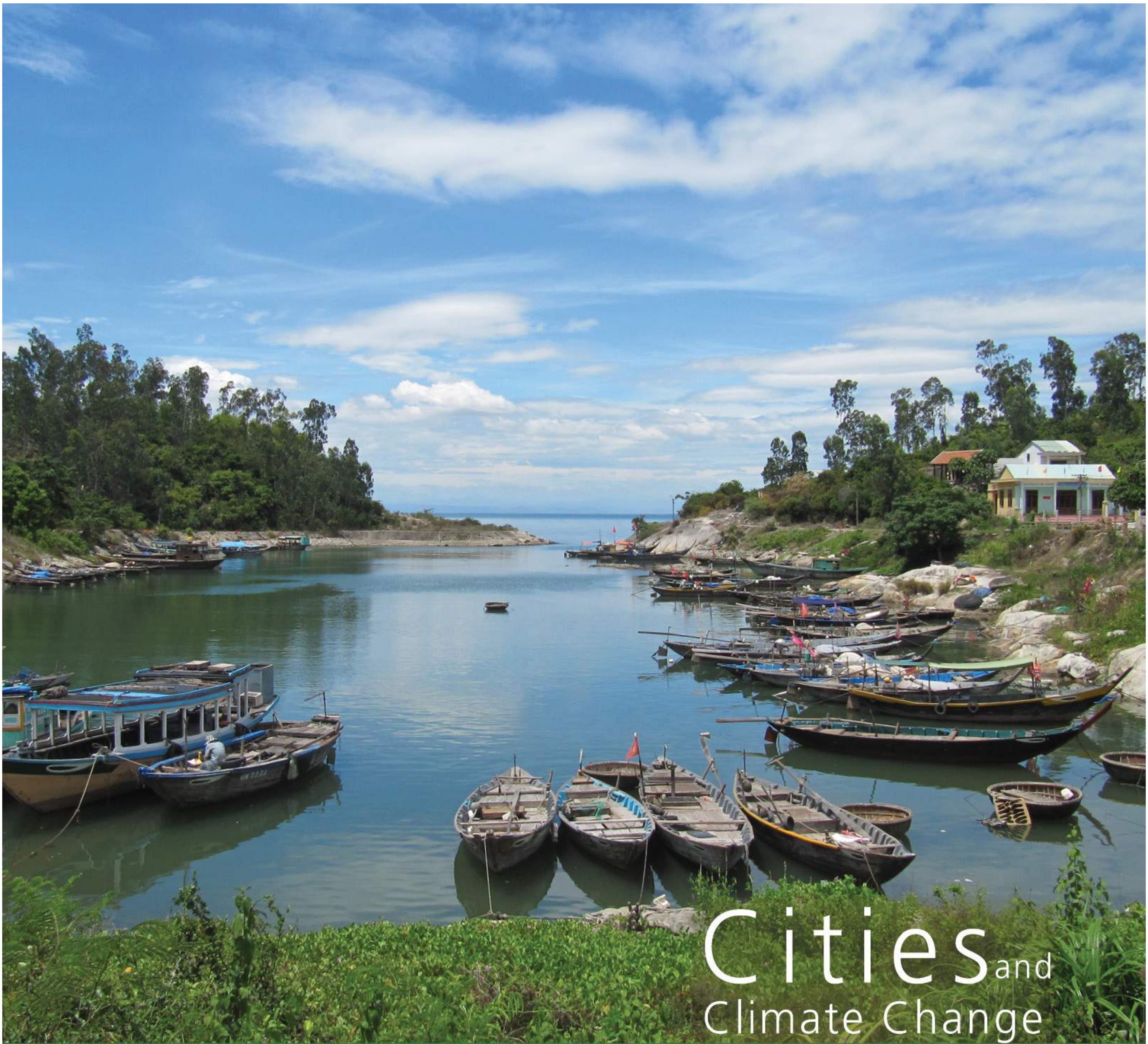

Cities and Climate Change Initiative

Hoi An, Viet Nam

Climate Change
Vulnerability Assessment

UN-HABITAT
FOR A BETTER URBAN FUTURE

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Vulnerability Assessment

Hoi An, Viet Nam – Climate Change Vulnerability and Adaptability Assessment

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INTRODUCTION

Hoi An is a grade III city thatwas upgraded from town to city under the management of the Quang Nam province in 2008, under Decree No. 10/2008/NĐ-CP of the Government. Thecity possesses ancient cultural and historical characteristics that date from pre-history (Tien Sa Huynh - about the second century). In the 15th century, Hoi An was a flourishing port town influenced by the Champa culture. The late 16th to 17th century saw an influx of Chinese and Japanese people immigrants, whose skills helped to develop Hoi An's commerce. With itsfavourablegeographic location, Hoi An quickly became a prosperous trading port.

Today, the town ofHoi An hasover 800preservedancient housesthat were influenced bytheChinese and Japanese inhabitantsof the past. Hoi Ancity was recognized asa UNESCOWorldCultural Heritage sitein 1999.Moreover, the Cham island of Hoi Anwas recognized asa World BiosphereReservebyUNESCOin 2009.With its ancient history, beautiful landscape and interesting culture, Hoi An has rapidlybecome animportanttourist destinationin QuangNam province and the Central region of Viet Nam.

Hoi An city has been impacted by many natural disasters in the past years. Hurricanes, flooding, salinity, coastal erosion and river bank erosion have all damagedthe local socio-economic situation. These natural disasters have caused significant impact to the city in the past. Results are even worse when two or more natural disasters occur at the same time. For example, hurricanes and floods in recent years (2006 and 2009) caused an estimatedUSD 1.4 to1.7 billion of damage to the city, ie approximately 17 to 19 per cent of the city's GDP.

Hoi An is now divided into nine wards and four communes. Tourism and services areidentified as key aspects of Hoi An's socio-economic development strategy for the near future. Tourism activities and services have increased from 50.5 per centof the city's GDP in 2003 to nearly 60 per centin 2010. However, the level of socio-economic development between the wards in ancient town such as Minh An, Tan An and rural communes such as Cam Kim, Cam Chau and Cam Thanh is uneven with great disparitiesin living standards. Consequently, the ability to deal with the impacts of natural disasters also varies significantly.

The impacts of climate change and natural disasters have a great impact on the daily life of the inhabitants of Hoi An. Rising sea levelshaveexacerbated the process of coastal erosion and saline intrusion. In addition, heavy rains and flooding have been occuring more frequently and with great impact, such as with more powerful rain storms and increased flood waters. Hurricanes and other extreme events are occuring more frequently and with greater intensity.

Recently, Hoi An has set its sights in developing an eco-city. Consequently, the Center for Urban Studies of Viet Nam National University conducted a climate change vulnerability and adaptivity assessment for the city of Hoi An. This was done with the cooperation of the United Nations Human Settlements Programme (UN-Habitat) via agreement OBMO78565, signed on September 9th, 2011.

Research objectives and scope: The main objective ofthis study is toassessthe vulnerabilityandadaptive capacityofurban systems(infrastructure -economic- cultural -social-ecological environment) with the impact ofclimate change(represented bythe increased intensity and frequency ofnaturaldisasters) as a basisfor proposingsolutions to improve adaptive capacityand mitigate climate change related disaster damagestoHoi An city. There have been many prior independent research projects conductedon Cham Islands andTan Hiep commune. The focus of this report will be on mainland Hoi An.

Research content:

- Identify natural disasters related to climate change that impact Hoi An city and forecast the magnitude andintensity of the disasters;
- Analyze the characteristics of uban systems of Hoi An (infrastructure -economic-cultural -social-ecological environment);
- Conduct a vulnerability assessment of Hoi An under the impact of major disasters whilst using the following components: exposure, sensitivity, adaptive capacity of the citys'systems;
- Propose measures for the city toimprove its adaptive capacity to climate change.

Main research methods:

- Collect, analyze and synthesize available literature;
- Conduct field trips and community consultations in hotspots;
- Organize workshops and consult with experts(department and city leaders);
- Use a digital model fordisaster emulation and forecasting based on various climate change scenarios;
- Statistic analysis;
- Assessment toolkit of UN-Habitat.

Report structure: This report has fivechapters: Chapter I and Chapter II give a general introduction to the research methodology used in the assesment and present anoverview of Hoi An City. Chapter III analyzes the current situation and presents the five major disaster typesthat could influence thesocio-economicsof Hoi Anand its technical infrastructure: flooding, salinity, coastal erosion, river bank erosion and hurricanes. Chapter IV assesses the impact of disasters on infrastructure, environmental resources and the socio-economics of Hoi An. Chapter V gives an overview of adaptive capacity at various levels; from households and communitiesto communes,wards and the city. Adaptive capacity is evaluated based on four component factors: institutional capacity and policy, technological capacity, financial capacity and human resources. The analysis of hotspots provided useful information about the multi-dimensional impacts of disasters and the adaptive capacity of people to such disasters. Chapter VI proposes solutions to improve the adaptive capacity of Hoi An to respondto the increasing challenges of climate change and disaster prevention.

Three workshops were held in Hoi An (September 2011, December 2011 and March 2012) in order to present the research results and content of the report and to obtain feedback and suggestions for improvement.

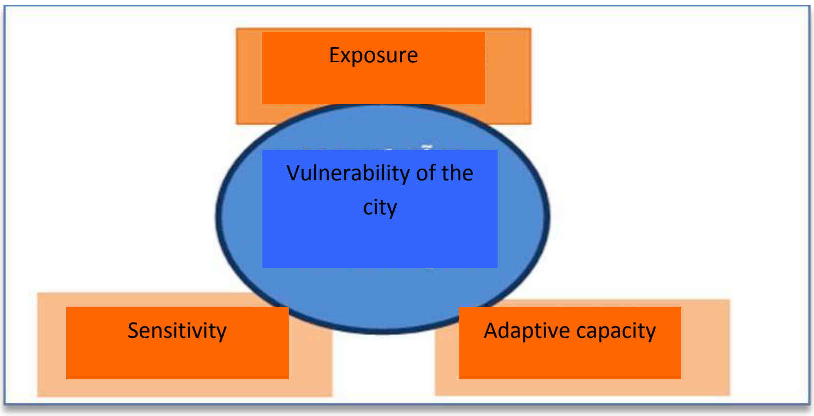
1. ASSESSMENT METHODOLOGY AND PROCEDURE

Methodology

The methodology used in this report is based on aframework used by many international agencies and organizations such as the World Bank, the Intergovernmental Panel on Climate Change, the United Nations Development Programme and UN-Habitat's Sustainable Cities Programme. The framework uses three factors in its assessment: exposure, sensitivity and adaptive capacity.

According to the Intergovernmental Panel on Climate Change, adaptive capacity is "the ability or potential of a system to respond successfully to climate variability and change"1. The Assessment Report of the Intergovernmental Panel on Climate Change points out that adaptive capacity is a function of several factors: wealth, technology, institution, information, infrastructure and social capital. Sensitivityis interpreted as the influence level of climate change affecting a system, including positive and negative impacts.Exposureis the expression of climate change and fluctuations in the frequency and severity of weather events[2]. Vulnerabilitywithin this analysis is understood to be a function of a series of social and economic factors andphysical and natural conditions that are expressed via the following: exposure, sensitivity and adaptive capacity. The higher the exposure, the higher the sensitivity and the higher vulnerability. In contrast, vulnerability is reduced if adaptive capacity is improved.

Figure 1. Vulnerability Framework



Vulnerability = f (Exposure, Sensitivity, adaptive capacity)

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[1] "IPCC Fourth Assessment Report: Climate Change 2007", http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch18s18-6.html, accessed 14 November 2013.

[2] UN-HABITAT. Participatory Vulnerability and Adaptation assessment: A toolkit based on the Experience of Sorsogon city, Philippines. (2010).

Although the above analytical framework gives direction to the climate change vulnerability assessment, the application to a specific area requires flexibility in accordance with local conditions and the ability to provide data.Exposure and sentivity assessments can be made based on observations of the progress of natural disasters and scenarios of future changes of climate events and their effects on subjects. Adaptive capacity assessments, however, require a specific methodology. There hasbeen a lot of varied research proposing and examining different methods of adaptive capacity determination (applied in different levels from a country to a specific area). Authors Susan L. Cutter, Christopher T. Emrich, Jennifer J. Webb, and Daniel Morath produced a general report on methodologies to assess vulnerability to natural disasters[3]. In their report, they introduce general and consistent definitions of key concepts used to measure and assess vulnerability to natural disasters and climate change. According to the authors, vulnerability is the sensitivity/response of a population, a subject, a system or an area to the impactsof natural disasters (hazards). Vulnerability alsodirectly affects the ability to prepare, respond and recover from disasters. Social vulnerability focuses on demographic and socio-economic factors that change the impact of a disaster on people in the area. In other words, the concept of social vulnerability points tosocial subjects and the exposure they suffer due to natural disasters. The authors also introduce the concept of resilience to indicate the ability of a community, a system or a locality ofminimizing or adapting to the impacts of natural disasters.

Process of climate change scenarios and related disasters in Hoi An

The objectiveof this research is to provide an initial assessment of the climate change adaptive capacity of Hoi An City. This was done by measuringthe adaptive capacity and vulnerability of natural disasters. The team used qualitative and quantitative methods, modeling climate change scenarios and selecting hotspots as the foundation for community consultation. A similar method as that used by UN-Habitat in Sorsogon City was applied[4]. The study was conducted using the following steps:

Step 1. Determine the types of climate change scenarios and major disasters that have specific impacts on Hoi An.

Step 2. Analyze the current situation of economic,social and cultural life inHoi An. Select groups of main subjects for further sentivity assessment. In this study, the three main groups selected for revision are: i) technical infrastructure (with sixcomponent groups); ii) environmental resources (with tencomponent groups) and iii) socio-economy (with

[3] Susan L. Cutter, Christopher T. Emrich, Jennifer J. Webb, and Daniel Morath (2009): Social Vulnerability to Climate Variability Hazards: A Review of the Literature. Final Report to Oxfam America. June 2009.

[4] UN-HABITAT. Participatory Vulnerability and Adaptation assessment: A toolkit based on the Experience of Sorsogon city, Philippines. (2010).

threecomponent groups). A specialized method wasused to determine the weight of these above groups with general vulnerability indicators.

Step 3. Develop scenarios for change of disasters when models and data are available, especially in the case of flooding. Forecast the development of natural disasters affecting Hoi An for further study. In this study, the main hazards considered were hurricanes, flooding, salinity, coastal erosion and river bank erosion.

Step 4. Perform aqualitative assessment on disaster sensitivity and exposure of the subjects for a specified time period. In this study, sensitivity and exposure in 2011, 2020 and 2050 of each component identified in step 2 wereevaluated via specialized method utilizing a scale of one to four.

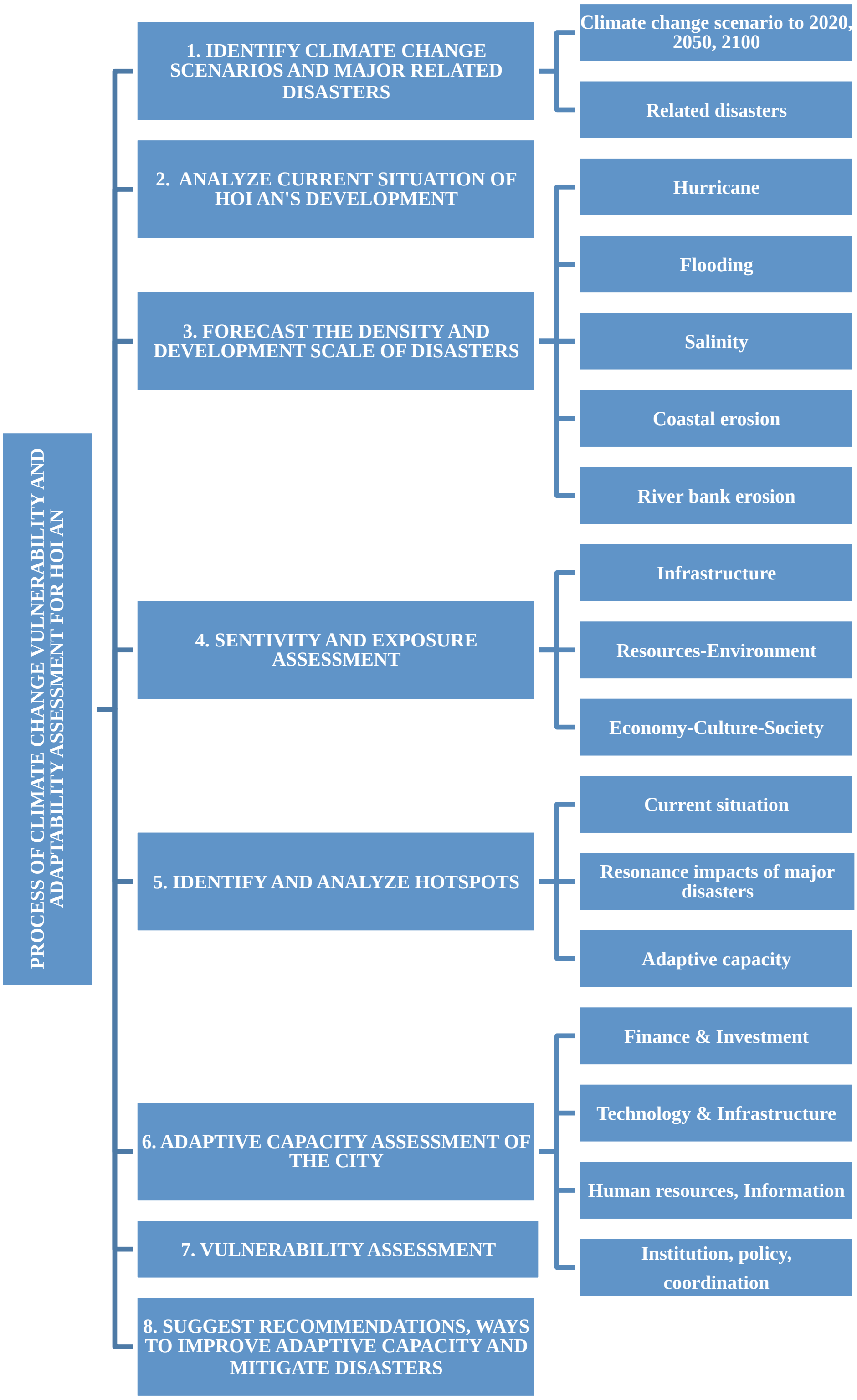
Step 5. Identify and analyze hotspots based on ananalysis of exposure and impact of disasters. In this study, four hotspots with exposure to each type of disaster were selected. Community consultationswereorganized to collect information about the disasters. Topics such as how the disasters affected the daily life of individuals, and how they could overcome the consequences of the disasters were discussed.Recommendations on ways to enhance the adaptive capactiy to future disasters in the area were made based on the results of the analysis.

Step 6. Apply aqualitative methodology towards a general assessment of adaptive capacity of the city. Community consultations and workshops with leaders of local departments were used to evaluate the following:technology, human and financial resources, policy and mechanisms, coordination and implementation capacity.

Step 7. Assess the vulnerability of Hoi An City based on themethodology of the Intergovernmental Panel on Climate Change (IPCC); collect and analyze the components of exposure, sensitivity and adaptability.

Step 8. Listrecommendations on ways to improve the adaptative capacity of Hoi An in order to mitigate the impact of disasters with the goal of creating a sustainable eco-city in Hoi An.

Figure 2. Process of Vulnerability and Adaptability Assessment for Hoi An



Determining climate change scenarios and related disasters in Hoi An

Climate change scenarios in Hoi An, Quang Nam

According to the national target program to respond to Climate Change of the Ministry of Natural Resources and Environment[5], climate change scenarios for the central area, including Hoi An city,arelisted in Table 1 below:

Table 1. Changes expected by 2100 for Central region of Viet Nam compared to the period 1980 to 1999

Changes	Low emission scenario (B1)	Medium emission scenario (B2)	High emission scenario (A2)
Increase in annual average temperature	1,9 ^{0}C	2,8 ^{0}C	3,6 ^{0}C
Increase in annual rainfall	5 %	7- 8 %	10 %
Sea level rise (cm)	65 cm	75 cm	100 cm

Source Tran Thuc et al., 2009[6]

Climate change scenario for Quang Nam[7]

Changes in annual average rainfall and temperature compared to the 1980-1999 period and sea level rise follow a medium emission scenario (B2). According to the medium emission scenario (B2), updated in 2011, increase in rainfall fluctuated in the lower ranges (increase by 3.6 per cent compared with an increase of7 to 8 per cent for the 2008 scenario).Sea level rise increased less (increase of 61 to 74 cm compared to an increase of 100cm) than the scenario of 2008.

Table 2. Changes expected by 2100 for central region of Viet Nam compared to the period of 1980 to 1999 with climate change scenario of 2011

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Temperature (ºC)	0.5	0.8	1.1	1.4	1.7	2	2.3	2.5	2.7
Rainfall (%)	0.7	1	1.5	1.9	2.3	2.7	3	3.3	3.6

[5] Ministry of Natural Resource and Environment (MONRE). Climate change and sea level rise scenario for Viet Nam. (2011)

[6] Tran Thuc., Nguyen Van Thang., Hoang Duc Cuong &Thai., T. H. *Development of climate change scenarios for Vietnam*, Proceedings of the workshop Climate Change Adaptation Vietnam. Ha Long Bay. (2009).

[7] Ministry of Natural Resource and Environment (MONRE). Climate change and sea level rise scenario for Viet Nam. (2011)

Sea level rise (cm)	8-9	12-13	18-19	24-26	31-35	38-44	45-53	53-63	61-74

Note: The report used the medium scenario of 2011 as the foundation to measure impacts of disaters related to climate change.

Related disasters

Disasters happening in the area of Hoi An (including natural and human caused ones) wereidentified and evaluated the "Geological Environment - Urban Infrastructure - Neighboorhood" below.The following is a diagram of interaction of the system Natural Environment-Infrastructure-Socio-Economic-Culture-Institution and the impact of climate change.

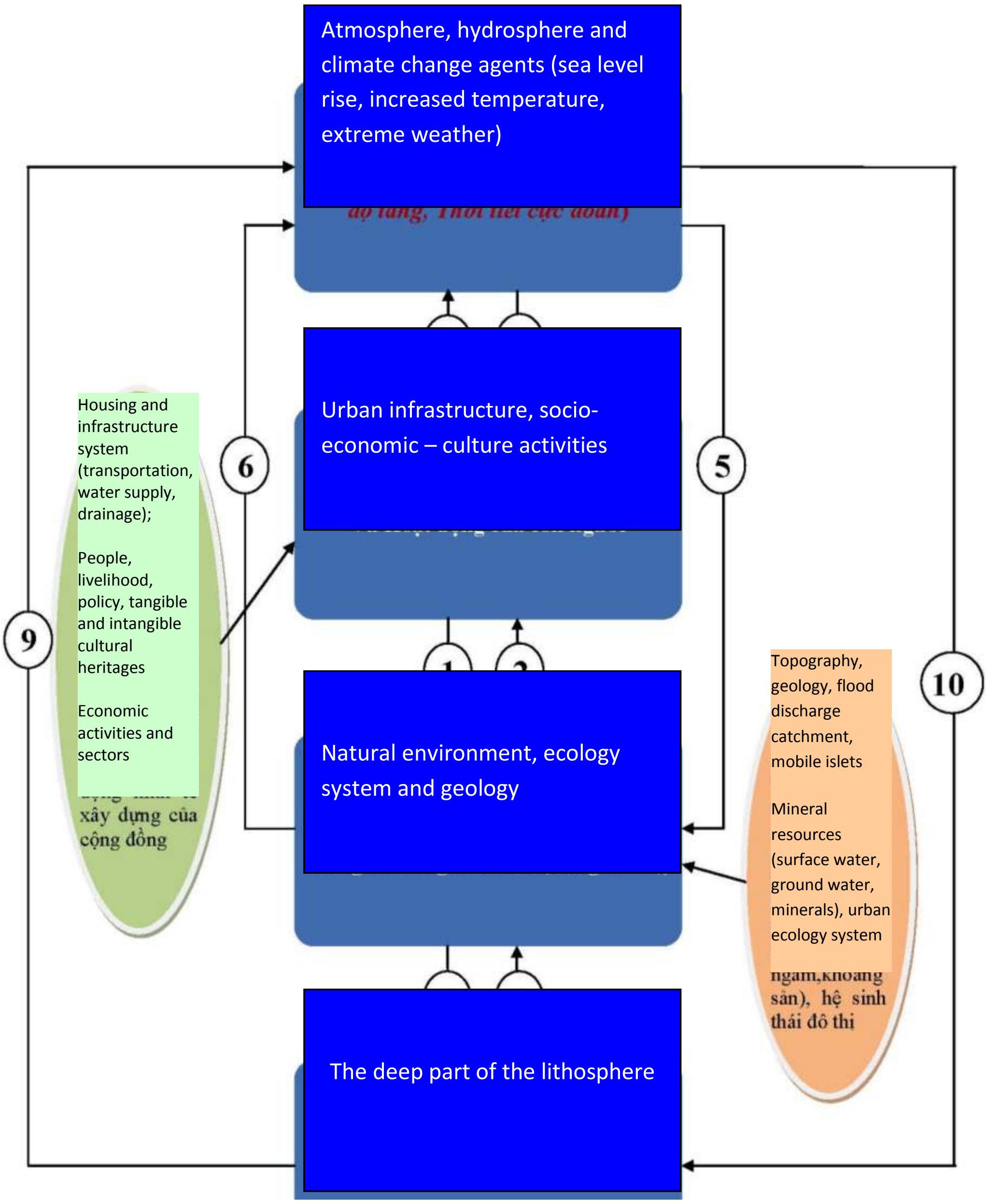


Figure 3. Diagram of interaction of the system Natural Environment-Infrastructure-Socio-Economic-Culture-Institution and the impact of climate change

1. Under the direction of impact number one(from urban infrastructure to geological environment), major geological disasters and processes occuring in an urban geological environment include:

- Coastal erosion caused by deforestation in poplar forest to build coastal resorts;
- River bank erosion caused by sand mining and channel widening;
- Land pollution, groundwater and surface water pollution.

