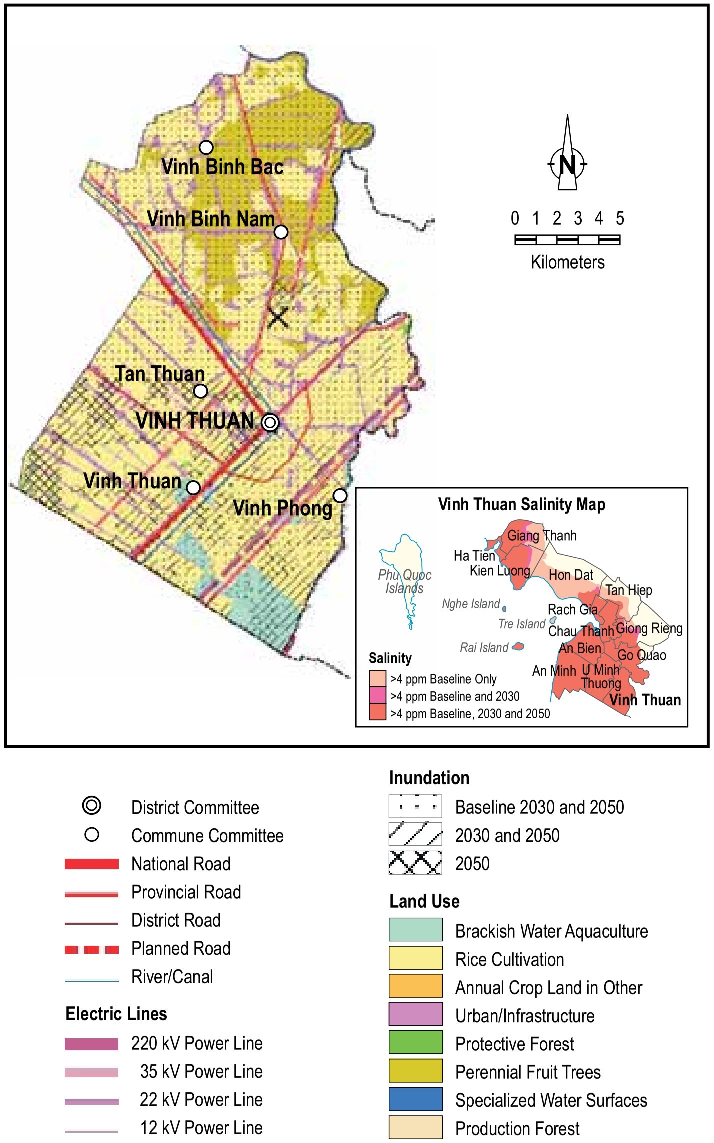


ha = hectare.

Inundation	Total	2000	2030	2050
Roads (km)	72.06	7.57	33.56	48.28
Power (km)	14.93	0.75	5.27	9.77
Agriculture Area (km²)	332.04	45.45	153.31	230.98
Aquaculture Area (km²)	17.2	0.7	2.9	6.5
Residential and Commercial Land (km²)	1.09	0.04	0.30	0.60

km = kilometer, km² = square kilometer.

Vinh Thuan Projected Inundation - Scenario A2



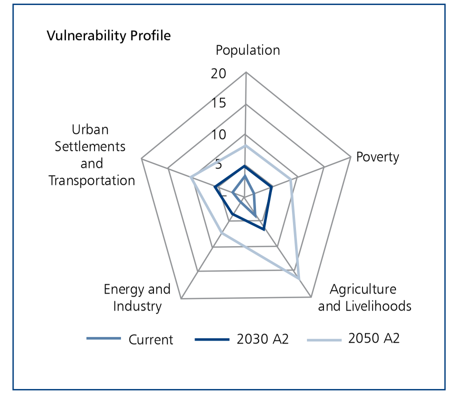
Population: Moderate population at moderate density and large family size leads to increased vulnerability as exposure to inundation rises.

Poverty: Low to moderate indicators result in increased vulnerability as exposure to inundation rises.

Agriculture and Livelihoods: A large rural population and limited alternative income sources are offset by available land per head of population. Increased exposure to inundation leads to high vulnerability in the future.

Energy and Industry: A very low reliance on industry for household income and a lack of industrial infrastructure lead to a very low vulnerability despite increased exposure to impacts.

Urban Settlements and Transportation: A moderate urban population and limited transportation infrastructure means that vulnerability remains low.



Exposure, Risk, and Control Measures

Exposure and Risk

	Time Period	Inundation	Salinity	Storm Surge
Hazard (% of Total Area)	Current	14	100	0
	2030	45	100	0
	2050	68	100	0
Risk Rating	Current	3	10	0
	2030	6	10	0
	2050	6	10	0

<5 Low risks 5–12 Medium risks See Table 13 pg. 32 for detailed descriptions

While exposure to flooding is low, it is projected to increase and the risk of inundation increases by 2030. The area is completely exposed to salinity, and the risk from saline intrusion is high.

Control Measures

Infrastructure	Flooding	Salinity	Storm Surge
Agricultural	•••	•••	•
Major Industry	•	••	•
Major Energy	•	•	•
Urban	••	••	•
Transportation	••	•	•

• Adequate •• Change (long term) ••• Improvement (medium term) •••• Rehabilitation urgent

Improvements in the control measures for agricultural infrastructure are required in the medium term in the areas of dike strengthening and improvements to sluice gates, improved crop handling and processing, as well as in improvements in rice varieties and cultivation methods. The overall status of the other sectors is good, with the control measures for the energy sector considered to be adequate in the near term. Some improvements in the control measures against flooding and salinity are required for the urban, industry, and transportation sectors in the long term. These are mainly related to raising structures above flood and saline water levels, protecting the town infrastructure from flooding and salinity, and improving urban drainage, water, and sanitation.

Climate Risks in the Mekong Delta
Ca Mau and Kien Giang Provinces of Viet Nam

This report presents the outputs of the Climate Change Impact and Adaptation Study in the Mekong Delta.

The study focuses on vulnerability assessment of two provinces in the Mekong Delta region: Ca Mau and Kien Giang. Using climate change modeling, socioeconomic data, geographic information system analysis, and expert opinion, the study identifies future climate conditions and assesses the effects of future climate scenarios on the natural, social, and economic systems of each district of Ca Mau and Kien Giang provinces. It provides provides province and district policy makers with an understanding of the key areas of vulnerability and risk hot spots with regard to climate change up to 2050. It provides practical measures that provincial and district administrations can take to inform and strengthen their climate change adaptation programs.

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ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to two-thirds of the world's poor: 1.7 billion people who live on less than $2 a day, with 828 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

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