2. Under the direction of impact number two(from geological environment to urban infrastructure), major disasters and processes arising in urban infrastructure(including communities) include:

- Destroyed dikes, embankments and roads in areas affected by coastal erosion and river bank erosion;
- Diseases in localities due to polluted environment (not significant).

3. Under the direction of impact number three(from urban infrastructure to atmosphere, hydrosphere, marine, river water and air pollution (including green house gas)) major disasters and processes dooccur. However, these processes are not significant in Hoi An and do not affect the city much.

4. Under the direction of impact number four(from atmosphere, hydrosphere to urban infrastructure), major disasters and processes occuringin urban infrastructure are:

- Flooding of urban infrastructure and diseases caused by rising sea levels and heavy rain;
- Destruction of houses and infrastructure due to hurricanes, waves and surface flow.

5. Under the direction of impactnumber five(from atmosphere, hydrosphere to geological environment), major exogenous geological disasters and processes occuring in urban geological environment are:

- Flooding of urban surface land caused by heavy rain and rising sea levels;
- Saline intrusion caused by rising sea levels and changes in river flow;
- Coastal erosion and river bank erosion caused by waves, wind and flows;
- Sedimentation of coastal estuaries due to changes in river flow.

6. Under the direction of impact number six, processes of energy accumulation and release from lithosphere to atmosphere and hydrosphere arenot significant.

7. Under the direction of impact number seven, the process of energy accumulation from deeper parts of the lithosphereis not significant.

8. Under the direction of impactnumber eight(from deeper part of lithosphere to urban geology environment), endogenous geological disasters and processes such as earthquakes and cracks in the ground can occur. In Hoi An, these disasters are not significant.

9. Under the direction of impact number nine(from deeper part of lithosphere to hydrosphere), endogenous disasters and processes such as tsunamis occur. In Hoi An, there havenot been any events like this.

10. Under the direction of impactnumber ten(from atmosphere to the deeper part of the lithosphere), the process of energy accumulation in the deeper part of lithosphere occurs but does not affect the city much.

Only disasters that occur under the direction of impacts four and five are related to climate change. They include flooding, salinity, coastal erosion, river bank erosion, coastal estuarine sedimentation, hurricane,cyclones and lighting. These disasters are further intensified and their effects on urban areas are more significant as climate change worsens (rising sea levels, temperature and rainfall, etc.)

Coastal erosion in Cua Dai and Cam An is caused not only climate change, but also from human activitiy(poplar deforestration to build coastal resorts). Likewise, flooding in Hoi An can be caused by flood discharges from the Tranh River hydroelectric plant. Thus, models of interaction among the system "Geological Environment-Urban Infrastructure-Neighborhood" arethe basis for determiningthe exact causes and conditions of disasters. Because of the resonance of natural causes and human activities, disasters in Hoi An tend to occur with increasing frequency and damage. This report will focus on major disasters influenced by climate change that strongly affect Hoi An: hurricanes,flooding,salinity,coastal erosion andriver bank erosion.

2. CURRENT SITUATION OF URBAN DEVELOPMENT IN HOI AN

Natural Conditions

Figure 4. Typology – Geomorphology and geographic

Hoi An is divided into two parts: the mainland and islands.

The mainland: Hoi An city is located on the coastal and estuary plain of Quang Nam province in Thu Bon river basin. It has a low-lying and unstable topologic foundation which is cross cut and fluctuated, especially in estuaries, forming islands and creating the coastal and estuary wetland ecosystem of Hoi An. Hoi An's geological structure is quite complex, including young sediments with weak binding and sensitivity to natural impacts such as river flow andocean waves.

Islands: mainly low hills and mountains, small islands have truncated pyramid tops. The highest altitude above sea level ranges from 70 to 517 metres. The largest island is called Hon Lao island.In the east, there veryhighly steep eastern slopes, rocks surrounding foothills and no coastal alluvial ground.In the west, the slope flattensgently with less rocks and more coastal alluvial grounds which facilitate settlements and is suitable for tourism development. Boats and vessels can dockfor theexchange of goods and provide shelter from storms.

Climate conditions and hydrology

The average daily temperature in Hoi An is 25.6°C with a relatively high humidity of 82 per cent. On average, there are 147 rainy days per year with an annual rainfall of 2066 mm. Hoi An has two distinct seasons, a dry season, which runs from January to July, and a rainy season from August until December. The rainy season is characterized by the presence of typhoons and severe storms. Hurricanes often occur in September, October and November and are accompanied by heavy rain which causes flooding in the area.Rising sea levels and strong wind create large ocean wavesthat destroy the coastline. The number of hurricanes to reach Da Nang, Hoi An account for 24.4 per cent of total hurricanes that reached land in the 17th latitude. In addition to hurricanes, the number of floods in Hoi An is increasing. There has been a phenomenon of more than one flood happening at the same time and flood peaksare growing higher year after year: 1964 (3.40 metres), 1998 (2.99 metres), 1999 (3.21 metres), 2007 (3.28 metres) and 2009 (3.32 metres).

Hoi An is mainly influenced by the hydrological regimes of major rivers such as the Thu Bon and De Vong rivers. Generally, the flows are relatively regulated but slow velocity can causeaccretion leading to shallow beds. During thedry season, some parts of the river are shallow and water found there is affected by salinity. The Hoi An sea is affected by the tidal regime of thecentral region's sea, whose tide is twice a day. The tidal amplitude is average 0.6metres. The maximum tidal level is 1.4 metres and the minium 0.00 metres. Hurricanes have waves with a large amplitude. The maximum height of waves can be up to 3.40metres at a distance of 50metres from the coastline, which can cause severe damage to the coastal region. Duringthe dry season, due to low river levels, the sea intrudes into the mainland causing salinity which affects the livelihoods of the local people.

Human impacts that alter the natural conditions of Hoi An

In addition to natural impacts,Hoi An also suffers from human impacts. These include blocking river flows to build dams and flood discharges from the upstream hydropower reservoirs (seen in the A Vuong - Tranh River). The consequence of these actions is the Thu Bon River becoming shallow and drained, which facilitates the intrusion of sea water. In addition, the river also suffers from unexpectedly large flood discharges. Other human impacts include thedeforestation of protective forests (poplar forests) from Cam An to Cua Dai to build resorts. The development of some of the infrastructure has resultedin making the coast line vulnerable to sea waves and wind. Additional impacts includesand mining along the Thu Bon River, which results in imbalances to the river road, a decreased stability of the river bed and changes in the river flow.

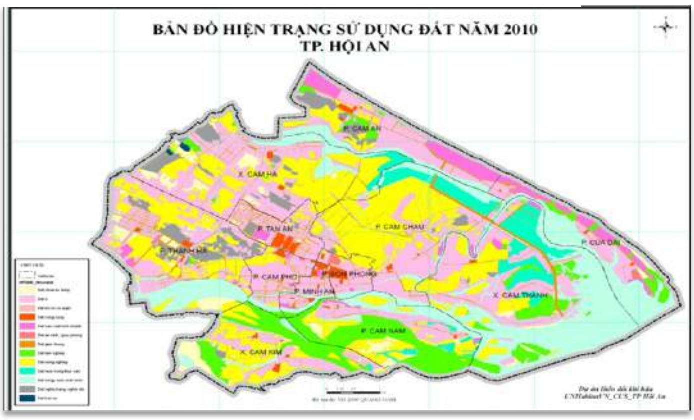
Land use, urban construction and infrastructure

Land use

The city's average land area is 106m^2/person and theresidential land is 129m^2/person. The ratio of urban land over inner-city population is 78m^2/person[8]. The ratio of rural land over rural population is 123m^2/person. These ratios are higher than the target of residential land under the standards of a grade I city (54 ÷ 61m^2/person) in Viet Nam. The resulting conclusion is that the demand of residential land and land for housing construction in the future can be met without urbanization of agricultural land.

[8] Hoi An city Division of Urban Management. Amended Master Construction Plan for Hoi An city toward 2020. (2011)

Figure 5. Land use in Hoi An in 2010

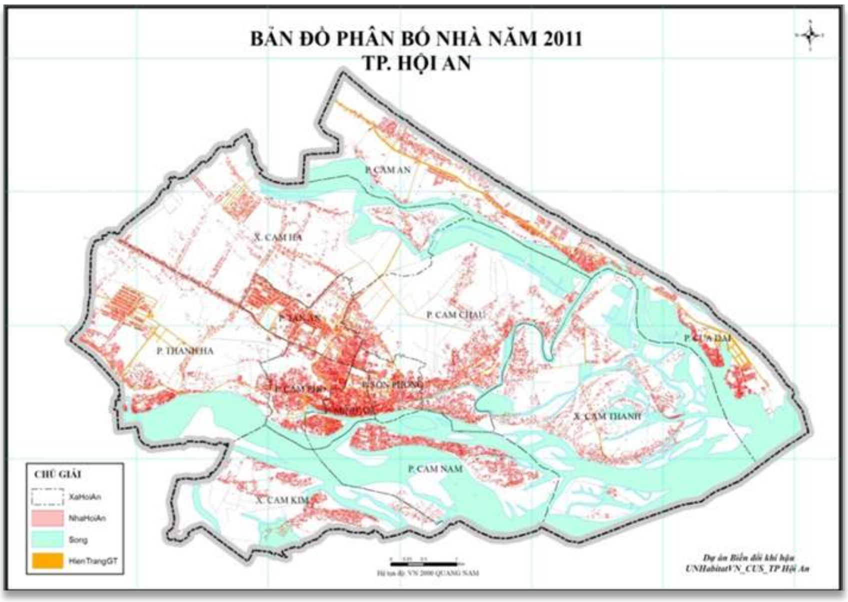


The total area of paddy fields is 461.47 hectareswhich is distributed amonggeneral urban structure, creating Hoi An's urban space. Thes surface area of rivers and streams occupies over 23 per centof the total area of the city. This is characteristic of Hoi An and needs to be maintained in order tobalance the environment in the lower section of Thu Bon river.

Current situation of construction and housing

Housing: There are only 42 condominiums (no additional condominiums have been built since 2005) and 21,078 single houses in the whole city, 95 per centof which are permanent and semi-permanent houses.. Housing density is distributed largely in the Minh An, Tan An and Cam Pho wards (Figure 6). Thisincludes the ancient town – one of the areas significantly affected by annual floods in Hoi An.

Figure 6. Housing distribution of Hoi An in 2011



Headquarters of administrative units: The head offices of Municipal Party Committee, the People's Committee, the People's Council and the city's departments are located in the administrative center of

Son Phong ward and Minh An ward. The headquarters of other departments are not centrallylocated and are housed in old buildings which do not meet the demands of the users.

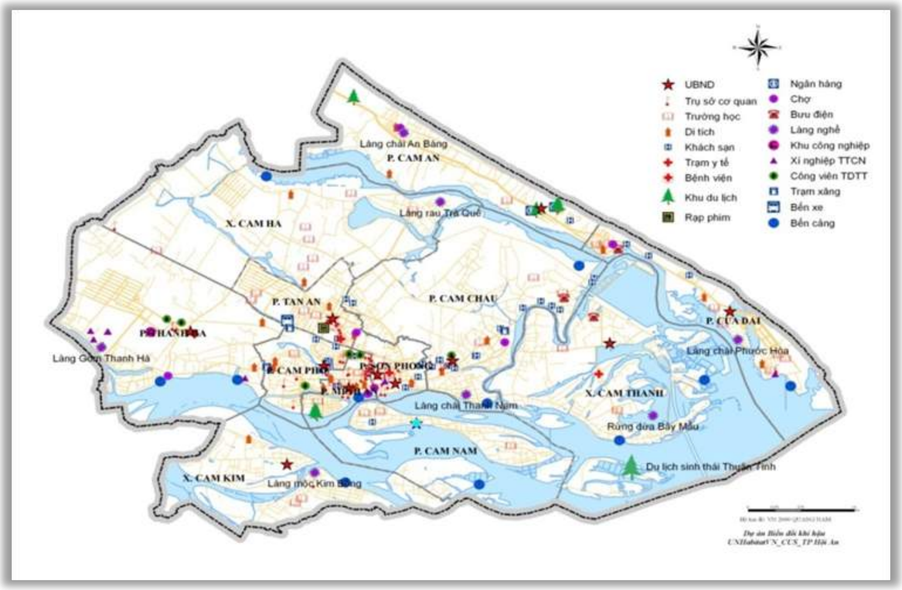
Cultural buildings*:* In the city there isonelibrary, 18 reading rooms and14 radio studios. In additional, there are many cultural buildings such as the Hoai River Square, An Hoi Garden, the Monument of Nguyen Duy Hieu, etc.

Educational buildings: The kindergartens, elementary schools and high schools in Hoi An (all wards and communes) are located in a limited, defined area and suffer from deteriorated classrooms. The only areas that do not have a high school are Cam Po, Cua Dai and Cam Ha. Overall, the city is equipped with three high schools, two colleges and one university.

Medical buildings: Medical buildings in the city are currently being upgraded. Hospitals are located in the city center, which makes it easier to serve patients. However, its locationis disadvantageous forsolving environmental problems caused by diseases. The city has twohospitals, onemedical center and 13 medical service units.

Public parks and sport centres: The city has onepark where the historical museum and entertainment area for children are located. There are twosports areas in the center of Hoi An.

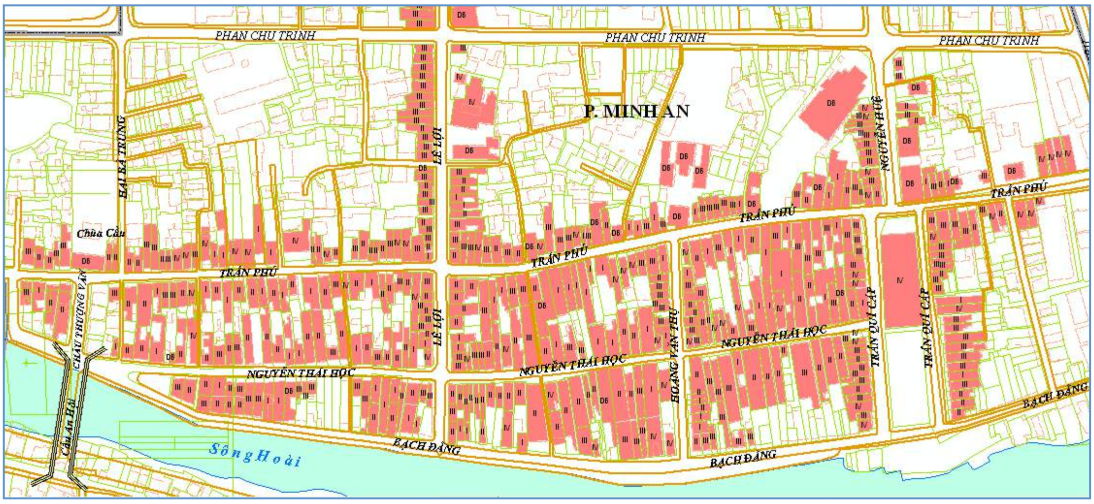
Figure 7. Distribution of social infrastructuresystem



Relics: In Hoi An's ancient town, there are 1107 relics in the old quarter, 80 per centof which belong to private owners. There are fourtypes of relics based on different preservation level. The relics in the city are works with high cultural, historic, scientific, artistic and architectural value. The relics werebuilt in riparian areas with low topography, so they are very sensitive to climate change impacts such as flooding, hurricanes, etc.

Beside relics, the city also has beautiful architectural buildings such as churches, temples, pagodas, etc. These structure require regularly scheduled restoration.

Figure 8. Distribution of relics in the oldquarter of Hoi An



Road traffic system: Hoi An possesses a nearly completed internal and external road traffic network. It was designed following a West North- East South format in order to allow for favorable traffic conditions amongst the various regions. Even so, there are still numerous areas that suffer from discontinuous and interrupted traffic flow. To date, the Cam Kim and Tan Hiep communes are not been connected to the city center. The road system in Hoi An is classified in three groups: major urban roads, regional roads and internal roads (Table 3).

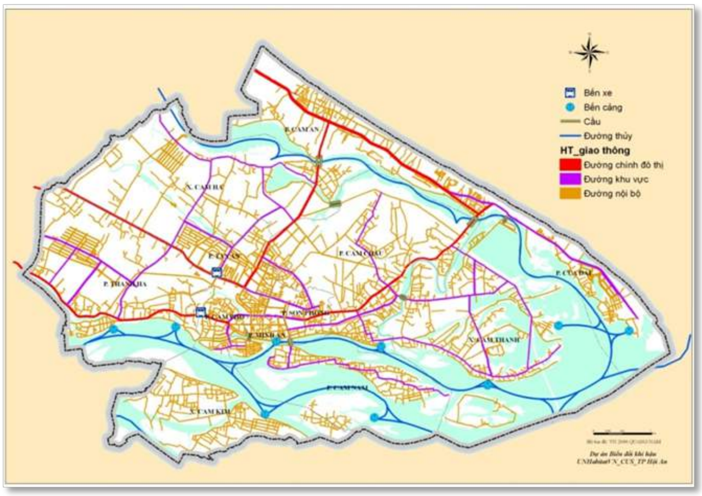
Table 3. Target indicators of road system of Hoi An under level of roads

Type	Area (ha)	Length (km)	Percentage of transport land (compard to residential land) %	Road density (compared to land area) (km/km2)	Road density (km/1000 people)
Major roads	28.82	22.11	1.8	0.48	0.25
Regional roads	38.92	43.29	2.4	0.94	0.48
Internal roads	125.40	323.17	7.8	6.99	3.60
Total	193.14	388.57	12.0	8.41	4.33

Because the city does not have an airway orrailway transportation network, major urban road systemsare important for connecting Hoi An to other provinces and cities. The network of regional roads and internal ones serves the city's domestic traffic.

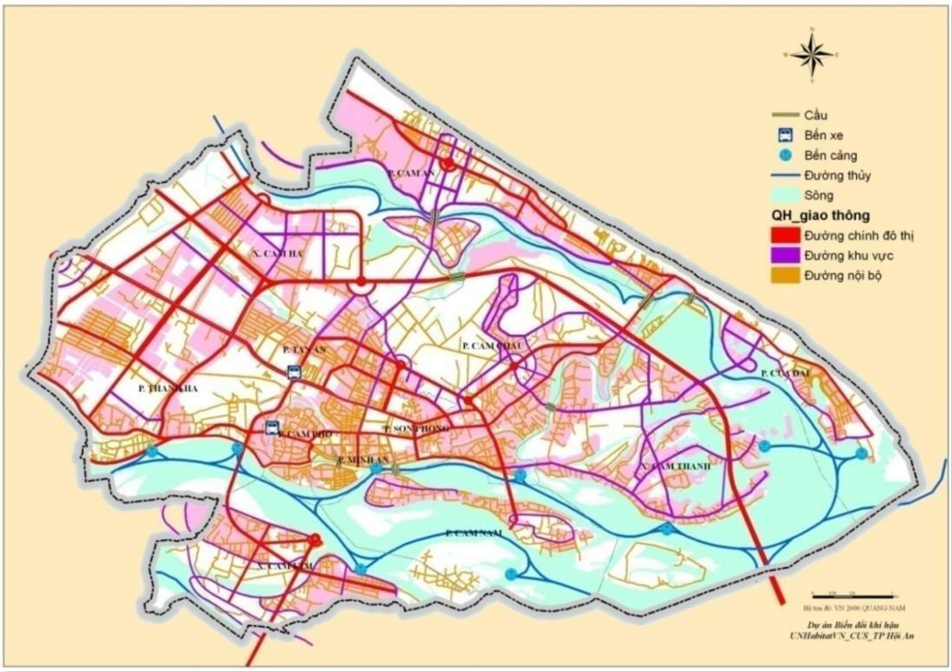
Waterway traffic system: Hoi An is home to two rivers, Thu Bon and Truong Giang, and a network of canals, rivers and streams.Its relatively flexible system of wharfs allow it toconvey goods (mainly minerals like sand) and to serve the residential and tourism demands of localities in the area which have under-developed road traffic system (like Cam Kim commune). However, the channel depth of waterway routes is limited and usually aggradated and filled. Therefore, Hoi An is limited to passenger ports andsmall wharfs to serve tourists and local people (boat with under 200 passengers andsmall load transportation-under 5 ton vessels).

Figure 9. Current situation of transportation system in Hoi An



Transportation system planning of Hoi An to 2030: Planning for the transportation system to 2030 has been amended to focus on the development of road traffic in order to achieve the following:better diversity and circulation of the system, unification and synchronization, flexible structure, safety, environmental friendliness, and design in accordance with the architectural landscape of the city. The city also plans to develop strong public traffic system with acentripetal model. (Figure 10).

Figure 10. Transportation system planning for Hoi An to 2030



Planning for the transportation system to 2030 has a target of asphalting 80% of major urban roads and regional ones. The internal road system is assumed to remain fixed due to lack of detailed planning.

Clean water supply system

Hoi An's water supply plant hasacapacity of 6,500 m^3/day, which provides enough clean water for 75,000 personsunder grade III city standards of 80 liters/person/day. Most of the supply comes fromsurface water taken from Vinh Dien River (4,500 m^3/day and night), the rest is supplemented by poor quality ground water (mostly mined in sandy soil at a depth of 12metres maximum)of very little and unstable volume (2,000 m^3/day) Table 4shows the correlation between the length of the water supply network, and pipeline density versus the area of residential land and population (2009) by ward and commune.

Table 4. Length of water supply network, pipeline density and population by ward and commune

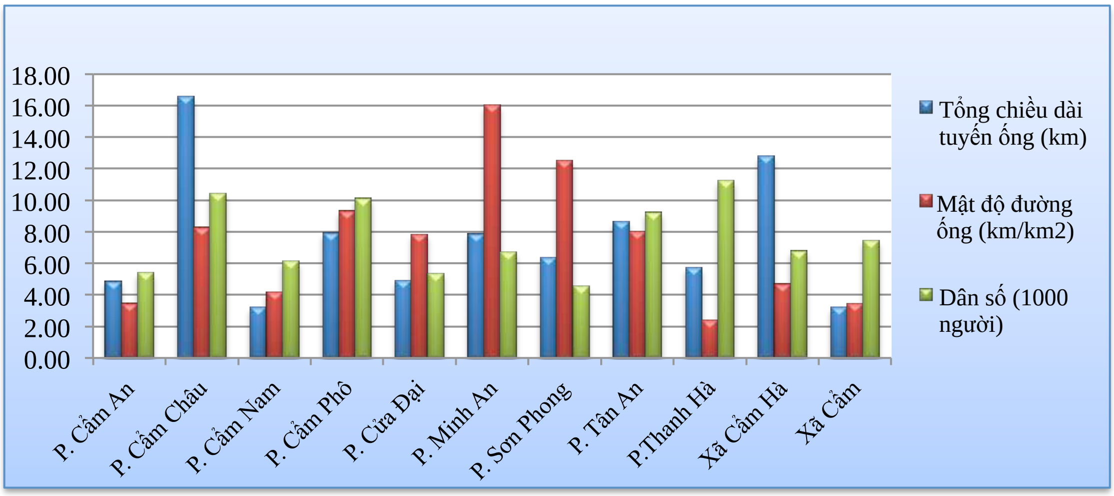
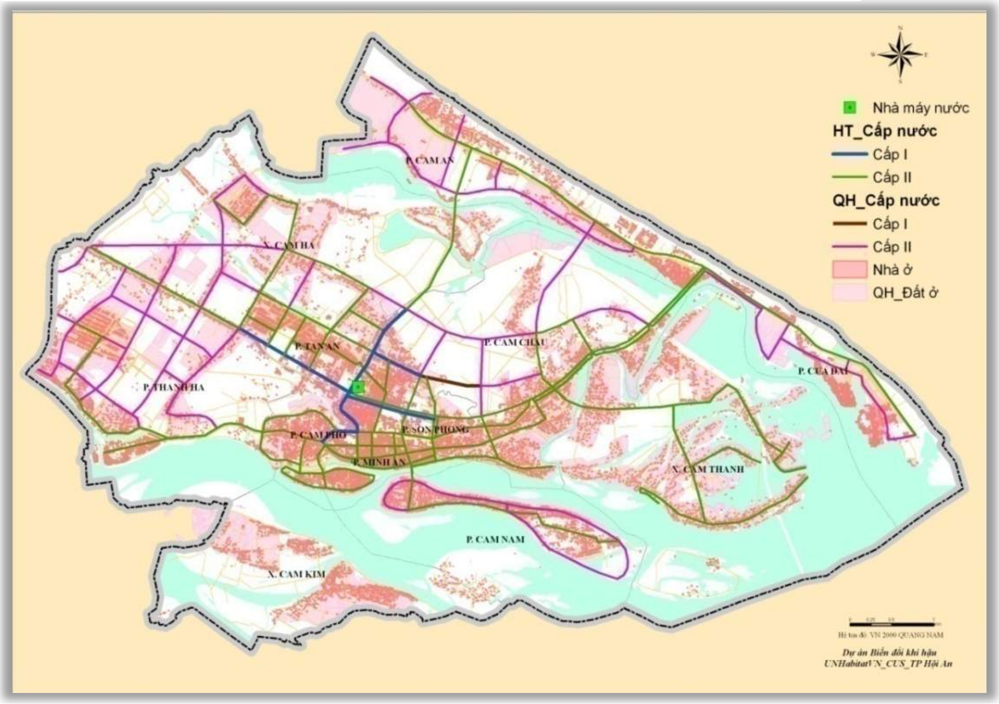


Figure 11. Map of the projected water supply network in Hoi An in 2020



Water drainage infrastructure

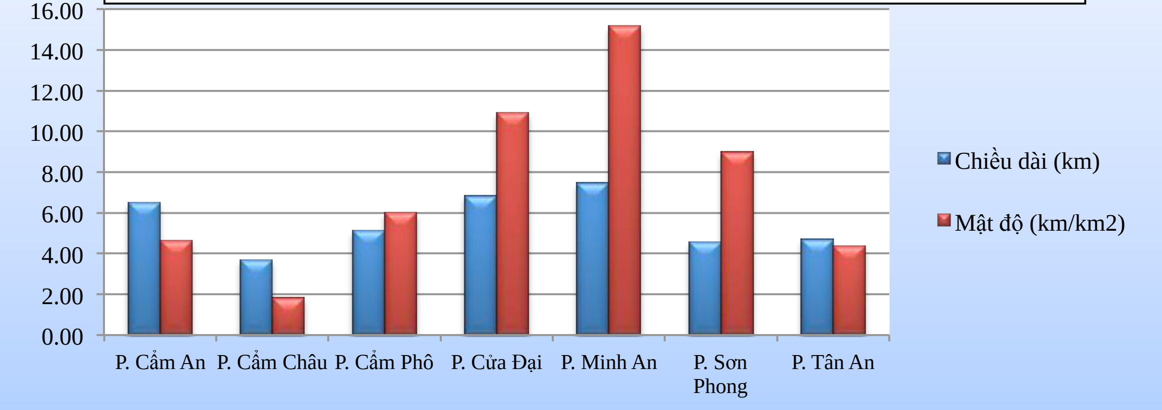
The water drainage system of Hoi An can be divided into threeseparated areas: inner-city area, coastal tourism area and suburban area.

Wastewater drainage systems of inner-city and coastal tourism areas: These areas include thewards located inthe old quarter (Son Phong, Tan An, Minh An, Cam Pho) and in the coastal tourism area (Cua Dai, Cam An). The areas have relatively completed wastewater collecting sewer systems with reinforced concrete arch culverts and closed drainage channels. However, the systemsarestill used for rainwater, domestic wasterwater, industrial wastewater and other public wastewater.

In the old quarter, the wastewater drainage system is composed of a high-density polyethylene (HDPE) pipeline which runs underground along the main internal roads towards the wastewater treatment plant located in the 8th hamlet in the Cam Thanh commune. The plant has a treatment capacity of 6,700 m^3/day. The plant is running a project to install a wastewater collecting sewer system, which will be used to strengthen the local capacity of wastewater drainage inthe ancient town. The system is expected to ensure the collection and drainage of rainwater and wastewater in 4 wards with anestimated population of about 38,200 persons. The total length of the pipeline network is 48.7km of gravity pipeline and 3.5km of penstock. Some small drainage channels are used for the discharge of wastewater directly into the Hoi An river. The wastewater of the Hoi An hospital is locally treated by septic tanks and discharged directly into the drainage line located on Tran Hung Dao street.

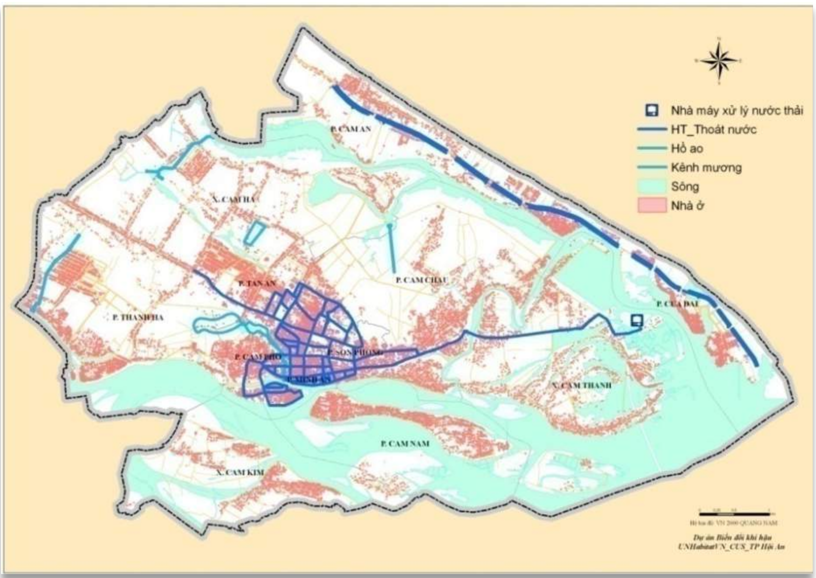
In the tourism quartersof Cua Dai ward and Cam An ward,the construction ofa drainage system along both road sides is nearly completed, having reinforced concrete arch culverts with adiameter of 800mm to 1200mm. The drainage system runs along the coastal youth route.

Table 5. Length and density of drainage pipelines in inner-city area and coastal tourism area



Suburban area: Data for the infrastructure system for collection of wastewater in suburban areas is not available. Currently, rainwater and wastewater are discharged directly into the natural environment without being thoroughly treated viathe network of channels and ditches. Cam Ha commune hasa Ba Moi dragline (4 m x 1.20m) of 1km in length used for the drainage of rainwater intoa 130ha basin for the De Vong river. Thanh Ha ward has a 1.3 km long dragline (2m x1.50m in size), which is equipped with a reinforced concrete structure and a cap for rainwater drainage intoa 100ha basin for the Hoi An river. There is also a system of canals for irrigation and drainage with atotal length of up to 29.3 km.

Figure 12. Drainage network in Hoi An



Infrastructure of electricity supply, urban lighting and communications

The infrastructure of the electricity grid and communication systems of Hoi An meets the basic demands of the city. The transformer stations and transmission lines are designed to be locatedin high and solid areasto avoid the impact of natural disasters, such as flooding and extreme weather caused by climate change. The overall assessment of theinfrastructure of the electricity supply and communication systems shows that they are resistant to climate change impacts.

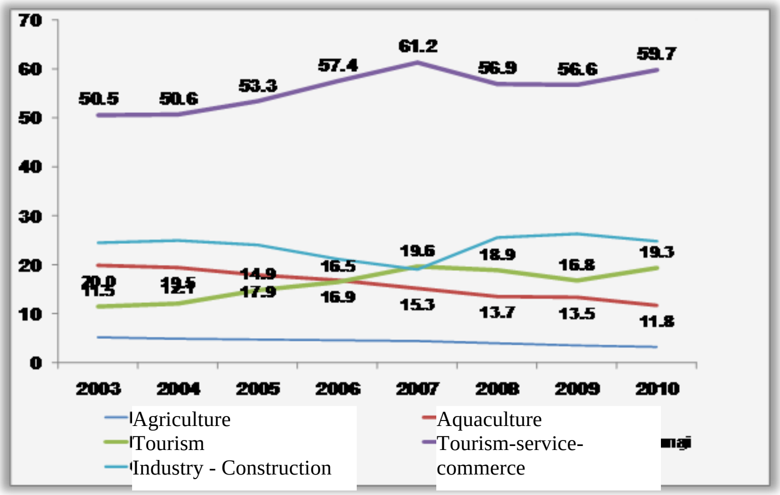
Current social of economic-cultural-social infrastructure

Current situation of socio-economic development

Hoi An is a small urban city under the management of Quang Nam province with total area of 6,171ha and total population of 90,265 persons[9]. For the period between 2004 and 2010, Hoi An had an average economic growth rate of 11.5 per cent, which is much higher than the national one. Tourism, commerce and servicesincreased sharply from 50.5 per cent in 2003 to 59.7 % per cent2010. On the other hand, agricultural growth decreased from 5 per centto nearly 3 per centduring the same period. Although lower than in past years, fishery and aquaculture growth was still high at 11.8 per centin 2010. This trend reflects the rapid urbanization process of Hoi An.

Many wards, such as Cam Kim, Cam Ha and Cam Chau are heavily dependant on agricultural and fishery activities.

Table 6. Economic structure of Hoi An, 2003-2010



Source: calculated using Hoi An Statistical Yearbook (2011)

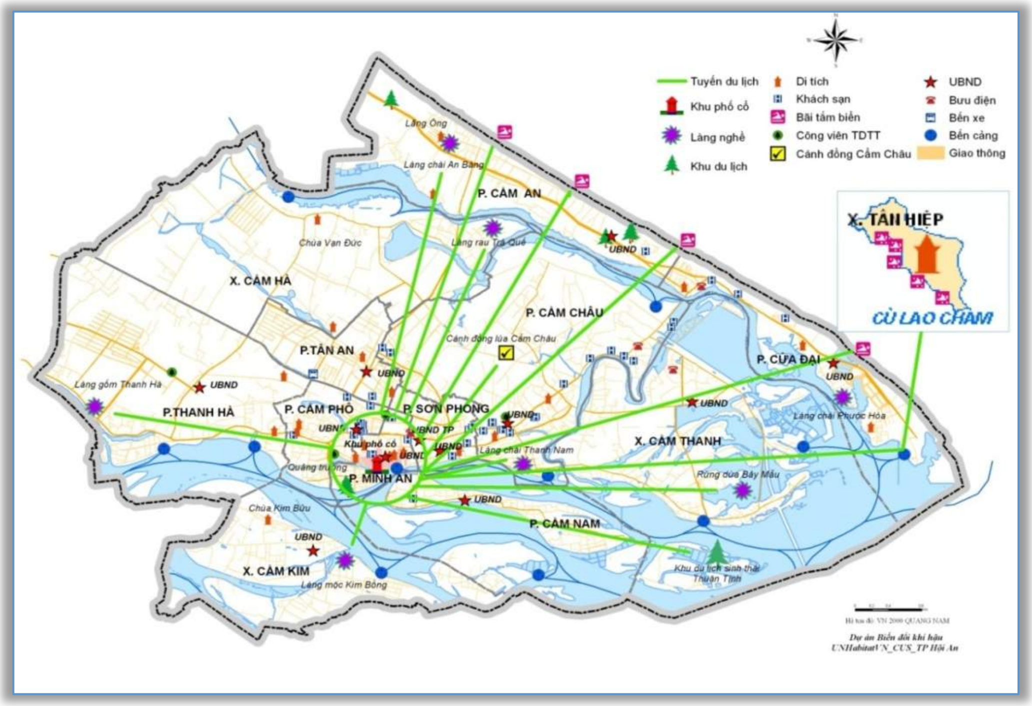
[9] Hoi An Division of Statistics. Hoi An city Statistic Yearbooks (2005-2010).

Statistics shows significant difference insocio-economics among the various wards and communes of Hoi An city. The proportion of households working in agriculture in the entirecity is 12 per cent. However, greater numbers can be found in the following wards: Cam Kim (25.5 per cent), Cam Ha (37.7 per cent) and Cam Chau (24.8 per cent).

Industry, small-scale industry and handicraft account for 19 per cent of the city’s total gross domestic product.Similar to other production and trading activities, industry has an uneven distribution in the city.Industrial output per capita differs 15 times between Son Phogn ward and Tan Hiep commune. In the entirecity, only 10.7 per centof the labor force works in the industry sector; Minh An ward has the highest rate at19 per cent, while theCua Dai and Cam Chau wards have the lowest rate at 4.8 per cent. Thanh Ha ward has the highest product value for industry, small-scale industry and handicraft, accountingfor more than 20% of total industrial product value, whilst Cua Dai is the lowest at 1 per cent.

Commerce and tourism are key economic sectors for the citydue to interest in Hoi An’shistorical quarters,the World Biosphere Reserve Cham islands and famous beaches such as Cua Dai andAn Bang. The city's tangible cultural heritage includesalmost 1,350 relics from the 17th century. Intangible cultural heritage such as unique folk performances andtraditional festivals are big attractions for tourists. Ancient craft villages like Thanh Ha pottery village, Kim Bong carpentry village, Tra Que vegetable village, Thanh Nam fishing village, along with the unique landscape of Bay Mau coconut forest or Cam Chau paddy field also contribute to tourism as ecotourism spots.

Figure 13. Tourism map of Hoi An



Poverty and access to basic services

Adaptive capacity to climate change and to natural disasters depends on many factors, including access to information andsocial services. In Hoi An, there is a definite discrepancy amongst the various wards and communes.

While the ability to access electricity and clean water supply is high and equal amongsy communes and wards, the quality of these services differ in each area. The wards located in thecentral area have better access to services with better quality, while rural communes and coastal areas are provided with lower quality of services. This can be proven via official data and through interviews and surveys in various localities. Cam Kim, Tan An and Cua Dai have difficultyaccessingclean water. The electricity supply in these communes, especially in Cam Kim, is usually disconnected duringstormy days, affecting production and the livelihoods of people.Access to communication among different areas of the city also differs significantly. The percentage of households having computers, telephones, TV and radio differs between the various regions of the city. This impacts on the ability of local people to access information related to natural disasters, including warnings and information used to raise awareness on prevention methods. Furthermore, areas that are mainly affected by natural disasters such as Cam Kim, Cam Ha, Cam An and Cua Dai have the lowest access to information.

Hoi An has arelatively low poverty rate of 2.8 per cent (in 2010).Its ability to access basic social services is relatively high compared to other districts of Quang Nam. Nearly all of the households have access to clean water and hygienic toilets. However, the rate of malnutrition in children under twoyears of ageis still high at 7.48 per cent. Like other socio-economic indicators, there is a significant disparity among the variouswards of Hoi An in terms of indicators of access to social services. The communes of Cam Kim andCam Thanh and the wards of Cam Nam, Cam An, Cua Dai are localities having high poverty rates and lower access to social services.

The various wards and communes have large differences in living standards and livelihoods and therefore, are affected by different impacts. Due to the big differences in living standards and livelihoods of people, impacts of changes in economy, environment and climate will differ from area to area and among different subjects. Those areas where people still depend on agriculture and fisheries will be affected more adversely by natural disasters and have higher vulnerability. Changing livelihoods in those areas is more difficult due to limited financial, human and social resources. Thedifferencesin livelihoods should be considered in the planning and implementation process of policiesto prevent disasters and reduce their impacts.

Natural resources and the environment

Resources

Forest resources: Forests are concentrated in Cu Lao Cham, the coastal areas and the urban outskirts of Hoi An. Hoi An has 739.52 hectares of forest, accounting for 11.98 per cent of its area. Special-use forests (534.9 hectares) are found Cu Lao Cham (remote island of Tan Hiep). Protected forest areas can be found in Thanh Ha, Cua Dai, Cam An, Cam Kim, Cam Thanh in Cu Lao Cham and Cam Thanh Nipa.

Vegetable-rice fields: Both paddy fields and vegetable farming are agricultural resources found in Hoi An. Vegetables are grown in all wards except for the Minh An ward, accounting for 893.37 hectares. The largest field area is located in Cam Chau at 219.15 hectares. Paddy fields cover an area of 850 hectares and account for productivity increases of 57 to 60 kg / ha. In 2010, rice production reached 4544.1 tons. The areas in which vegetable are grown are typically in low-lying and prone to flooding during the rainy season. Cam Chau's field is not only the "rice bowl" of Hoi An, but also acts as a regulator for the downtown area during the flood season and as the "green lungs" for the city. The fields of Cam Chau are also scenic tourist attractions.

Surface water: Surface water is vital to Hoi An. It is not only is used for agricultural production, for industrial enterprises and as a water supply for the city, but it also has a unique role in the "water culture" of Hoi An.

The city of Hoi An has interlaced river and canal systems that are influenced by the hydrological regime of Thu Bon River Basin and coastal estuaries. Thus, they are usually dry during the dry season and suffer from salt-water intrusion. During the rainy season, the river water levels rise, causing widespread flooding.

Groundwater: The groundwater in Hoi An is an extremely important resource for the local water supply of the city. According to initial survey data, Hoi An may have three aquifers. The first is anon-pressured surface aquifer with a water depth of one to five metres. The second is a pressured aquiferof5 to 30metresin depth and acts as a source of water for the population. The third is a pressured with a depth of 50 to 70metres that holds a water-rich layer. There is a need to study the extraction of water for municipal use in the future.

Fisheries: Cu Lao Cham is known for its quality of fishery resources and provision of fish and other aquatic creatures. It possesses diversified coral reefs and sea grass which put Cu Lao Cham on the list of 18 protected marine areas in Viet Nam.

In addition to Cu Lao Cham, fishery resources are growing in the mainland in Cam Chau, Cam An, Cam Nam, Cam Ha, Cam Kim and Cam Thanh. The farming area is largest in Cam Thanh at 150.82 hectares. Aquaculture area has decreased from 270.46 hectares in 2006 down to 246.33 hectares in 2010.

Aquaculture resources are impacted on a yearly basis by flooding in Hoi An, which can go up to depths of two to three metres. Impacts include erosion, fish being swept away and damage to boats and fishing gear.

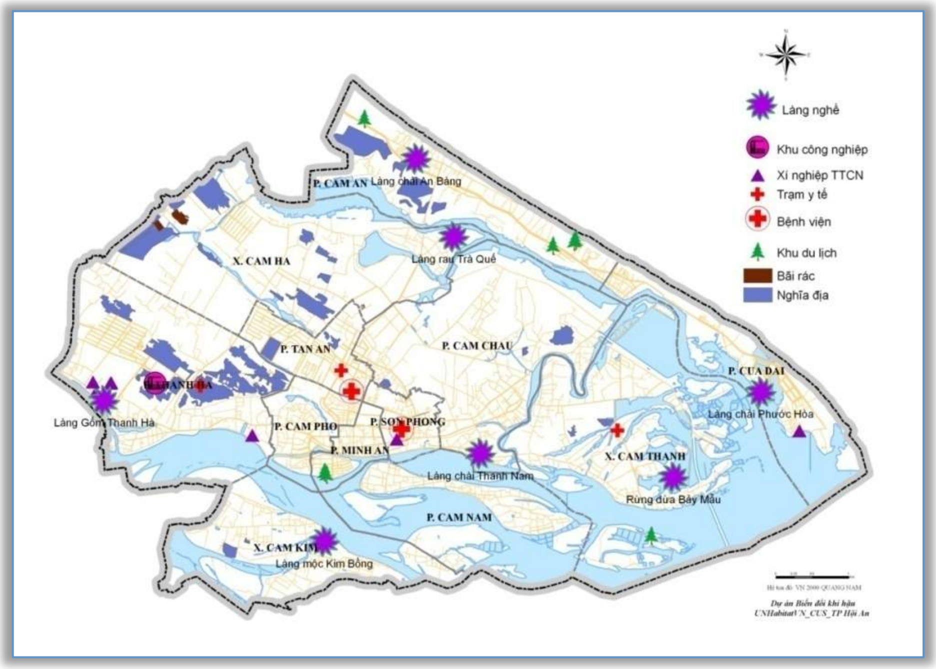
Minerals: The city of Hoi An has three types of minerals:

- Fuel minerals: Peat of Cam Ha (now belongs to Thanh Ha). Due to its small-scale, low quality and low economic efficiency, it should not be exploited.
- Metallic minerals: Ilmenite (Titanium) is found in Cam An on a small-scale.
- Construction material minerals: sand, grit, gravel, limestone reefs, etc. The total reserve of sand in Cam Kim is 22,116,000 m^3. In addition, there are 419,200 $m^3$of leveling sand in Bau Oc Ha. Sand mining erodes large surfaces of arable land, affecting the lives and live[1]ihoods of local people.

Environment

Potential sources of pollution in Hoi An include hospitals, industrial zones, handicraft villages, production and processing facilities, garbage dumps and cemeteries and graveyards. Climate change is exacerbated by flood hazard, causing environmental pollution to spread in the soil, surface water, and groundwater.

Figure 14. Map of sources of pollution



Urbanization and urban governance in response to climate change

Urbanization

Hoi An city was recognized as a World Cultural Heritage site in 1999 and a Type 3 City in the province of Quang Nam in 2008. In addition, Cu Lao Cham was declared a World Biosphere Reserve in 2009, making it a tourist attraction that promotes economic, cultural and social development in Hoi An. It also aids in the promotion of services and trade within the tourism industry. The production value of services and trade has increased rapidly, growing from VND 666, 981 million in 2003 to VND 2,582,858 million in 2010.

Hoi An's population increased from 82,452 inhabitants in 2003 to 90,265 in 2010, of which 77.16 per cent is found in urban areas. The population density in 2010 was 1,463 people/ km^2, concentrated in the center wards which account for over 30 per cent of entire population. The population density of the varies significantly: Minh An's density is10,154 people / km^2, which is12 times higher than that of Cam Thanh and 65 times higher than the density of the island of Tan Hiep Commune. Furthermore, there are on average over 4,000 tourists per day in Hoi An, which create additional pressure on the urban environment and social infrastructure- particularly in the historical sector of Hoi An.

In order to meet the demands of urbanization, the city has expanded its infrastructure. The Trung Nhi road was build in the 1990's in order to create a buffer zone and respond to the increased housing demand in the old town. In 2004, Hoi An built the Hoai River Square to expand the city across the Hoai River. It has become a public space where cultural and touristic events in the city take place.

Based on city planning approved in 2005[10], several new residential areas located around Tan An, Thanh Ha, Cam Pho, Phong and other are as have been developed. To match the pace of urbanization and construct a city meeting the requirements of a potential World Heritage site, the city is implementing an adjustment plan to 2030. This will see the development of new urban centers that are linked to the ancient town. Hoi An is looking to develop a city that incorporates Eco-Culture and Tourism, one that preserves cultural heritage whilst responding to the needs brought upon by urbanization and rapid economic development.

Urban governance in response to climate change

This section lists the tasks of all units within the Quang Nam's People's Committee (see figure 15 below for its structure):

- The People's Committee of Quang Nam overseas the Hoi An People's Committee and approves the budget, as well as the socio-economic development plan of Hoi An town;
- The Department of Agriculture and Rural Development of Quang Nam province is a specialized agency within the provincial People's Committee. Tasks include assisting the provincial People's Committee in performing state management related to the following: agriculture, forestry, salt production and fishery, Irrigation and rural development, flood and storm prevention, and safety of agricultural products, forest products and fisheries;
- The Steering Committee for Flood and Storm Prevention and Search and Rescue is under the Quang Nam Provincial People's Committee. The Vice-President of Quang Nam Province receives storm information updates from the Central Steering Committee for Flood and Storm Prevention and

[10] Hoi An Division of Urban management. Master Construction Plan for Hoi An city to 2020 (2005).

Search and Rescue. This information is used to guide the Communal Steering Committee on flood control deployment of scientific research related to climate change;

- The Management Board of Cu Lao Cham Marine protected area (MPA) is under the Department of Agriculture and Rural Development of Quang Nam province. It is responsible for managing eight islands and the surrounding areas of Cu Lao Cham. The primary responsibilities of the management board are conservation of ecology and communication to raise awareness -related to the protection and conservation of Cu Lao Cham Islands and the island's ecosystem. In addition, the Management Board gives technical advice on Hoi An City and cooperates with the Department of Natural Resources and Environment in Hoi An on the management plan (tourism planning and development and environmental regulation) for Cu Lao Cham MPA;
- The Economic Room of Hoi An is the focal point for responding to floods and storms, evacuation operations and the management of dikes, canals and sewer systems. It is also responsible for the management of economic development, community training, the preparation of annual reports on activities (including damage assessment reports) and annual work plans for floods and storms. These reports are submitted to the Steering Committee for Flood and Storm of the city, led by the Vice-Chairman of City People's Committee of Hoi An;
- The Natural Resources and Environment Room of Hoi An town is in charge of planning ways to adapt to climate change and building and implementing projects related to resource management and city environment. It is the focal point for the formulation and implementation of the eco-city development projects of Hoi An. In addition, the office is responsible for the implementation of water resource management planning, which is a challenging task as the impacts of climate change have made the approach to integrated management of water resources more relevant and more urgent;.
- The Urban Management Room of Hoi An city is responsible for implementing the city master plan (spatial planning), infrastructure management and construction in the area. Currently there is no integration between spatial planning and other development orientations or investment projects under eco-social development. It is challenging to integrate climate change issues into the planning / urban planning because it requires the consideration of the different plans to evaluate the results;
- The Finance and Planning Room of Hoi An city is responsible for the development plan/ planning of economic and social affairs in city and allocating budgets under the direction of the Hoi An’s People's Committee.
- The Steering committee of Flood and Storm control of Wards and Communes is responsible for implementing flood protection plans for every household (using a three per cent reserve fund for disasters from the local budget).

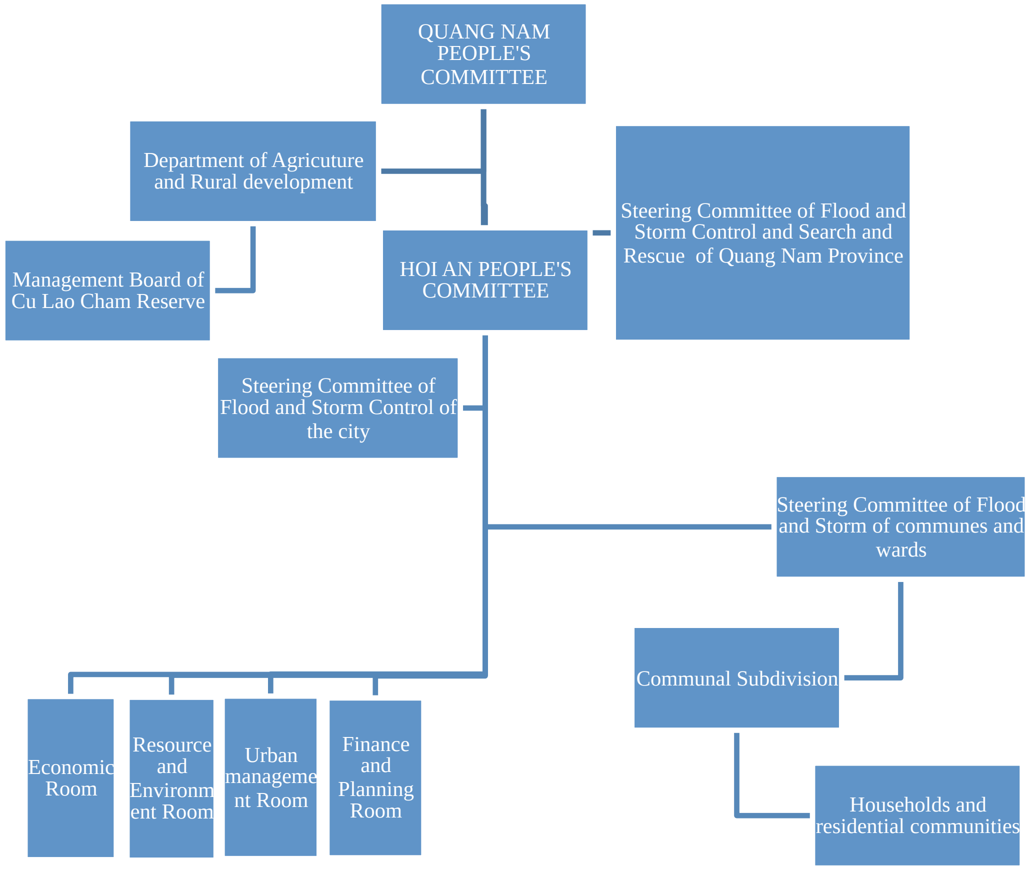


Figure 15. Quang Nam People's Committee Structure

3. CURRENT SITUATION AND POSSIBILITY OF FLOODING

Flooding

Flood situation in Hoi An

Hoi An is located in a central coastal plain within a dense network of rivers. Storms in the area can cause widespread heavy rain and flooding of high magnitudes. The city is downstream, hence heavy rain combined with tides make water levels rise quickly.

In recent years, due to the impacts of climate change and sea level rise, the severity of storms and rain has increased, causing more areas to be inundated and levels of inundation to rise. Floods normally arise from September to December and during that time, there are usually three to five major floods. In 1964, there was widespread flooding with certain areas covered by 3.4 metres of water. From 1997 to 2004,there were 38 flash floods with flood levels higher than 1.7 metres. From 1996 to 1999, Quang Nam had 15 major floods; the flood of 1999 drew flood waters of nearly three metres. In 2006, Hoi An had two level 3 flash floods of up to1.82 metres. In 2007, Hoi An had five flash floods, twoof which were particularly large with floods peaking being 2.03and 3.28 metres. In 2008, there were a few small floods with a flood alert level of 3. In 2009,there were 11 that caused severe damage in terms of life and assets. Local reports show severe storms and floods occurring with increasing frequency and with more dire consequences. The development of inundation maps is urgently required to help local governments with planning, prevention and mitigation of damage caused by flooding.

Method used to develop flood model

To date there have been many simulation studies on flooding for Thu Bon river basin. The research methods mainly include:

• Hydrological surveys and topography (traditional method);

• Investigation of flood marks of major floods which have occurred;

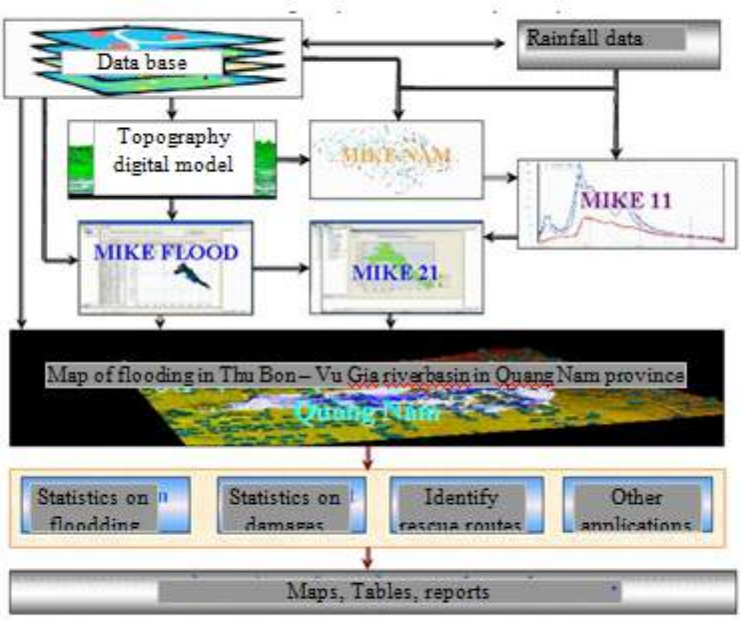
• Application of hydraulic and hydrological models.

Flood maps constructed using the traditional method and flood marks were developed by local officials in Hoi An. These maps are highly reliable but only represent floods that have occurred in the past. They cannot be used as an indicator for predicting future floods. Developing maps by combining surveys of flood marks and hydraulic and hydrology simulation helps to overcome the drawbacks of traditional methods. This methodology has been applied throughout the world.

The development of a hydraulic model of river basin Vu Gia- Thu Bon is a component of the Disaster Risk Management Project, which is sponsored by the International Association, the Social Development Fund of the Japanese Government and the Program of Policy Capacity Building for

Human Resources Development of the Embassy of the Netherlands. The model and was developed by the Department of Water Resources at the Institute of Geographic Sciences of Viet Nam and leading experts and was delivered to Quang Nam province at the end of 2010.

Figure 16. Model of flood mapping for Quang Nam
(Source: Institute of Geography - Vietnam Institute of Science and Technology)



Maps of flood forecasting in Hoi An

Hoi An city occupies a small area of Thu Bon River Basin, therefore a projected flood map of the city can be based on the results of flood map scenarios for Quang Nam province. However, it is important to note that:

- As these scenarios were developed without Tan Hiep commune (Cu Lao Cham);
- The inundated area does not include the river area;
- Total area is calculated using a digital map and not the measured area in reality;
- The flood maps predicted under climate change scenarios and sea level rise are calculated for the river basins of Vu Gia - Thu Bon based on input data of the digital elevation model of scale 1/10000 - 1 / 25,000. The map of Hoi An city uses the scale of 1/5000;
- Maps of flood forecasting over the period show that the flooded area does not increase much, even without changes in the area. However, the depth of flooding increases remarkably. For example, the area forecasted to be flooded by three to four metres of water increases from year to year: 17.47 per cent in 2020, 24.21 per cent in 2050, and 41.45 per cent in 2100.

Figure 17. Map of flooding forecast in Hoi An according to scenario 2020

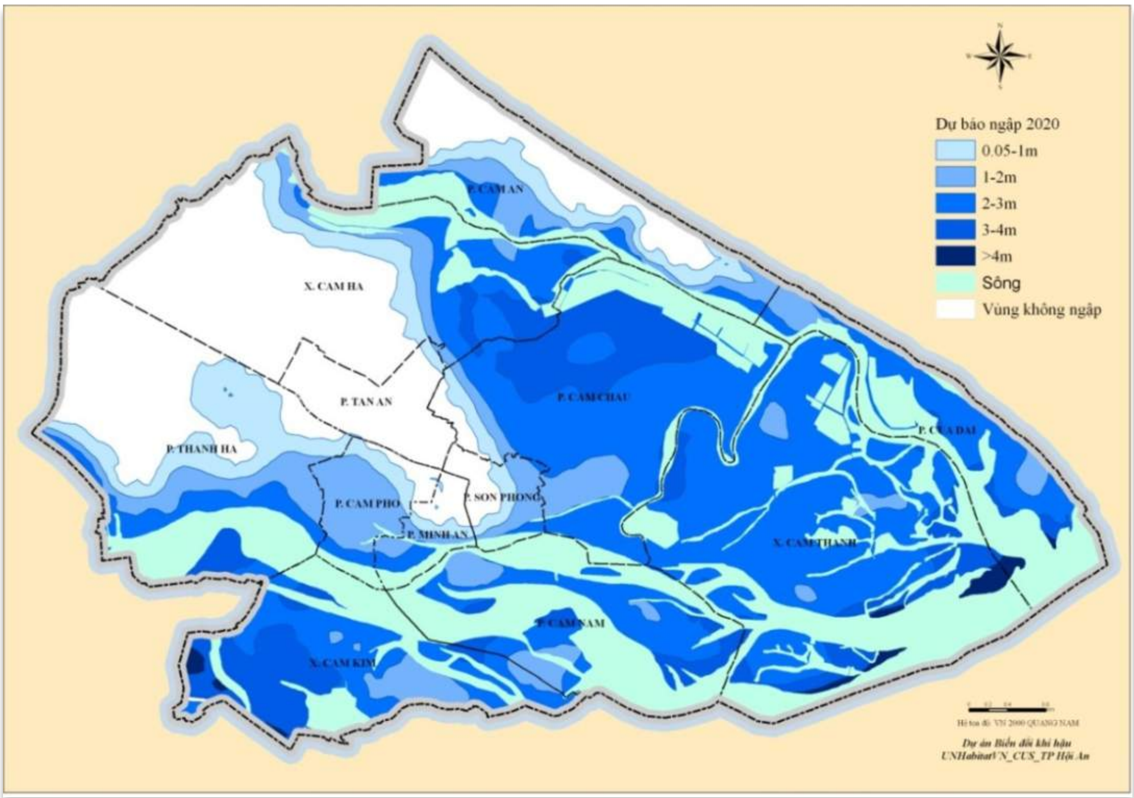


Figure 18. Graph of flooding forecast in Hoi An according to scenario 2020

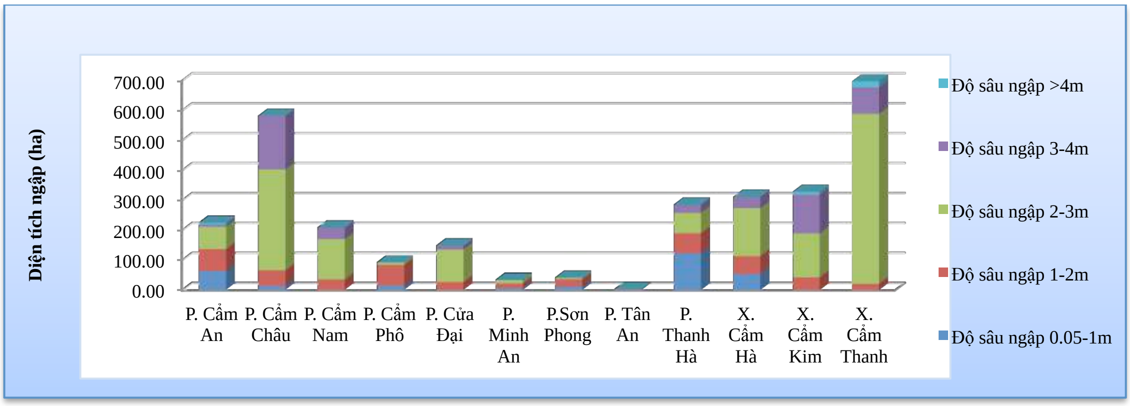


Figure 19. Map of flooding forecast in Hoi An according to scenario 2050

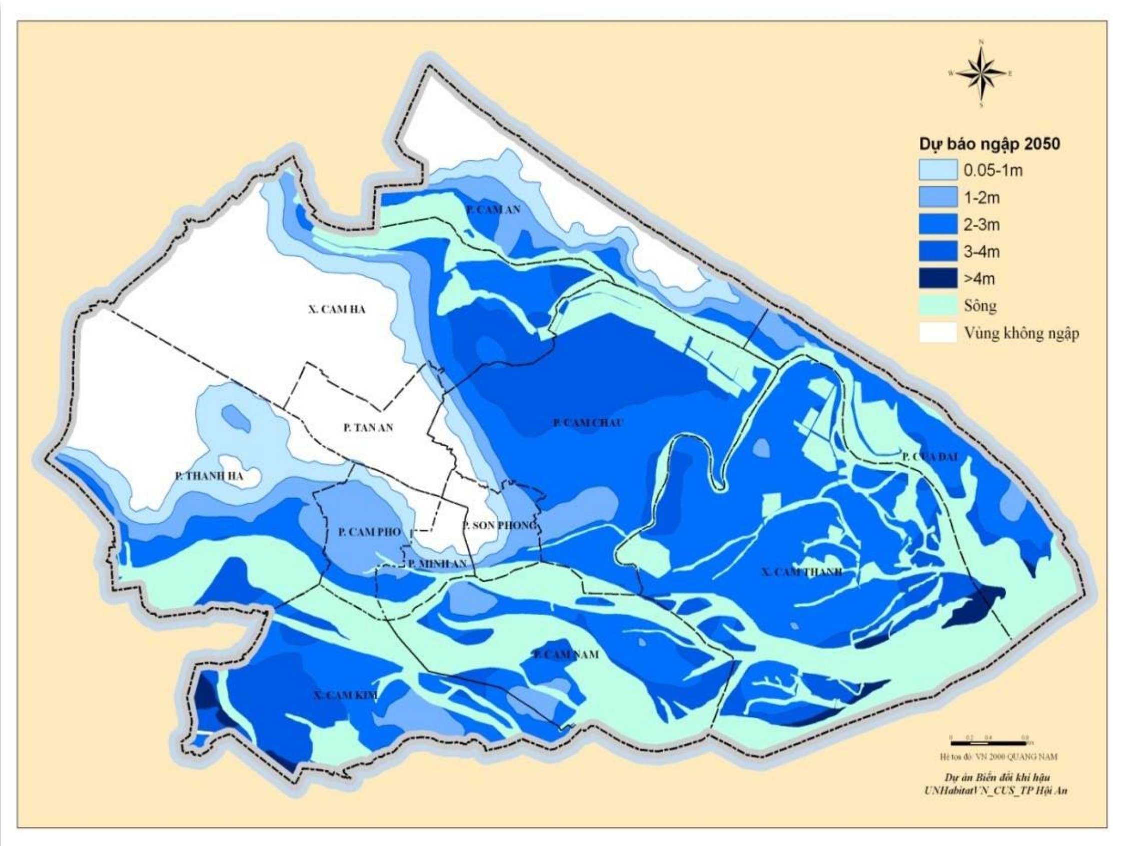


Figure 20. Graph of flooding forecast in Hoi An according to scenario 2050

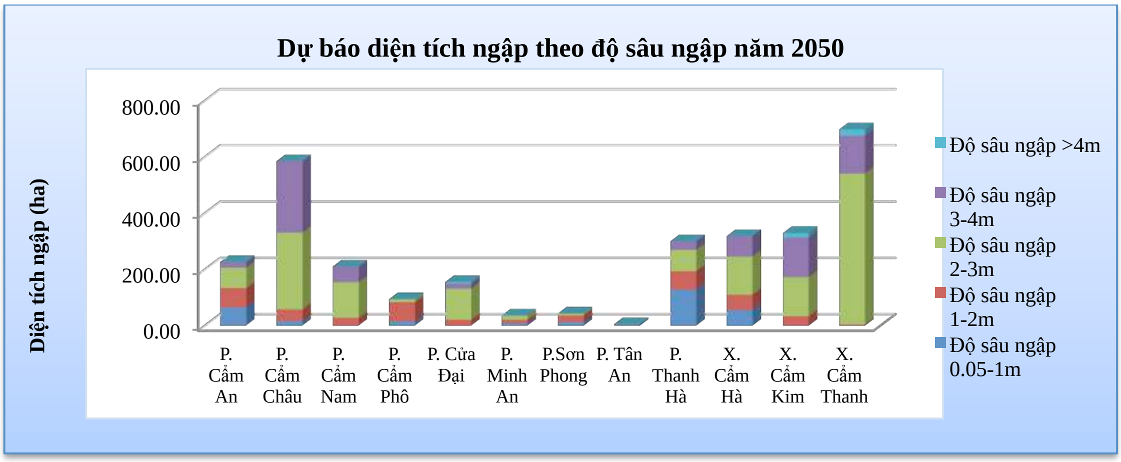


Figure 21. Graph of flooding forecast in Hoi An according to scenario 2100

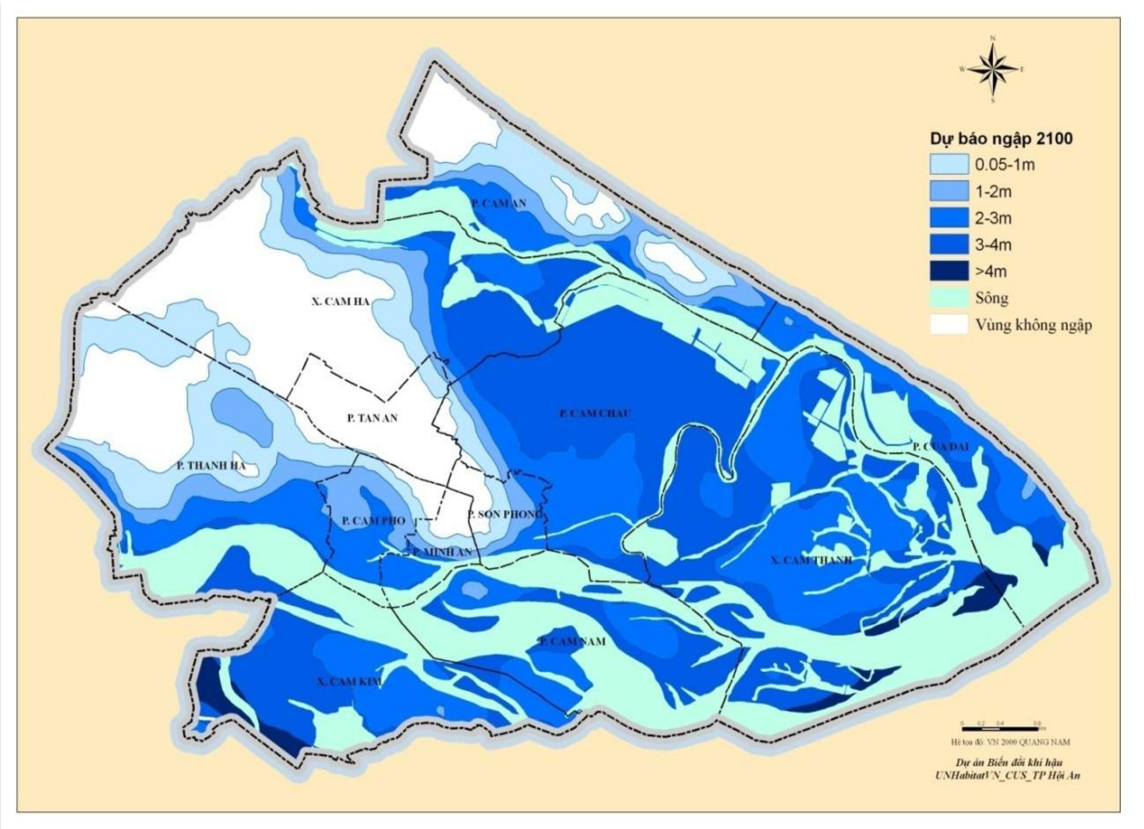
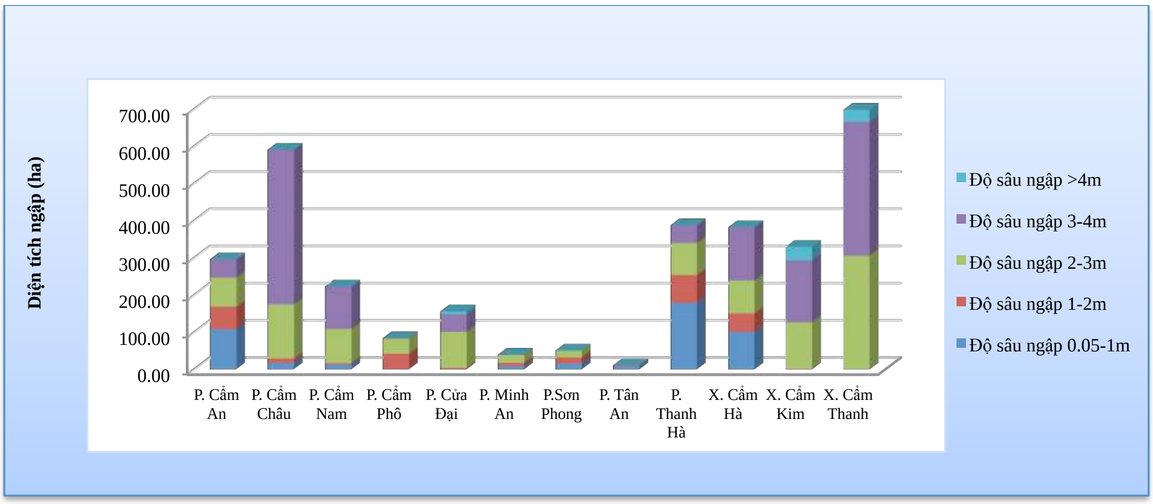


Figure 22. Graph of flooding forecast in Hoi An according to scenario 2100



Maps of terrains with flood forecasts for the city of Hoi An

Overlapping maps of flood forecasts using the digital elevation model built for the city of Hoi An (assigned to each level of flood maps) clearly show the effectiveness of the MIKE GIS hydrology model. With urbanization, permeability and drainage capacity decrease, so there risk of flooding, even at heights of four metres. In the amendment of the 2011 construction plan, flood elevation was forecasted to be +2.48 m (P repeat cycle = two years). However, under a scenario taking into account climate change impacts and sea level rise, an area with elevation of 4metres could have an inundated area of 167.85hectares (2020), 187.06 hectares (2050) and 366.85 hectares (2100). Figures 23and 24 show total area and forecasted flooding levels in 2020 for different types of terrain.

In the amended construction plan of Hoi An City in 2011,a digital elevation model of Hoi An was built based on measured terrain points using a scale of 1/5000 and the contour lines of river topography from a geological map with a scale of 1/10000 of Hoi An in 2008. The Tan Hiep commune (Cu Lao Cham Island) digital elevation model was built combining cadastral maps 1/5000 in a new survey in 2010 (the western part of the island) with terrain 1/25000 of other areas.

When overlaying with flood maps, terrain elevation maps of Hoi An are classified into five levels:

- Level one: height< one metre;
- Level two: Elevation one to two metres;
- Level three: two to three metres;
- Level four: three to four metres;
- Level five: height four metres.

Based on scenarios incorporating climate change and sea level rise, areas to be flooded were identified and levels were detailed using ArcGIS software in the figures below.

Figure 23. Map of total area and forecasted flooding level 2020 for different types of terrain

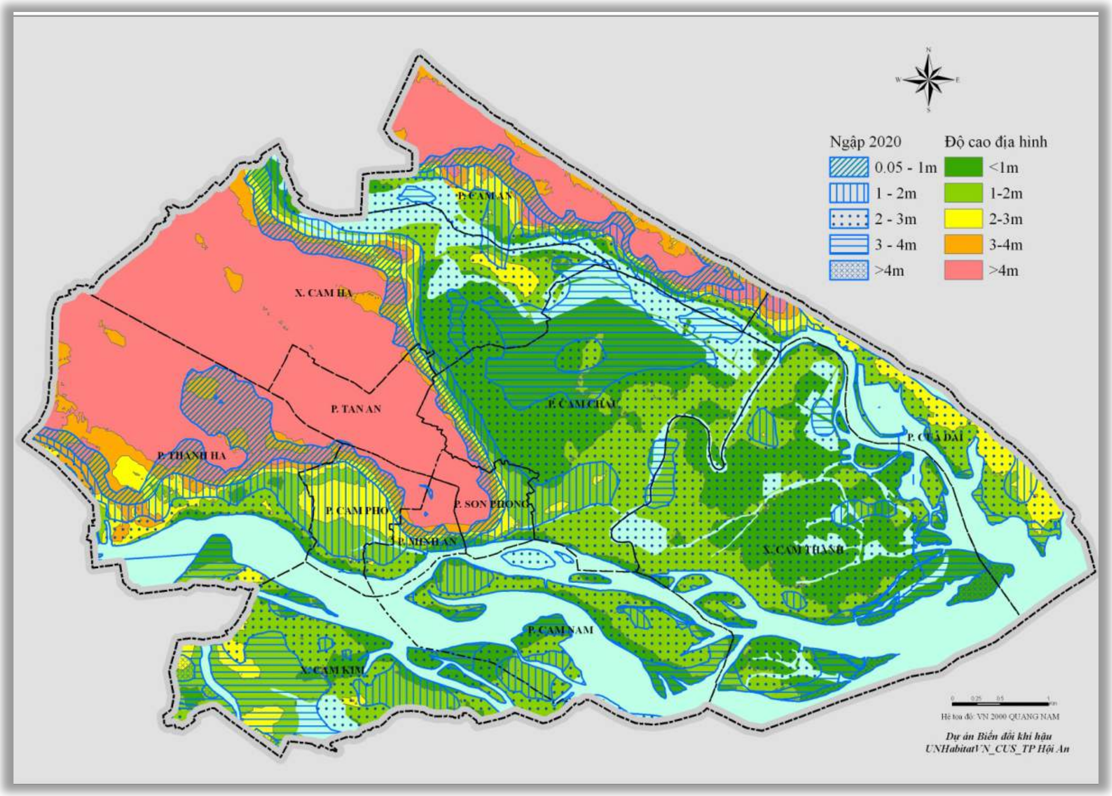
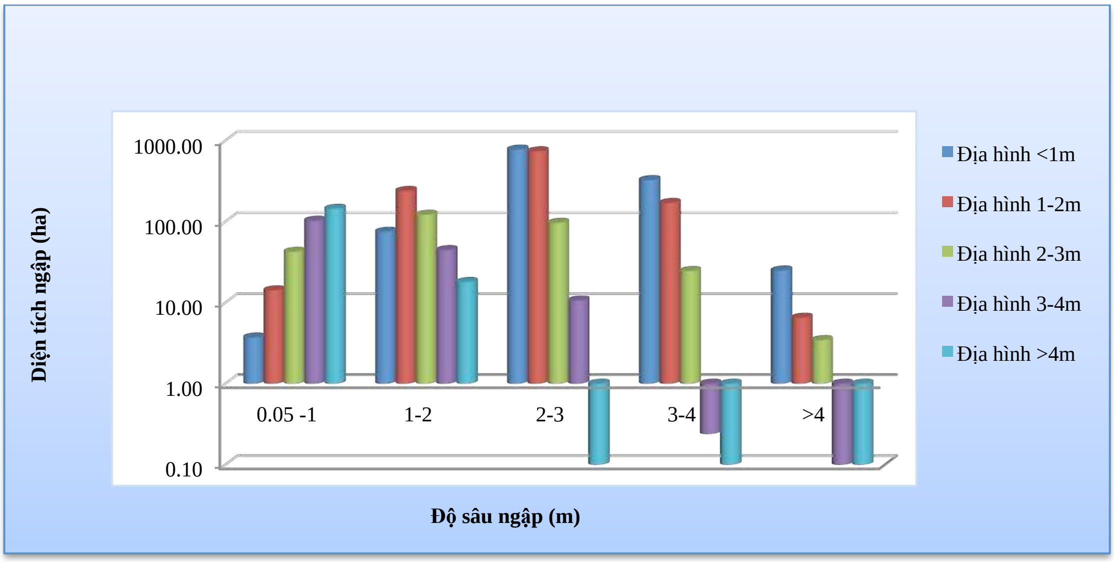


Figure 24. Graph of total area and forecasted flooding level 2020 for different types of terrain



Possibility of permanent inundation by sea level rise if there are no adaptation measures

The scenario of average sea level rise announced in March 2012 predicts that Quang Nam will see sea level rise increases of 8 to 9cm (2020), 12 to 13cm (2030), 25 to 27cm (2050) and 66 to 77cm (2100). The hydraulic model shows rises in sea level of 11.7cm (2020), 30.1 cm (2050) and 73.7cm (2100). To ensure consistency with the flood model calculated above, average data of sea level rise scenario was used in the project (section 3.1.1).

Using ArcGIS software, figure 25 was developed to show a map of the risk of permanent flooding if no adaptation measures are taken. According to this map, total areas flooded are predicted to be 54 hectares (2020), 70 hectares (2050) and 487 hectares (2100). Flooding is predicted to be primarily in the riparian areas and especially in the low-lying areas of Cam Ward Chau and Cam Ha (rice fields).

Figure 25. Risk of permanent flooding if no adaptation measures are taken

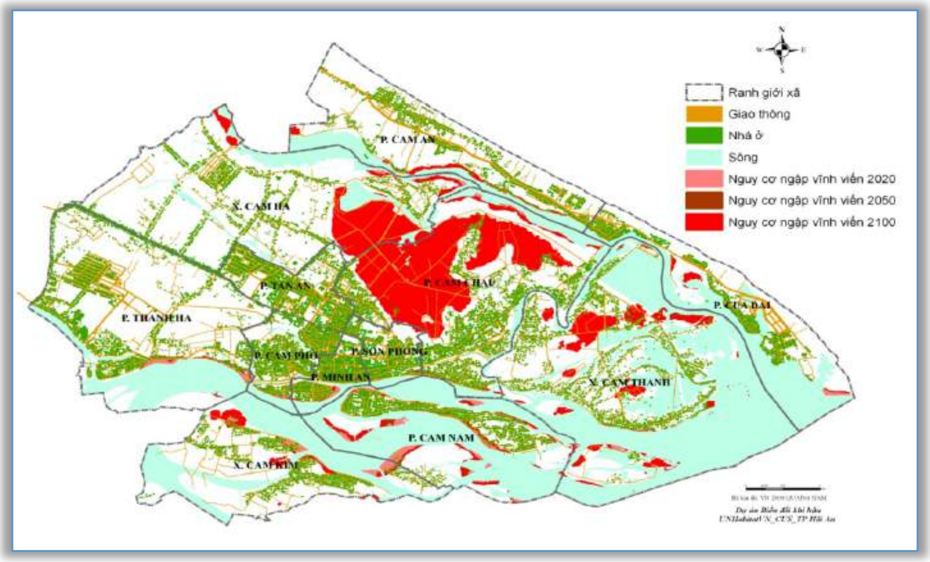


Table 7 represents different types of land that are at risk for permanent flood by sea level rise for various scenarios: 2020. 2050 and2100. If there are no timely response measures, the most flooded areas will focus on agricultural land concentrated in Cam Chau ward and part of Cam An. This is quite concerning because in 2100, the total land area at risk for permanent flooding accounts for nearly 13% of the mainland city of Hoi An (not including water surface area).

Table 7. Area of permanent in dundation of a number of land types

Land type	Area (ha)		
	2020	2050	2100
Unused land	7.72	9.11	16.13
Land of public buildings	0.96	1.20	1.63
Traffic land	2.82	3.50	25.98
Forestry land	7.82	9.45	25.31
Agriculture land	14.19	18.39	311.71
Land of aquaculture	5.78	9.83	49.77
Residential land	13.09	16.68	53.61
Land for business	1.09	1.48	3.23
Total (not including waterface land)	**53.46**	**69.64**	**487.38**

Salinity

Salinity situation

The salinity of surface water, soil and groundwater is increasing and affecting plant and animal farming, while decreasing crop production and limiting water supply.

Surface water salinity

Salinity in Thu Bon River basin is affected by river flow and tidal regime of the Cua Dai sea. Tides push salt water in land, and if the discharge of upstream water is not large enough to push back the saltwater, the salinity area widens and salinity levels increase. April, July and August are the months when the possibility of salinity in the rivers is largest. In one month, there are two tidal periods, thus there two cycles of salinity. For areas located near the sea, the salinity difference between estuaries is not large. However, the more upstream the areas are, the larger the salinity difference is. There are occurrences where the surface layer is completely fresh, but very salty at the river-bottom.

Thu Bon river- Hoi An

- Water level corresponding to the average flow: +0.76;

- Average flood water level: +2.48;
- Water level in dry season: +0.19;
- Average tidal amplitude of 0.6 m, max tide = 1.4m;mintidal =0.00m;
- Salinity is always greater at the tidal peak than at the tidal foot and increases from March to July, beginning to decline in late August, with highest salinity in late June and late July.

According to monitoring data from past years, salinity has decreased from down stream to up stream: 8 to10 km from Cua Dai, salinity decreases faster, and15km away, salinity is almost zero. Note that the length of the river through the city of Hoi An is only8.5km, which means that water in Thu Bon River in Hoi An is saline.

Co Co River

There is no up stream flow in the Co Co River, hence water is usually saline. From the Phuoc Trach Bridge upstream, salinity decreases slowly and between the tidal peak and tidal foot, fluctuations of the water layers are not large. The results collected show that saline intrusion of 2 to 4 per cent has reached the foot of the De Vong dam at hamlet No 2B of Cam Ha village. At the Phuoc Trach Bridge and Ttra Que, the salinity can reach 20 to 25 per cent in April and 10 to 15 per cent in October.

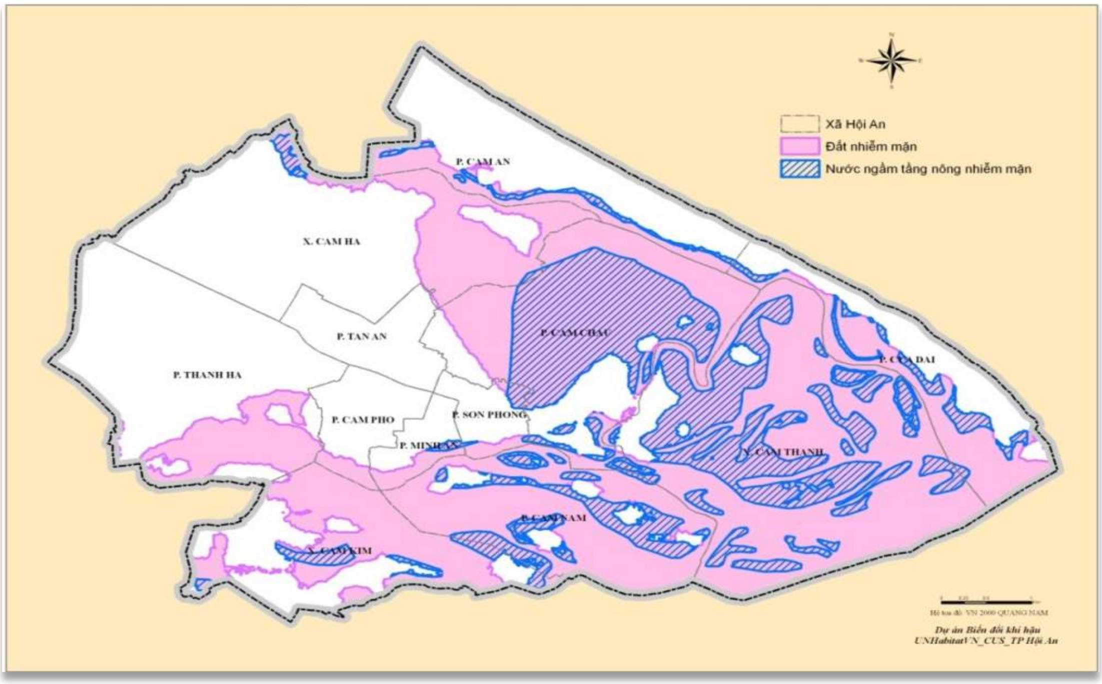
Groundwater salinity: A no pressure aquifer is located along the beach and in the downtown and old town area of Hoi An. The river has been contaminated by saltwater intrusion and the loss of water has impacted urban residents and affected crop growth. There are two pressure aquifers, the first (distributed into the ranges below the weak water barrier along the major rivers) has not been contaminated by salt water but is still at risk for salinity. The second aquifer is distributed throughout Hoi An and is less likely to be contaminated with salt water. Studies on ground water salinity in Hoi An are not available, but are needed to assess determine solutions to protect water resources and ensure urban water supply.

Soil salinity: The low-lying are as along rivers and along the coast are constantly being contaminated with salt water, which is turning soil alkaline and saline. Tidal intrusion area has increased, causing the loss of rice cultivated area and crops (in the absence of dike systems). Currently, most of the rice cultivation are as of Hoi An and crops are protected using systems of saline prevention dikes.

Forecast of salinity

As mentioned, all surface water in Hoi An has been contaminated by salt water; however the two pressured aquifers are currently not affected. This report focuses only on the prediction of soil salinity and non-pressured aquifer salinity. To simulate the risk of saltwater intrusion in Hoi An, the consultant group used digital terrain elevation models combined with the highest tide levels among the sea level rise scenarios in Quang Nam. The result of the forecast scenario for 2020 showed highest rising tides of 1.55 metres. Figure 26 shows the area is likely to become inundated if no preventive measures are implemented.

Figure 26. Soil and non- pressured aquifer which is not saline (2020)

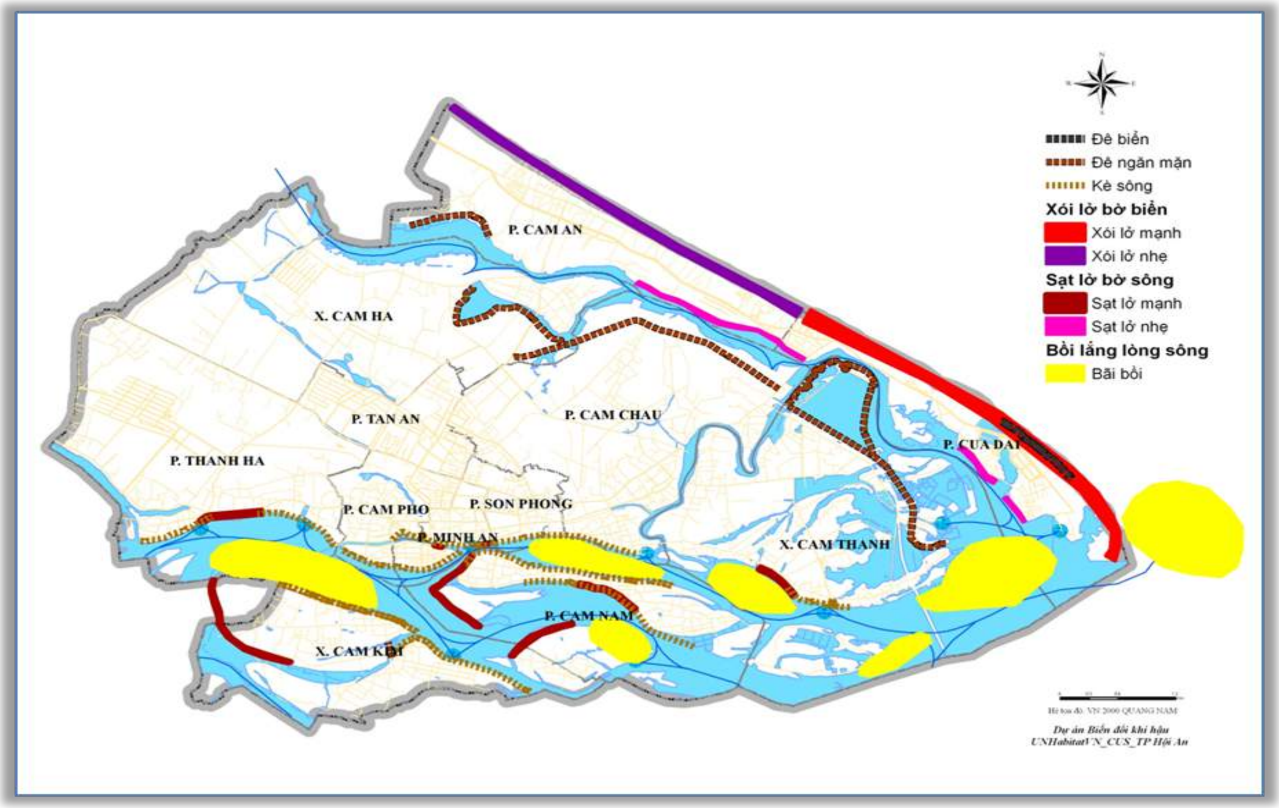


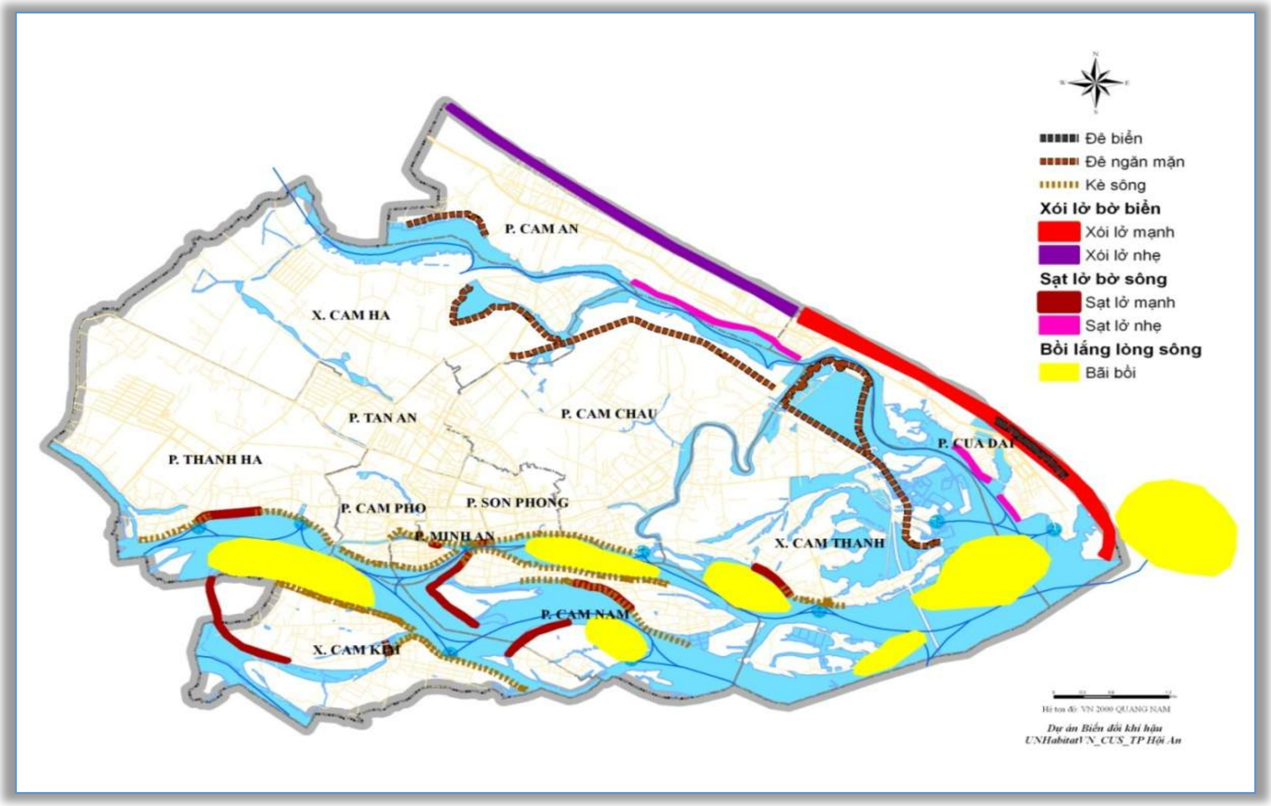
Coastal erosion

Urban coastal areas of Hoi An

Coastal erosion is also a severe problem in Hoi An, with many areas being affected by it. This has been especially apparent in the Cua Dai ward area, where the village of Phuoc Trach was lost to erosion. Another example of coastal erosion can be found in the bank of the Thu Bon river estuary. The erosion at the bank is further exacerbated by high waves and severe storms. The loss of pine forests along the coastline, which acted as barriers to storms and waves, has also aggravated the problem. In the most seriously affected areas of Cua Dai, between 10 and 20 metres of land on the shoreline are eroded every year. Cam An has an average erosion rate of 0 to 2metres per year.

Figures27. Status of coastal erosion and sedimentation

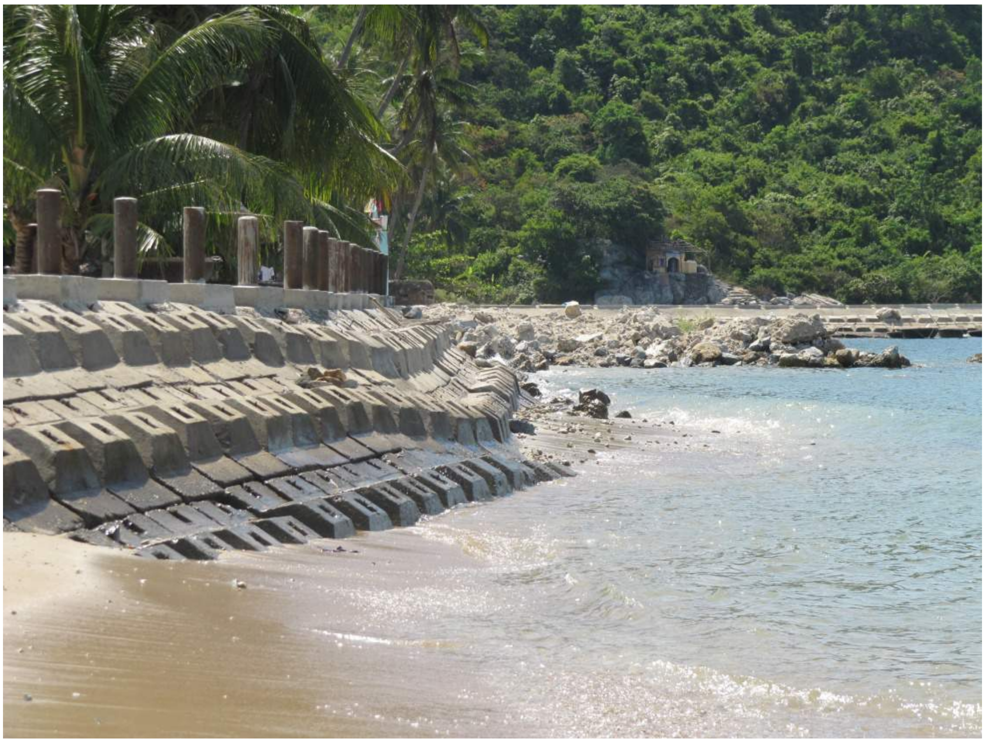




Area along Cu Lao Cham coastal line

Coastal erosion in Cu Lao Chamis quite significant along the coastal beaches. Erosion intensity varies and depends on terrain conditions, geomorphology, geology, the direction of the beach, etc. The figures below show an example of beach erosion in Bai Huong, an area that has been severely affected by erosion caused by waves and wind storms.

Figures 28. Embankment along the coastal line of Cu Lao Cham.



Embankment along the coastal line of Cu Lao Cham.
Author: Nguyen Thi Khang, Cu Lao Cham, September 2012

Climate change scenarios for Viet Nam show that rising sea levels in the central region are projected to reach 12cm, 30cm and 75cm in 2020, 2050 and 2100 (compared to1980 to 2000). This will be in conjunction with the evolution of extreme and unusual weather, hence the process of coastal erosion in Hoi An and Cu Lao Cham is likely to increase with more intensity.

Riverbank erosion

Like coastal erosion, riverbank erosion is also an issue of concern around Hoi An. Serious landslides have occurred along the Thu Bon river in the Thanh Ha, Cam Nam wards, Cam Kim and Cam Thanh communes, and along the De Vong River in the Cam An and Cua Dai wards. Although the rainy season in Hoi An is short, around 80 per cent of the total water volume passing through the rivers occurs from September to December. Hence, there is a significantly different amount of water passing through the rivers (main driver of riverbank erosion) depending on the season.

In addition to riverbank erosion, there is also the occurrence of river sand mining within the city. River sand mining has led to the destabilization of the riverbanks. The banks of the Thu Bon and De Vong rivers have a loose sediment composition, which means that they are more prone to erosion through increased water flow and human activity.

The geological structure of river-banks and the islands near Thu Bon river estuary is of mostly new sediment material, which is less cohesive and more sensitive to the effects of water and other human impacts. Landslides that occur during floods, when river flow is high, destroy river banks. Landslides that occur after major floods result in lower river water levels and underground water discharged from the riverbank causing landslides. Tidal conditions with large amplitude during the dry season also create effects of "uploading" in the river, causing the loss of riverbanks.

Riverbank erosion has led to loss of large areas of agricultural land and has affected the houses of urban residents living along the river and coastal areas. In these areas, there is more fluctuation in flows, riverbeds and the shoreline. There have been many studies on changes in estuarine, coastal and river fluctuations for the Thu Bon river of Hoi An area, however more specific research (including monitoring and forecast) on stable riverbed and riverbank in Hoi An area as the basis for response measures to protect river banks from erosion is required.

Climate change with sea level rise increases the amplitude of tidal estuaries and rainfall increases the upstream flow velocity and energy in the river, causing a severe riverbank erosion process in Hoi An.

Typhoons

Storms in Hoi An usually occur during the rainy season, between September and December. They are normally comprised of strong winds and heavy rain, and can also cause storm surges. This means that storms can cause damage as a result of high winds, local landslips and flash and coastal flooding. According to measurements recorded in nearby Danang, Hoi An experiences almost 25 per cent of storms that make landfall in Viet Nam. The most severe storms usually occur in years that have abnormally high rainfall – in excess of over 2,400 mm per year. During storms, wind speeds can reach 110 kilometres per hour, with unpredictable changes in direction, causing damage to buildings, including the culturally and economically important historic buildings found throughout the city. During such storms, wave height can be up to 3 metres above average sea-level, causing erosion and damage to natural banks and flood defences in the Cam An and Cua Dai wards.

In recent years, several storms have damaged property and injured people in Hoi An. Examples of such storms are Hurricane Xangsane in 2006, and Tropical Storm Lekima in 2007, which led to two separate flood peaks, leaving three quarters of the city’s land area flooded. Impacts included severely damaged crops, which negatively impacted trade and the flooding also caused widespread damage to buildings. Typhoon Ketsana in 2009 caused similar damage, while in 2011, a severe storm combined with water discharge from the Song Tranh hydro-electric plant, upstream on the Thu Bon river, to cause serious flooding.

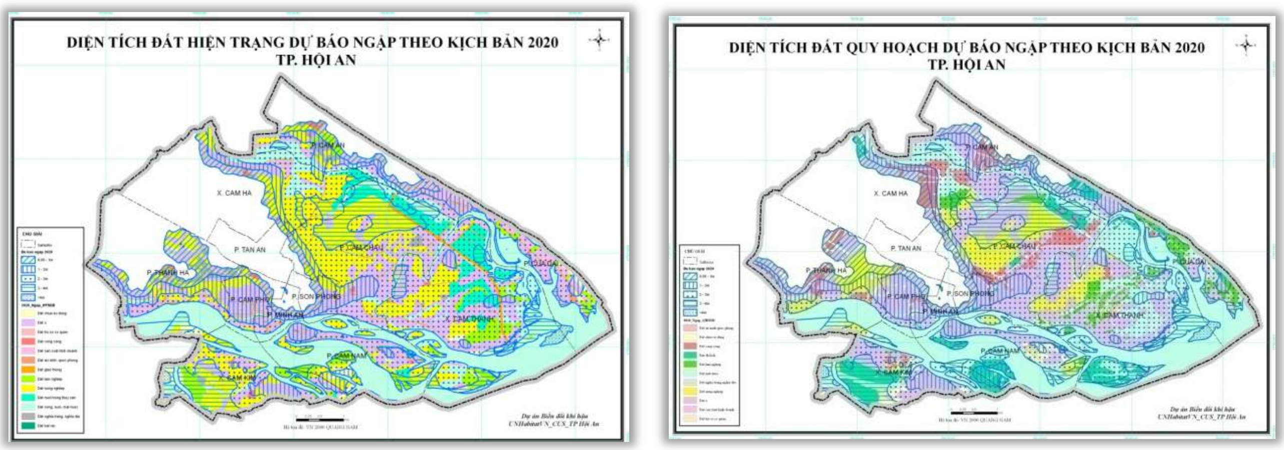
Other climate agents such as thunderstorms, lightning storms and fog occur in the Hoi An area, but the intensity, scale and impacts are relatively lower than the above agents. Hence, the latter will not be assessed further in this report

4. DISASTER IMPACT ASSESSMENT

Impacts of floods

Flood impacts on land-use types.

Figures29. Huo Map of flood forecast for Hoi An with climate change scenario by 2020



The following scale is used to assess the vulnerability of flood hazards on land use based on the percentage of land area that has been flooded: over 75 per cent of the area flooded - four points; 50 to 75 per cent of the area flooded - three points; 25 to 50 per cent of the area flooded: two points; below 25 per cent of the area flooded - one point. Sensitivity to different types of land use was evaluated according to a depth ratio of flooded area over 2metres. The above principles were used in an assessment of the impacts of flood hazards, which is further discussed in section five of this report.

Flood impacts on housing

There is significant probability for housing to be negatively affected in Hoi An, seeing as over 50 per cent of houses in the city are classified as semi-permanent. Semi-permanent housing is significantly more sensitive to the effects of flooding, storms and sea-level rise. Erosion has already caused damaged to housing in the coastal area; the entire village of Phuoc Trach was relocated due to erosion affecting nearly 200 households. Within the next 3 to 5 years, it can be expected that around 55 houses in the area will be seriously impacted by erosion if no adaptation actions are taken. Increasing the permanent housing rate in Hoi An will significantly reduce the impacts of flood hazards on residential and construction infrastructure.

Figure 30.Types of building, exposure and sensitivity.

Types of buildings		Exposure	Sensitivity	Weight
Housing	Permanent and semi-permanent houses	Grading scale of flooding from 1 – 4 based on the percentage of houses and buildings being inundated with the depth of more than 1 m: More than 75% of housing being inundated: –4 ; 50 – 75%: 3; 25 – 50%: 2; less than 25%: 1	Grading scale from 1 – 4 based on the percentage ofhouses and buildings being inundated with the depth of more than 3m	0.15
	Temporary houses		Grading scale from 1 – 4 based on the percentage of houses and buildings being inundated with the depth of more than 2 m	0.3
Other types of buildings	Historical relics and ancient buildings		Grading scale from 1 – 4 based on the percentage of houses and buildings being inundated with the depth of more than 2m	0.5
	Other types of buildings		Grading scale from 1 – 4 based on the percentage of houses and buildings being inundated with the depth of more than 3m	0.05

Impact of flooding on the transportation system of Hoi An

Every year, the transportation infrastructure of the city is severely affected due to flooding, resulting in damage in the billions of VND. Damage can arise from erosion, flaking, broken pavement, etc. This then results in pressure on city construction and maintenance and most significantly on the road network. Figures 30 and 31 show maps of flooding impact on transportation under flooding scenarios for 2020 and 2050. Planning for the development of infrastructure for 2030 will be designed using flood scenarios estimated for 2050. The impacts of flooding to transportation infrastructure are a precondition for an assessment of adaptability and vulnerability.

Figure 31. Map of flooding impact on transportation under the flooding scenario by 2020

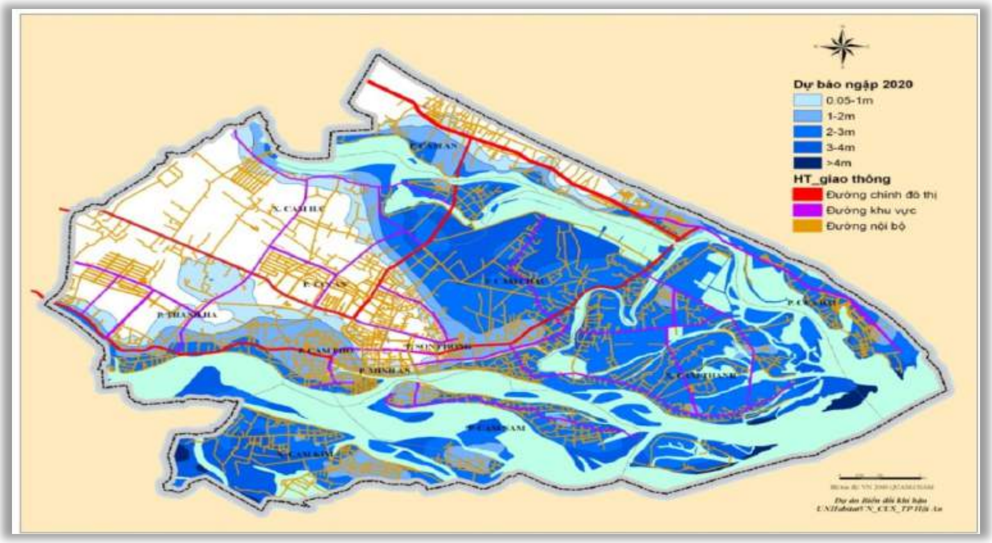
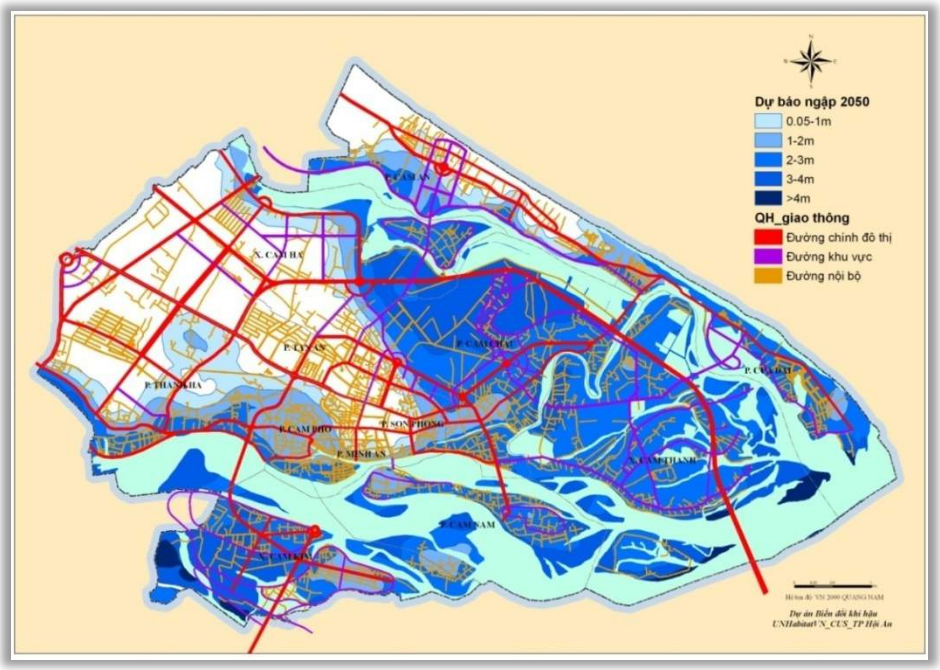


Figure 32. Map of flooding impact on transportation under the flooding scenario by 2050



The following scale was used to assess the vulnerability of flooding catastrophes on transport: over 75 per cent of area flooded - four points; 50 to 75 per cent of area flooded - three points; 25 to 50 per cent of area flooded -two points and below 25 per cent of area flooded - one point.

To assess the effects of floods on the road system, it was necessary to evaluate the impacts on transportation function, internal circulation as well as transportation between other provinces, regions and neighborhoods of the city. An evaluation was made based on the rate of flooding for every road (main road, regional and local) in the wards for different levels of flooding. The evaluation of the flooding rate shows the impact of flooding on roads in each ward and commune that meet the needs of transportation. Note that the assessment of flooding impact on the quality of roads is very complex and should be studied in more detail in the monograph.

Transportation needs were evaluated using the following flood depths: 0.05 to 1 meter, 1 to 2metres, 2 to 3metres and over 4metres. This report assumes that roads with flooding greater than one meter will not be able to be used for circulation.

Table 8. Assessment of the impact of flood disasters on the Transport system of Hoi An

Area	Impact of flooding on road system under scenario 2020	Impact of flooding on road system under scenario 2050
Cẩm Nam	Very strong 1	Very strong 1
Cẩm Thanh	Very strong 1	Very strong 1
Cửa Đại	Very strong 1	Very strong 1
Cẩm Kim	Very strong 1	Very strong 1
Cẩm Châu	Very strong 1	Very strong 1
Cẩm Phô	Strong 0.75	Strong 0.75
Cẩm An	Very strong 1	Strong 0.75
Minh An	Average 0.5	Average 0.5
Sơn Phong	Average 0.5	Average 0.5
Thanh Hà	Average 0.5	Average 0.5
Cẩm Hà	Average 0.5	Average 0.5
Tân An	weak 0.25	weak 0.25

Table 8 summarizes the assessment of the impact of flood disasters on the Transport system of Hoi An, where main roads, regional roads and internal roads were assessed under two scenarios: 2020 and 2050. Key takeaways include:

- The following communes are greatly affected, having an inundated area of more than 1 meter for each road and a total coverage greater than 75 per cent: Cam Nam, Cam Chau, Cua Dai, Cam Thanh, Cam Kim and Cam An;

- The following communes are moderately affected, having an inundated area of more than 1 meter for each road and a total coverage greater than 50 to 75 per cent: Cam Pho ward;
- The following communes are also affected, having an inundated area of more than 1 meter for each road and a total coverage greater than 25 to 50 per cent: Son Phong, Ming An, Thanh Ha and Cam Ha wards;
- The following communes are mildly affected, having an inundated area of more than 1 meter for each road and a total coverage of less than 25 per cent - Tan An ward.

Figure 33. Rate of flooding or roads to communes- 2020

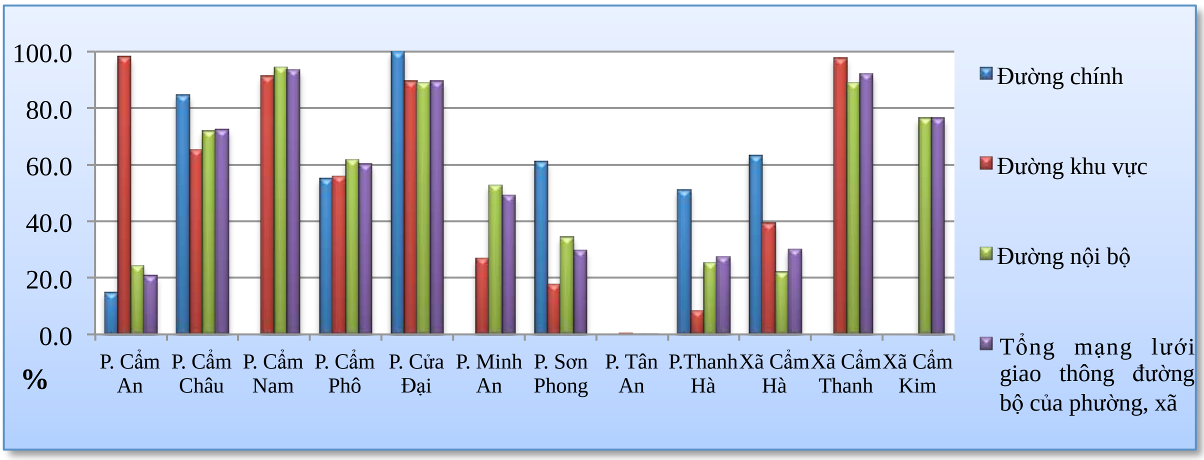
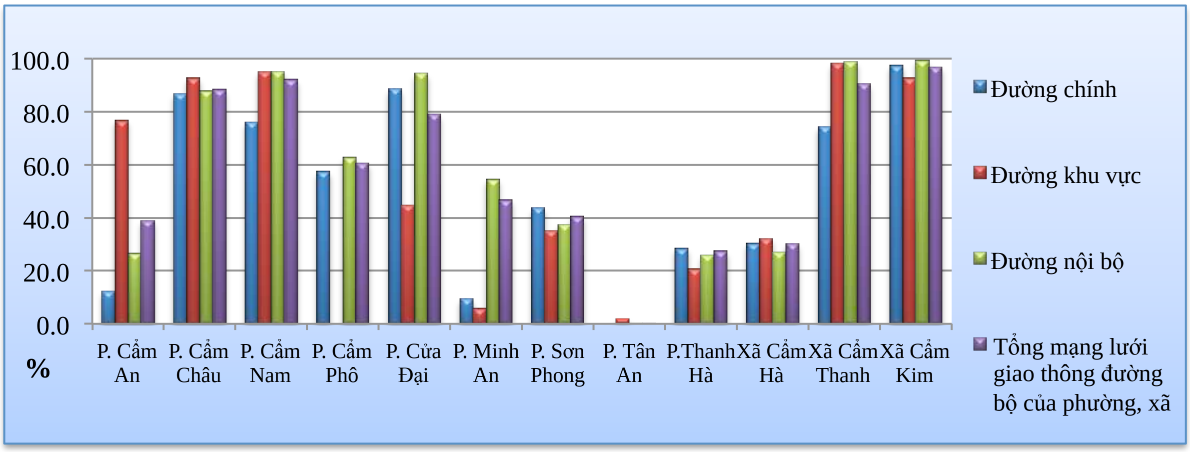


Figure 34. Rate of flooding on roads to communes- 2050

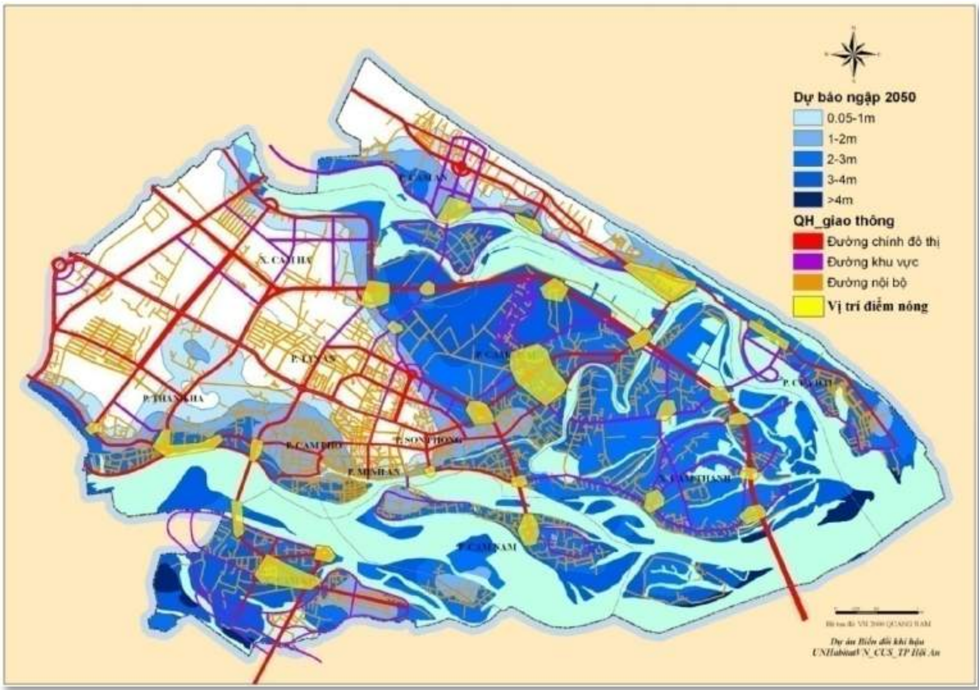


An assessment of the impact of flood disasters on the Transport system of Hoi An is further detailed in section five.

Hot spots

Figure 35 shows the location of hot spots in the road system under a flooding scenario of 2050. Road hot spots are identified based on their strategic importance in the transportation network and based on the flood depths under flooding scenarios 2020 and 2050. Hence, the locations of hot spots are often found to be at intersections or junction location and between main roads.

Figure 35. Location of hot spots of road system under flooding scenario in 2050



Impacts of climate change on water supply capacity of the city of Hoi An

Currently, there are a large number of residents using self-dug wells, particularly in the residential areas of Cam Thanh and Cam Kim and in some areas of Cam Chau and Cua Dai. This is the result of the pipeline not being available and also occurs when the water capacity does not meet the water demand of the people. This central area is low, with an average elevation between 0.5 to 1.7 metres, and is frequently subject to flooding between two to four metres. Moreover, the well mouths have a low elevation and are hence affected by flooding, which impacts water quality. In order to meet water demands, households must often purchase water containers, which they then transport to their areas. Overall, access to clean water of good quality in these areas is extremely difficult to come by.

The assessment of impact or sensitivity to flooding disasters on the water supply network is evaluated based on the access to clean water when households are flooded and the distribution level of the city's water system during floods.

Scores calculated for the impact or sensitivity of the water supply network are based on the proportion of people having access to clean water in each commune/ward:

- Very strong= four,
- Strong= three,
- Moderate = two;

- Weak=one.

Note that the capacity to supply water has a weight of 0.4 and the distribution of the water supply network has a weight of0.6.

The Tan An, Cam Pho, Minh An and Son Phong water supply network (variety of level I and level II) overlap with each other. The water supply pipeline is buried underground and is not affected by climate change and related climate impacts such as flooding, salinity, drought, etc. The water supply network is rate one (weak).

The water supply networks of Thanh Ha, Cam Ha and Cam Nam are limited. However, there is a planned expansion of the water supply network. In the Cua Dai and Cam An wards, the network of water supply pipelines is quite complete and can serve the needs for clean water of the urban population clusters in the region. The water supply network is rate two (moderate).

The Cam Kim, Cam Chau, Cam Thanh areas have few or no water supply pipelines. The households in this area use wells or purchase water from other areas at high cost. In addition, this area is low and the terrain is frequently flooded, affecting the water supply. Hence, there is a lack of clean water and access to clean water is very low. The rating is three (strong) and four (very strong).

Table 9. Impact of disaster on water supply in Hoi An

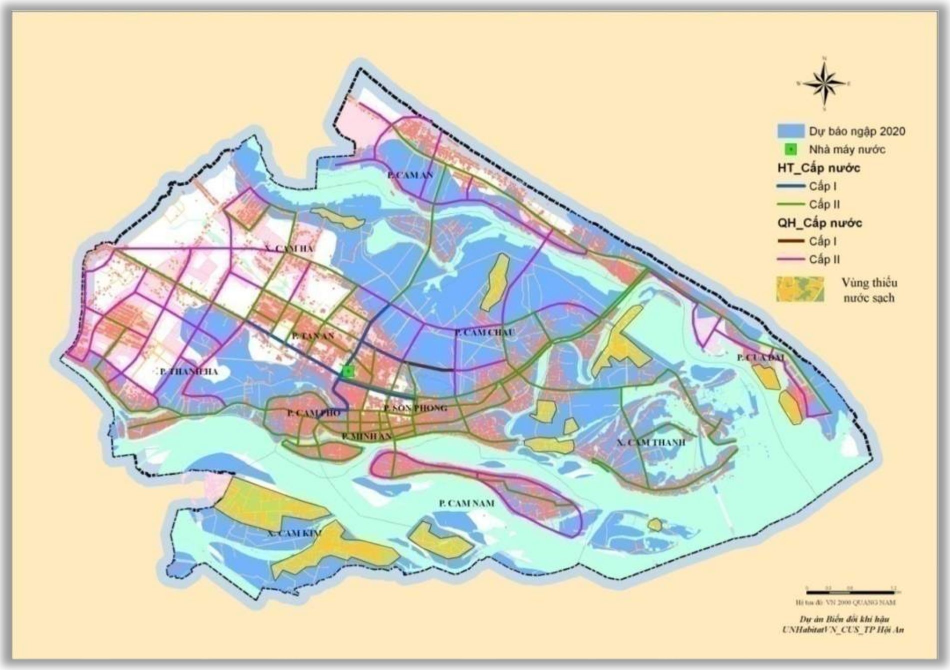
	Impact of flood		Impact of salinity	
	Status	Planning	Status	Planning
Water resource use	0.5	0.25	0.5	0.25
Water supply pipeline network				
Tân An, Cẩm Phô, Minh An, Sơn Phong	0.25	0.25	0.25	0.25
Cửa Đại và Cẩm An	0.5	0.25	0.5	0.25
Thanh Hà, Cẩm Hà, Cẩm Nam,	0.5	0.25	0.5	0.25
Cẩm Thanh, Cẩm Chau	0.75	0.5	0.75	0.5
Cẩm Kim	1	1	1	1

There is insufficient data to accurately assess the impact in Tan Hiep island. Calculations for the entire city can be found in chapter five.

Hot spots of the water supply system

Figure 37shows the location of hot spots of the water supply system, meaning areas with high population that do not have residential pipeline networks installed. These areas are affected by severe flooding, making access to clean water very difficult. The map identifies the network of water supply pipelines, the distribution of houses, residential areas and inundation locations with estimated time lines in 2020.

Figure 36. Location of hotspots of water supply network in Hoi An



Impacts of climate change on drainage of the city of Hoi An

The following criteria are used to assess the impact of flood disasters and the impact of climate change on water systems: local drainage capacity and extensive drainage capacity. Local drainage capacity is the ability to collect and drain wastewater and rain from the wards and communes and is evaluated based on the current state of drainage networks in the region. Extensive drainage capability is identified as the extensive water drainage capacity of the city when the whole basin cannot be drained during a flood.

Local drainage capability: Areas with underground or sealed sewer lines do not affect the quality of the pipes during flooding. Moreover, wastewater collection does not affect the surrounding environment, thus should be rated high. Areas with open drainage are rated average. The area has no sewer system of concrete drainage.

Extensive drainage capability: This is evaluated based on the occurrence of deeply and widely flooded areas caused by rain from the upstream broad-based model of the city. The area which is not flooded is evaluated as high. Areas with flooding of zero to two metres or less are rated average. Areas that have more than two metres of flooding are rated as low.

Table 10. Capacity of the drainage system in each commune

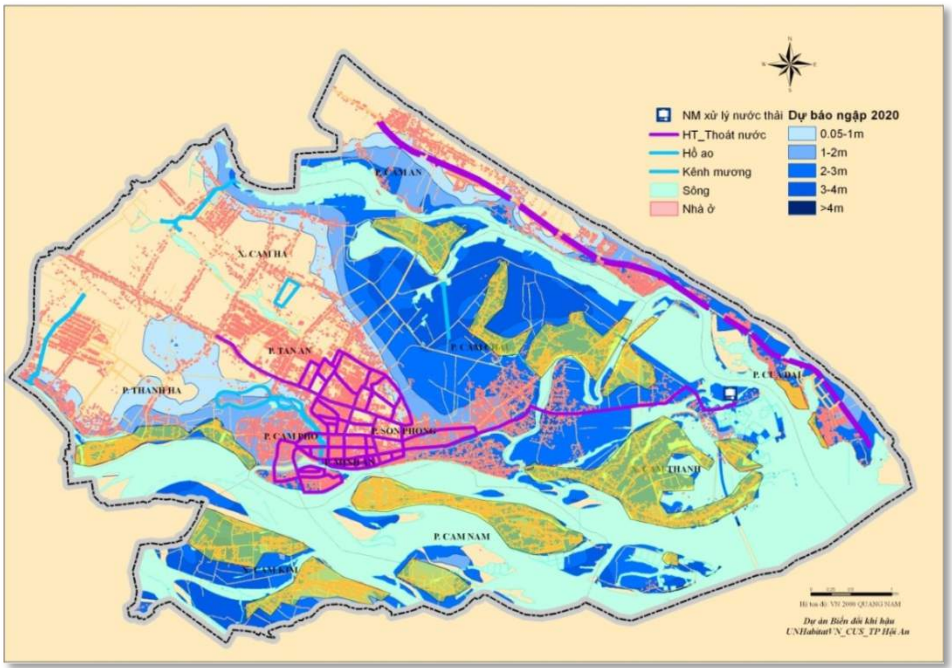
	Local drainage capacity	City wide drainage capacity
Inner city area		
Tân An	Good	Very good
Sơn Phong	Very good	Average
Cẩm Phô	Very good	Average
Minh An	Very good	Weak
Coastal tourism zones		
Cẩm An	Good	Good
Cửa Đại	Good	Weak
Suburban region		
Cẩm Hà	Average	Very good
Thanh hà	Weak	Average
Cẩm Châu	Average	Very weak
Cẩm Thanh	Average	Very weak
Cẩm Kim	Very weak	Very weak
Cẩm Nam	Very weak	Very weak

Hot spots of the drainage system

The following map shows the location of hot spots for drainage system which are the location of the focus are as of population, but no system of sewer lines. At the same time these are the areas affected by severe flooding. Location of hotspots in the drainage system is shown on the basis that the network map of sewer lines, housing distribution maps, residential areas, residential land and projected flood map in 2020.

Figure 38 shows the location drainage system hotspots in Hoi An – locations with no sewer line systems. The map identifies the network of water supply pipelines, the distribution of houses, residential areas and inundation locations with estimated timelines in 2020.

Figure 37. Location map of the hotspots of drainage system in Hoi An



The impact offloodingto the socio-economic conditions

As Hoi An is located in a flooding-prone area and flooding is considered as the most damaging geo-hazard to the people in the region. Flooding disrupts daily life of the habitants and causes damage to crops and assets. Agricultural areas in Cam Kim, Cam Thanh and Cam Nam are the most affected by flooding.

According to Clare Twigger-Ross (2005), the impacts of flooding on households and the community include i) economic impacts; ii) non-economic losses; iii) impacts on physical health; iv) impacts on psychological health; v) impacts associated with evacuation and temporary accommodation; vi) household disruption and; vii) community and neighborhood changes. During community interviews conducted in various Hoi An hot-spots, the focus was on the direct economic impacts of flooding on households and the community, e.g. loss of crops and assets, damage to the house and other assets and the cost of clean-up after flooding. Household disruption is an important aspect of the impact of flooding and it relates also to health, education and employment opportunities compromised by flooding.

Interviews conducted in Cam Kim show that the costs of flooding are quite substantial. It was also noted that the poor and women are most affected by the impacts of flooding. Cam Kim is an island-commune which is isolated from the main city by a river. Using a ferry is the only method of transportation available for linking the commune to the rest of the city. Cam Kim is seriously affected by flooding. Every year, the community experiences on average five to seven floods, lasting from three to five days. In 2009, flood waters remained high for almost 4 weeks, seriously disrupting the daily life of the residents of the commune. Children couldn't go to school because ferries stopped operating due to fears of strong river flows. Essentially, all public services ceased to operate during the flooding time. Loss of income also occurred because many people couldn't go to work because of the transport disruption. Additional impacts of flooding include the risk of epidemics due to environmental contamination and pollution.

In urban areas, flooding seems to have limited impact due to the ability of residents to respond to the risk. Although downtown Hoi An is also affected by flooding, its intensity and duration is much weaker than what is found in lowland rural areas like Cam Kim. In Hoi An, there were reportedly losses of commodities in some shops during the flooding time because the owners of the shops could not evacuate the shop on time. Business disruption also took place during the flooding, resulting in income losses. Damage to historical structures in Hoi An are the biggest cause of concern, especially during flooding and typhoons.

The quantitative assessment of vulnerability, level of impact and level of sensitivity was rated on a scale of one to four:

- Very strong = four;
- Strong = three;
- Moderate = two;
- Weak = one.

Synthesis calculations are further discussed in chapter five- assessment of vulnerability. The following were quantitatively assessed: impact of flooding on the business activities of the commune and economic damage during flooding for all wards or communes with agricultural, industrial or commercial services. Calculation for the whole city is taken on average. Synthesis calculations are presented in chapter 5, section 5.3 - Assessment of vulnerability.

The impact of flooding on ecology

Surface water, groundwater, marine resources, primary forest in Cu Lao Cham and preventive forests (along the coast) are not significantly affected by flooding. Therefore, the report assesses the impact of floods on production forests, rice and crop cultivation and fishery resources (aquaculture). Currently, there is no plan for mineral resource use. Landfills and industrial parks are located in high terrain areas and are therefore not affected by floods, however cemeteries are.

Exposure and sensitivity of these areas to floods were assessed based on intensity of flooding and inundation depth for each area using a scale of one to four as follows:

Table 11. Exposure and sensitivity of the areas to flooding

Affected areas	*Exposure*		*Sensitivity*	
	Scale of flooding	Grade	Inundation depth	Grade
Forest, paddy fields, aquatic resources, Cemeteries	Over 75% of total area of affected groups (forests, rice paddies, aquatic resources, cemeteries) are inundated	4	Over 75% of total area of the affected groups are inundated with more than 3 metres of water (for forests); more than 2metres (for rice fields and aquatic resources); more than 1meter for cemeteries	4

	75 – 50% of total area of affected groups are inundated	3	75 – 50% of total area of the affected groups are inundated with more than 3 metres of water (for forests); more than 2 metres (for rice fields and aquatic resources); more than 1 meter for cemeteries	3
	50 – 25 % of total area of affected groups are inundated	2	50 –25% of total area of the affected groups are inundated with more than 3 metres of water (for forests); more than 2 metres (for rice fields and aquatic resources); more than 1 meter for cemeteries	2
	Less than 25 % of total area of affected groups are inundated	1	Less than 25 % of total area of the affected groups are inundated with more than 3 metres of water (for forests); more than 2 metres (for rice fields and aquatic resources); more than 1 meter for cemeteries	1

Impact of salinity hazards

Scale of salinity

Scale of soil salinity

The forecasts for areas with saline intrusion (2020) are the following:

- Cam Thanh: 634.9 hectares;
- Cam Chau: 262.1 hectares;
- Cam Nam: 239.2 hectares;
- Cua Dai: 164.3 hectares;
- CamKim: 133.2 hectares;
- Cam Ha: 131.6 hectares;
- Thanh Ha: 93.4 hectares;
- Cam An: 78.0 hectares;
- Minh An: 12 hectares;
- Cam Pho: 10.2 hectares;
- Son Phong: 6.4 hectares;
- Cam Chau: 182 hectares;
- Cam Thanh: 60.4 hectares.

Figure 38. Land at risk of becoming saline according to land use plan 2030

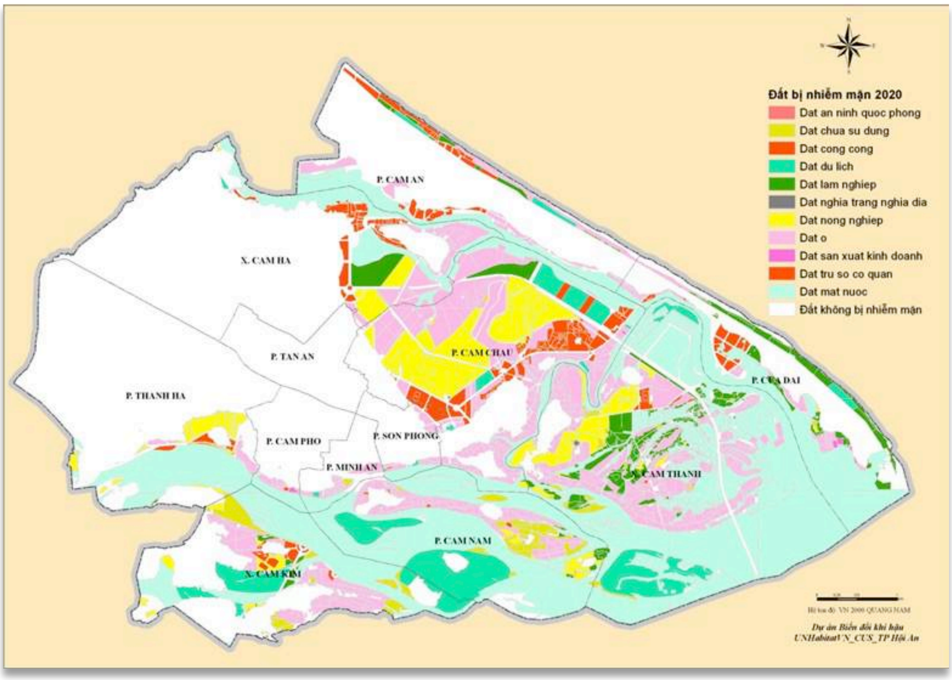
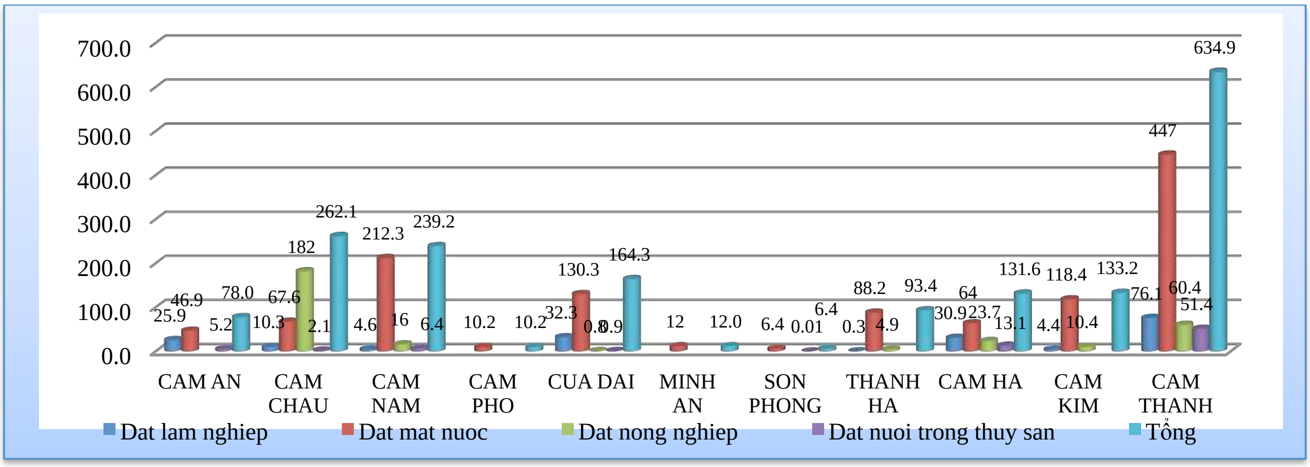
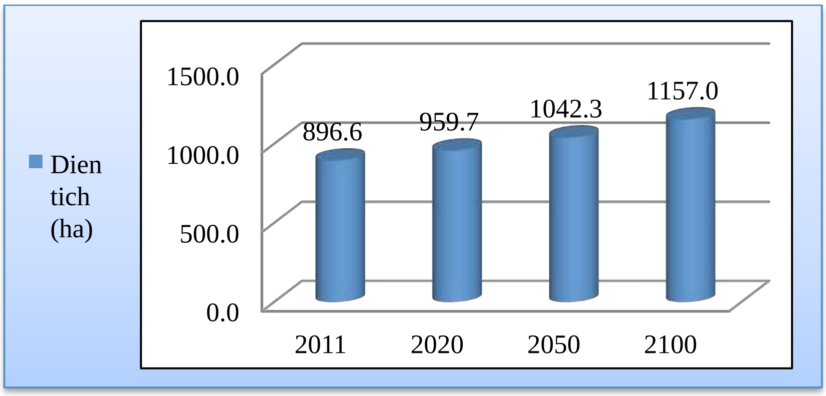


Figure 39. Land area being salinized under the 2030 scenario in 2020 (ha)



Scale of saline groundwater: Shallow groundwater aquifers without pressure aret he source of Hoi An’s water supply. Sea level rise scenarios for 2020, 2050 and 2100 predict that this aquifer is likely to become saline (see figure 41).The communes subject to the highest ground water salinity levels are CamThanh, Cam Chau, Cam Nam and Cam Kim. Salinity will affect the water supply and hence farming.

Figure 40. Areas of saline groundwater in the city of Hoi An scenarios



Scale of surface water salinity: Surface water salinity generally occurs during the dry season (January to August). In the city of Hoi An, the effects are mostly seen in June and July and affect irrigation and aquaculture.

The inhabitants of the Phuoc Hoa block of the Cua Dai ward believe that coastal erosion is the cause for salinity. Between 1975 and 2000, many residents grew poplar trees in order to stop storm surges, to alleviate the impact of strong winds and to reduce salinity. However, with the onset of tourism growth since the year 2000, poplar forests have been reduced in size in order to accommodate tourism infrastructure. The destruction of the trees has resulted in coastal erosion, degraded housing infrastructure and salt water over flows which have made the land saline. Effects include some local residents reporting that salinity has reduced their rice yield by up to 50 per cent.

Impacts of salinity

Soil salinity: Saltwater contamination threatens the agricultural activities of the people in the study area. Salinity has negatively and seriously affected the growth and development of crops and livestock. In An My and Cam Chau, salination turns soil acidic, resulting in decreased areas of production and crop growth. For example, certain areas have seen production drop from 3 crops to 1 or 2 crops per year.

Groundwater salinity: Groundwater salinity is gradually limiting the water supply in the city. The water plant in Hoi An is shut down frequently due to deep salt intrusion into the land. In July and August, the plant did not pump out water from 12h - 24h due to saline intrustion. In areas without clean water pipeline installations, people are required to use wells. However, the water is acidic and therefore needs to be filtered before use. In Phuoc Hoa, where groundwater salinity is severe, people are required to purchase water bottles.

Surface water salinity: Surface water salinity in the city negatively affects irrigation and aquaculture.

Assessment of salinity impacts

Table 12 below describes the vulnerabiliy and sensitivity of objects with salinity range evaluated based on saline area and salinity duration.

Table 12. Vulnerability and sensitivity of the objects with salinity range evaluated by saline (area) and salinity duration

Affected areas	*Exposure*		*Sensitivity*	
	Salinity scale	Grade	Duration of salinity	Grade
Surface water, soil, groundwater, and other forms of land use and urban socio-economic system	More than 75% of total area of affected groups are saline	4	Permanent salinity	4
	75 – 50% of total area of affected groups are saline	3	Salinity more than 6 months/per year	3
	50 – 25 % of total area of affected groups are saline	2	Salinity more than 3 months/per year	2
	Less than 25 % of total area of affected groups are saline	1	Salinity less than 3 months/per year	1

Overall calculations of salinity hazards are presented in chapter 5 - Assessment of vulnerability.

Impacts of other disasters

Urbancoastal areasof Hoi An

Erosion affects the entire coast of Hoi An, from Cam An (4km) to Cua Dai (4km). Coastal erosion is impacting large areas of beaches, amusement parks and threatening stable embankments and roads. This, in turn, affects the local activities such as tourism and livelihoods (mainly in the wards of Cua Dai). Table 13 describes the impacts and significance of erosion in the urban coastal areas of Hoi An.

Table 13. Erosion in urban coastal areas of Hoi An

Affected group	**Scale of impacts**	Significance
Technical infrastructure		
Beaches	Erosion affecting the entire coastal area, from Can An to Cua Dai.	In Cua Dai: Along the 4km coastal line, erosion can affect 10 – 15m of beach area per year. In some areas, erosion has reached the road. In Cam An: destruction speed is slow (0 – 2m/year).
Housing and commercial buildings	Erosion affecting housing and commercial buildings from Cam An to Cua Dai.	In Cua Dai: erosion destroyed the village of Phouc Trach and a row of villas of the Investment Development Joint Stock Company resort. Currently there are only 55 villas, housing and hotels that have not yet been affected by erosion. However, if there is no measure to protect the coastal line, the consequences will be serious in the next 3-5 years. In Cam An: about 23 houses and commercial buildings have been affected by erosion.
Road, embankments	In Cua Dai: Erosion directly impacts the road and embankment (about 100m). In Cam An: Erosion may affect traffic.	In Cua Dai. The road to the sea (100m) is being threatened. It has been reinforced, but is showing signs of deterioration. In Cam An: About 260 m of road in the planning area is at risk of being affected.
Socio-economic infrastructure		
Tourism	In Cua Dai: Erosion can affect the volume of tourists visiting, due to loss of beach area, loss of homes and hotel. In Cam An: little erosion effects on tourism.	In Cua Dai: Erosion is threatening tourism. In Cam An: No consequences.
Service activities	At Cua Dai: Erosion can affect livelihoods related to tourism. In Cam An: Erosion may affect livelihoods.	In Cua Dai: loss of beach resulting in damage to the livelihoods of the residents. In Cam An: No consequences.
Mineral resources		
Imenit mine	At Cua Dai: erosion has a direct impact on the Ilmenite mine minerals.	Erosion has destroyed a mine.
Hotspot	Cua Dai beach	

The impacts of coastal erosion hazardson roads, embankments, beach services, forest resources (forests) along the coast were evaluated according to scope (the ratio of affected coastline) and the percentage area of beach erosion:

Table 14. Impacts of coastal erosion hazards

Affected group	***Exposure***		***Sensitivity***	
	Length of coastal areas facing risk of erosion	Grade	Percentage of coastal areas being destroyed	Grade
Road, embankment, beaches, flood prevention forest	More than 75% of coastal line facing risk of erosion	4	More than 25% of coastal areas being destroyed	4
	75 – 50% of coastal line facing risk of erosion	3	10- 25% of coastal areas being destroyed	3
	50 – 25% of coastal line facing risk of erosion	2	5 - 10% of coastal areas being destroyed	2
	Less than 25% of coastal line facing risk of erosion	1	Less than 5% of coastal areas being destroyed	1

The impacts of coastal erosion on mineral resources were evaluated based on the scope (number of affected mineral deposits) and the area (%) of the eroded mine:

Table 15. Impacts of coastal erosion on mineral resources

	Exposure		***Sensitivity***	
	Number of mines being affected	Grade	Percentage of mining area being eroded	Grade
Mines	3 mines	4	More than 75% mining area being destroyed	4
	2 mines	3	75 - 50% mining area being destroyed	3
	1 mine	2	50 - 25% mining area being destroyed	2
			Less than 25 % mining area being destroyed	1

The integrated impact assessment of coastal erosion hazards to the city is summarized in chapter five - Assessment of vulnerability.

Impacts of riverbank erosion

Table 16 summarizes the impacts of riverbank erosion: effects of landslides on agricultural land, infrastructure (roads), and property, including offices and homes of urban residents of Hoi An along the 21kmThu Bon river basin and the 16 km De Vong river basin.

Table 16. Impacts of riverbank erosion

Affected group	**Scale of impacts**	Significance
Technical infrastructure		
Housing along river	Erosion can affect housing along the river	Thu Bon riverbank: landslide are likely to cause very serious consequences for about 95 houses on the river bank (no embankment). -Thanh Ha: 47; Cam Thanh: 17; Cam Nam: 26; Cam Kim: 1; Minh An 4th house (An Hoi). De Vong Riverbank: landslides can cause serious consequences to 590 houses and structures on the riverbanks: Cua Dai - 433; Cam An – 157.
Road along river	Erosion can affect roads along the river	Thu Bon riverbank: landslides are likely to cause very serious consequences for the 1.7 km road by the riverbank (no embankment): Thanh Ha - 0.6 main urban roads; Cam Nam - 0.1 km local transport system; Cam Kim- local transport system - 1km. De Vong Riverbank: landslides are likely to cause consequences, but not serious ones for the 0.4 km area of Cua Dai. Roads by the riverbank are at risk of landslides (no embankment). In Cam An Ward, about 1.3km main urban roads also are at risk but not severely.
Hotspots	Thanh Hà, Cam Kim, Cam Nam (wards/communes along Thu Bon river)	

The exposure and sensitivity of natural resources to river bank erosion are assessed based on the percentage of river banks at risk of erosion and the speed of bank destruction every year (number of points being destroyed):

Table 17. Exposure and sensitivity to riverbank erosion

Affected groups	*Exposure*		*Sensitivity*	
	Percentage of riverbank length at risk of erosion	Grade	Points affected by erosion annually	Grade
Paddy fields-crops	More than 75%	4	More than 10 points	4
	75 – 50%	3	10 – 5	3
	50 – 25%	2	5 – 2	2
	Less than 25%	1	Less than 2	1

An integrated impact assessment of coastal erosion hazards is summarized in chapter five- Assessment of vulnerability.

Impacts of typhoons

Storms bring about heavy wind, rain and waves of large magnitude. Waves have the potential to destroy the coastline and strong winds can cause major damage to houses (destroying roofs), urban infrastructure (damaging trees, power lines etc.), forestry resources, crops etc. Fishing can also be disrupted along the coastal wards of Cam An, Cua Dai and Cham Island. Table 18 below lists the scale and significance of the impacts of typhoons.

Table 18. Impacts of typhoons

Affected group	**Scale of impacts**	Significance
Technical infrastructure		
Roads, embankment and dikes along the coast	Storms can affect erosion along the entire coast; impact on sea embankments and roads along the sea.	Most serious impact to Cua Dai ward: beach close to the roads andunstable embankment.
Housing, construction, power grids, communication grid s	Storms can affect housing and other construction works, power grids and communications across the city.	Most serious impacts in Cua Dai, Cam An and Cu Lao Chamwards.
Natural Resources and the Environment		
Forests, paddy fields, crops	Storms can affect forest, rice crops across the city.	Most serious impacts inCua Dai, Cam An and Cu Lao Chamwards.
Socio-economic infrastructure		
Fishing	Storms can affect fishing.	Most serious impacts are to

	fishermen in Cua Dai, Cam An and Cu Lao Chamwards.

The vulnerability and sensitivity of the targets affected by hurricanes are based on affected range (urban area ratio) and the level of destruction caused by storms. The radius of a storm can be as small as tens of kilometres to as large as several hundred kilometres. Thus, an entire city and more can be affected by a storm. The degree of storm damage (sensitivity) depends on the level of wind and its frequency:

Table 19.Degree of storm damage

Affected group	*Exposure*		*Sensitivity*	
	Scale of impact from storm	Grade	Wind speed and frequency.	Grade
Housing, construction works, power and telecommunication cables,; Forest, rice fields and crops,; Fishing activities, aquaculture.	City wide	4	Higher than level 13 (40m/s); with frequency more than 25%	4
		4	From level 11 to 13 (30-40m/s); tần with frequency more than25%	3
		4	From level 8 to level 11 (20-30m/s); with frequency more than25%	2
		4	Lower than level 8 (20m/s); with frequency more thantrên 25%	1

The quantitative evaluation results for the city of Hoi An based on statistics for the past fifty years is presented in chapter five- Assessment of Vulnerability .

Resonant impacts of disasters

Hazards can cause severe impacts in isolation, however exposure and sensitivity is often greatest when a city experiences multiple or cumulative impacts of hazards. To demonstrate this, the assessment team prepared a table of accumulated impacts of hazards (Table 20)in order to reveal which hazards are likely to accumulate impacts, and where certain hazards can mitigate one another's impact.

Table 20. Impacts of disasters

	Storm	Flood	Salinity	Coastal erosion	Bank erosion
Storm		+	x	X	x
Flood	+		-	X	+
Salinity	X	-		X	x
Coastal erosion	+	x	x		x
Bank erosion	x	x	x	X	

Notes:

+: Hazards whose combination can increase the significance/intensity of impacts

X: Hazards that have no or little influence on each other

- : Hazards that can decrease the impacts on each other

The presence of large storms often leads to flooding disasters. The resonance of two natural disasters, storms and floods, can have citywide impacts, causing dual consequences. The latter can be particularly grave when there are "storms - flooding due to storm - flood inundation from upstream large flock" during surge time. Typhoons accompanied by rising sea levels, strong winds and large waves have the ability to destroy the coast. The resonance of the two disasters, storms and coastal erosion, can cause significant damage to urban areas. Floods with powerful water flows can exacerbate the scale and intensity of riverbank losses. However, they do have the ability to mitigate the effects of salinity.

A quantitative assessment of the impacts of dual resonance to urban disasters is very complex, thus requires further research. For example, flooding and salinity can reduce each other's impacts, while flooding and riverbank loss have little impact on each other. A review of resonance effects can be found in chapter five (impact of flooding and storms and storms and coastal erosion).

5. COMPREHENSIVE ADAPTIVE CAPACITY OF HOI AN

Overall adaptive capacity of Hoi An City

Implemented projects and programs in Hoi An to build adaptive capacity to climate change and natural disaster prevention

Several research projects and implementations related to coping with climate change and natural disaster have been undertaken with investment and participation from all levels of government and international organizations such as the World Bank and the Asia Development Bank (further details can be found in section five).In addition, projects from non-state enterprises have been deployed, having met the requirements of the city government on environment and climate changes issues, whilst improving the adaptive capacity of the community. One such project was implemented by the HB Corporation and is detailed in section five. The focus has been on coping with climate change focusing on flooding and storms, however projects related to adaptation to salinity and coastal erosion have been limited. Currently, the community's resilience to disasters is not comprehensive and other factors such as limited funding and inadequate access to technology further limit progress.

Assessment of comprehensive adaptive capacity of Hoi An city

Methodology

There are numerous methods available to evaluate adaptive capacity to climate change. Cutter et al. (2009) developed an index of social vulnerability in 2003. This index has 5 components, which are social, economic, environmental, institutional and infrastructure. The application of this index requires information and database for 42 major quantitative indicators. In the case of Hoi An, it is difficult to apply this index to assess adaptive capacity and vulnerability due to lack of data. Hence, the research team used qualitative methods based on Cutter's elements of adaptive capacity indices.

Four sub-indices are proposed for this indicator: technology, financial, human resources and institution. Within the institution factor, there are four-subcomponents: policy, implementation, coordination and management. Questionnaires on how respondents feel about these sub-factors on four-scale (4: best and 1: worst, see Annex 5.4) performance were distributed to 25 key experts in Hoi An.

Questionnaires were sent to 25 experts in the Hoi An and they were asked to rate the sub-factors on a scale of 1 to 4, where 1 is worst and 4 is best (further details can be found in section 5.4). Four disasters were selected for assessment: flooding, salinity, coastal erosion and river bank erosion. In addition, some resilience indicators based on 7 components mentioned above were also used in the evaluation.

Developing adaptive capacity indicators and weighing each disaster

Two weight types can be used in order to assess the adaptive capacity of each disaster based on the seven integral indicators. The first is the simple weighted approach, where the indicators (technology, finance, human resources and policy) all have equal weight of 0.25. In addition, the four indicators in the policy group (policy, coordination, implementation, system) all have a weight of 0.0625.

The alternative method is to give an indicator a higher weight if the current value of the indicator is low. For example, technology capacity is weak. Thus, a certain improvement in technology may yield greater results compared with the same effort in other areas. In other words, weights are identified inversely to the current status. The results of this methodology can be found in table 21 below.

Table 21. Adaptive capacity indicators and weights

Indicators	Weights identified inversely to current status
Finance	20.6
Technology	22.0
Human resource	14.5
Policy	8.9
Management	9.9
Coordination	11.7
Implementation	12.4

Figure 41. Adaptive capacity of indicators to 5 disasters in Hoi An

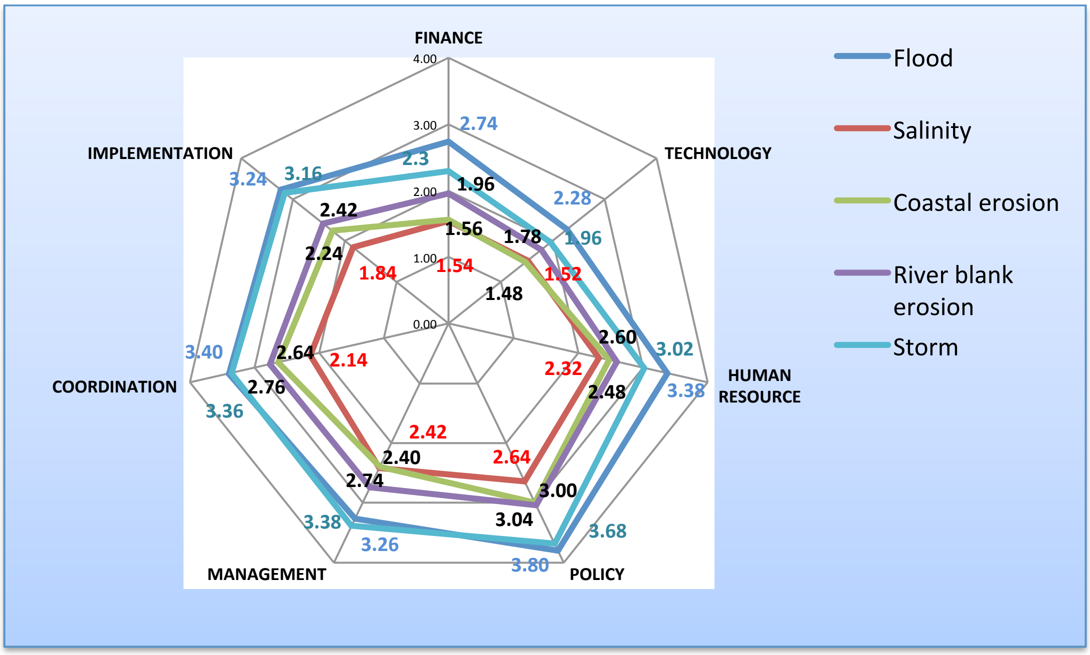


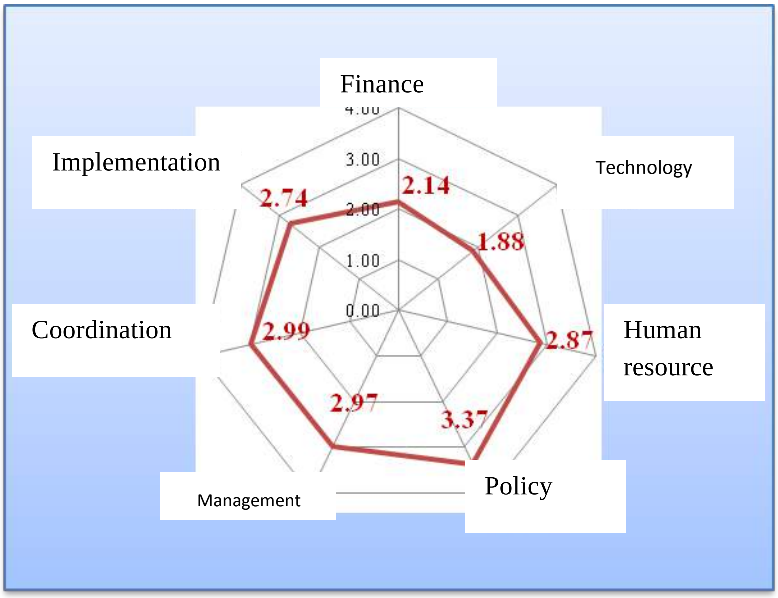
Figure 42 displays the results of the adaptive capacity of indicators to five disasters in Hoi An and shows that resilience to flooding is greatest and salinity is minimal. This demonstrates that the city government pays more attention to flooding and less in coping with salinity. It appears that technological capacity is considered the weakest for all the disasters, especially for salinity. So far, there have hardly been any big changes in helping people deal with the phenomenon of salinity. The figure also shows that local policies related to flood prevention and response are relatively good (this was also noted during public consultation). Finally, improving coordination and developing human resources for adaptation to climate change should further emphasized.

Developing resilience indicators for natural disasters

Weights were determined for all five disasters using a comprehensive index that took into account the importance of each disaster. The results are: flooding (0:28), coastal erosion (0.16), river bank erosion (0.08), salinity (0.18) and storms (0.3).

Figure 43 summarizes the assessment of the comprehensive adaptive capacity of Hoi An to natural disasters. The policy factor received the highest score (3.07/4), which demonstrates that Hoi An has good policies for responding to climate change. Results from public consultation on hot spots also reaffirmed this judgment. Other area such as technology (1.88) and finance (2.14) require improvement. Human resources and implementation also need more improvement.

Figure 42. Assessing the comprehensive adaptive capacity of Hoi An to natural disasters



Vulnerability Assessment of Hoi An

Methodology and evaluation process

Vulnerability (V) is a function of three factors: exposure (E), sensitivity (S) and adaptability (A) or V = f (E + S, A). Hence, the higher the exposure, the larger the sensitivity (for objects that are directly affected, the higher the size and level, the greater the vulnerability). Conversely, vulnerability will be reduced if adaptive capacity is improved.

In the case of Hoi An, the authors assessed three groups with the target components. The three groups considered were: i) technical infrastructure (with six target compositions), ii) environmental resources (with seven target composition) and iii) socio-economics (with three targets components). The investigation results of city officials to respond to climate change were used to determine the weights of the three groups for each disaster (floods, coastal erosion, river erosion, salinity and storm). For example, when calculating the coastal erosion hazard, the weight of the infrastructure group is 0.35, that of the environmental resources group is 0.30 and the socio-economic group is 0.35. Weights for each group of subjects were evaluated via expert opinion. For the socio-economic groups, agricultural activities, industrial activities and commercial services were calculated based on the proportion of each activity in the city's total national income.

Assessing exposure (ability, scale of hazard occurrence) and sensitivity (ability and intensity of influence caused by hazards) of each hazard was calculated for each indicator component based on analysis and marking criteria presented in chapter four. These indicators were aggregated into an overall index (E + S) for each target group by calculating the weighted sum of the index components. The general index (E + S) is typical for impacts of each hazard throughout the city, which is calculated by the sum (weighted) of the indexes (E + S) of the three groups.

When assessing aggregate impacts or the synergy of many hazards, they can be computed in the same way as a hazard calculation. However, group indexes and component indexes are calculated based on comparison and choosing the maximum value of each target component. For example, to assess the exposure of "land use" for the combination of flooding and storm, the maximum value of the indicator must be selected: storm (value is one) and flood (value is three). The value of the criteria is found to be three. The selection and calculation of the maximum value is thus given a quantitative assessment of scale, impact intensity and adaptability for the combination of disasters. Results for the

Assessment results and calculations

The assessment results for exposure (E), sensitivity (S), and total (E + S) for each hazard can be found in tables 18 to 25 below. The synthesis adaptive capacity (A) of urban disaster is presented in the table 26 and 27.

Based on an evaluation of exposure (E), sensitivity (S) and adaptability, the level of vulnerability in Hoi An for each hazard and its combinations were evaluated and found to be the following:

- Low: riverbank erosion;
- Medium: salinity and coastal erosion;
- Medium – high: floods and hurricanes;
- High: combination of storms and sea erosion;
- High - very high: combination of storms and flooding.

Table 22. Summary of exposure and sensitivity to flood of Hoi An

AFFECTED OBJECTS	FLOOD									
	Exposure(E)			Sensitivity(S)			Weighted	Average E+S		
	2011	2020	2050	2011	2020	2050		2011	2020	2050
Technical infrastructure							**0.3**	**4.8**	**5.5**	**5.7**
Land use	2	3	4	3	4	4	0.2	1.0	1.4	1.6
Houses	2	3	4	2	3	3	0.2	0.8	1.2	1.4
Electricity, lighting and communications	2	1	1	2	2	1	0.1	0.4	0.3	0.2
Transportation	3	3	3	2	2.9	3	0.2	1.0	1.2	1.2
Water supply	3	2.5	2	3	2	1.28	0.15	0.9	0.7	0.5
Water drainage	2.4	2.7	3	2.2	2.4	2.6	0.15	0.7	0.8	0.8
Natural resources – Environment							**0.3**	**4.7**	**4.8**	**5.0**
Forests	4	4	4	1	2	3	0.15	0.8	0.9	1.1
Rice fields	3	3	3	3	3	3	0.45	2.7	2.7	2.7
Surface water	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Groundwater	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Seafood	2	2	2	2	2	2	0.2	0.8	0.8	0.8
Minerals	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Grave yards	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Eco - Culture- Social							**0.4**	**4.1**	**4.6**	**5.1**
Industrial –Handicraft	1.73	1.92	2.11	1.73	1.92	2.11	0.3	1.0	1.2	1.3
Agriculture	2.14	2.38	2.62	2.76	3.07	3.38	0.3	1.5	1.6	1.8
Commerce-Service	1.94	2.15	2.37	2.13	2.37	2.61	0.4	1.6	1.8	2.0
Total								**4.5**	**4.9**	**5.2**

Table 23: Summary of exposure and sensitivity to salinity of Hoi An

AFFECTED OBJECTS	SALINITY									
	Exposure(E)			Sensitivity(S)			Weighted	Average E+S		
	2011	2020	2050	2011	2020	2050		2011	2020	2050
Technical infrastructure							**0.2**	**4.2**	**3.5**	**3.0**
Land use	3	2	2	4	3	2	0.2	1.4	1.0	0.8
Houses	2	2	2	3	3	2	0.2	1.0	1.0	0.8
Electricity, lighting and communications	1	1	1	2	2	1	0.1	0.3	0.3	0.2
Transportation	1	1	1	1	1	1	0.2	0.4	0.4	0.4
Water supply	3	2	2	2	1.25	1.25	0.15	0.8	0.5	0.5
Water drainage	1	1	1	1	1	1	0.15	0.3	0.3	0.3
Natural resources – Environment							**0.35**	**4.4**	**4.7**	**4.8**
Forests	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Rice fields	1	1	1	3	3	3	0.3	1.2	1.2	1.2
Surface water	4	4	4	3	3	3	0.15	1.1	1.1	1.1
Groundwater	1	2	2	1	2	3	0.15	0.3	0.6	0.8
Seafood	2	2	2	4	4	4	0.25	1.5	1.5	1.5
Minerals	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Grave yards	1	1	1	1	1	1	0.05	0.1	0.1	0.1
Eco - Culture- Social							**0.45**	**3.0**	**3.3**	**3.6**
Industrial –Handicraft	1.5	1.6	1.8	1.3	1.5	1.6	0.3	0.8	0.9	1.0
Agriculture	1.8	2.0	2.2	2.2	2.5	2.7	0.3	1.2	1.3	1.5
Commerce-Service	1.2	1.3	1.4	1.1	1.2	1.3	0.4	0.9	1.0	1.1
Total								**3.7**	**3.8**	**3.8**

Table 24: Summary of exposure and sensitivity to coastal erosion of Hoi An

AFFECTED OBJECTS	COASTAL EROSION			
	Exposure(E)	Sensitivity(S)	Weighted	Average E+S
Technical infrastructure			**0.35**	**3.6**
Land use	3	2	0.2	1.0
Houses	2	2	0.2	0.8
Electricity, lighting and communications	2	2	0.1	0.4
Transportation	2	2	0.2	0.8
Water supply	1	1	0.15	0.3
Water drainage	1	1	0.15	0.3
Natural resources-Environment			**0.3**	**6.1**
Protective forests	4	4	0.45	3.6
Surface water	1	1	0.1	0.2
Groundwater	1	1	0.1	0.2
Seafood	1	1	0.05	0.1
Minerals	2	3	0.25	1.3
Grave yards	1	1	0.05	0.1
Economic - Culture- Social			**0.35**	**2.6**
Industrial –Handicraft	1.2	1.2	0.3	0.7
Agriculture	1.6	1.7	0.3	1.0
Commerce-Service	1.3	1.1	0.4	1.0
Total				**3.8**

Table 25. Summary of exposure and sensitivity to river erosion of Hoi An

AFFECTED OBJECTS	RIVER EROSION			
	Exposure(E)	Sensitivity(S)	Weighted	Average E+S
Technical infrastructure			**0.35**	**3.4**
Land use	3	2	0.2	1.0
Houses	2	2	0.2	0.8
Electricity, lighting and communications	1	1	0.1	0.2
Transportation	2	2	0.2	0.8
Water supply	1	1	0.15	0.3
Water drainage	1	1	0.15	0.3
Natural resources – Environment			**0.3**	**3.4**
Forests	1	1	0.05	0.1
Rice fields	2	2	0.7	2.8
Surface water	1	1	0.05	0.1
Groundwater	1	1	0.05	0.1
Seafood	1	1	0.05	0.1
Minerals	1	1	0.05	0.1
Grave yards	1	1	0.05	0.1
Eco - Culture- Social			**0.35**	**2.3**
Industrial –Handicraft	1.2	1.1	0.3	0.7
Agriculture	1.2	1.0	0.3	0.6
Commerce-Service	1.2	1.2	0.4	0.9
Total				**3.0**

Table 26: Summary of exposure and sensitivity to storms of Hoi An

AFFECTED OBJECTS	STORMS			
	Exposure(E)	Sensitivity(S)	Weighted	Average E+S
Technical infrastructure			**0.35**	**4.0**
Land use	1	1	0.2	0.4
Houses	4	3	0.2	1.4
Electricity, lighting and communications	4	2	0.1	0.6
Transportation	3	2	0.2	1.0
Water supply	1	1	0.15	0.3
Water drainage	1	1	0.15	0.3
Natural resources – Environment			**0.3**	**5.9**
Forests	4	2	0.15	0.9
Rice fields	4	3	0.45	3.2
Surface water	1	1	0.05	0.1
Groundwater	1	1	0.05	0.1
Seafood	4	3	0.2	1.4
Minerals	1	1	0.05	0.1
Grave yards	1	1	0.05	0.1
Eco - Culture- Social			**0.35**	**5.3**
Industrial –Handicraft	2.0	2.0	0.3	1.2
Agriculture	4.0	3.0	0.3	2.1
Commerce-Service	3.0	2	0.4	2.0
Total				**5.0**

Table 27: Summary of exposure and sensitivity to storms + flood of Hoi An

AFFECTED OBJECTS	STORMS + FLOOD (BASE YEAR 2020)			
	Exposure(E)	**Sensitivity(S)**	**Weighted**	**Average E+S**
Technical infrastructure			**0.35**	**6.0**
Land use	3	4	0.2	1.4
Houses	4	3	0.2	1.4
Electricity, lighting and communications	4	2	0.1	0.6
Transportation	3	2.9	0.2	1.2
Water supply	2.5	2	0.15	0.7
Water drainage	2.7	2.4	0.15	0.8
Natural resources – Environment			**0.3**	**5.9**
Forests	4	2	0.15	0.9
Rice fields	4	3	0.45	3.2
Surface water	1	1	0.05	0.1
Groundwater	1	1	0.05	0.1
Seafood	4	3	0.2	1.4
Minerals	1	1	0.05	0.1
Grave yards	1	1	0.05	0.1
Eco - Culture- Social			**0.35**	**5.5**
Industrial –Handicraft	2.0	2.0	0.3	1.2
Agriculture	4.0	3.0	0.3	2.1
Commerce-Service	3.0	2.4	0.4	2.2
Total				**5.8**

Table 28. Summary of exposure and sensitivity to storms + coastal erosion of Hoi An

AFFECTED OBJECTS	STORMS + COASTAL EROSION			
	Exposure (E)	Sensitivity (S)	Weighted	Average E+S
Technical infrastructure			**0.35**	**4.6**
Land use	3	2	0.2	1.0
Houses	4	3	0.2	1.4
Electricity, lighting and communications	4	2	0.1	0.6
Transportation	3	2	0.2	1.0
Water supply	1	1	0.15	0.3
Water drainage	1	1	0.15	0.3
Natural resources – Environment			**0.3**	**6.3**
Forests	4	4	0.15	1.2
Rice fields	4	3	0.45	3.2
Surface water	1	1	0.05	0.1
Groundwater	1	1	0.05	0.1
Seafood	4	3	0.2	1.4
Minerals	2	3	0.05	0.3
Grave yards	1	1	0.05	0.1
Eco - Culture- Social			**0.35**	**5.3**
Industrial –Handicraft	2.0	2.0	0.3	1.2
Agriculture	4.0	3.0	0.3	2.1
Commerce-Service	3.0	2	0.4	2.0
Total				**5.4**

Table 29. Summary of adaptive capacity to disasters in Hoi An

ADAPTIVE CAPACITY	FLOODING	SALINITY	COASTAL EROSION	RIVERBANK EROSION	***STORMS***	***WEIGHT***
FINANCE	2.74	1.54	1.56	1.96	2.3	0.21
TECHNOLOGY	2.28	1.52	1.48	1.78	1.96	0.22
HUMAN RESOURCES	3.38	2.32	2.48	2.60	3.02	0.15
POLICY	3.80	2.64	3.00	3.04	3.68	0.09
SYSTEM	3.26	2.42	2.40	2.74	3.38	0.10
COORDINATION	3.40	2.14	2.64	2.76	3.36	0.12
IMPLEMENTATION	3.24	1.84	2.24	2.42	3.16	0.12
TOTAL	**3.0**	**1.9**	**2.1**	**2.3**	**2.8**	

Table 30.Levelling of exposure, sensitivity and adaptive capacity

Level	*Exposure and sensitivity*	*Adaptive capacity*
Very high	>5	>3
High	4-5	2.5-3
Medium	3-4	2 – 2.5
Low	< 3	<2

Table 31.Assessment of exposure, sensitivity and adaptation

Disaster Risks	Exposure and sensitivity (E+S)			Adaptive capacity – A	Vulnerability - V
	2011	2020	2050		
Flooding	4.5	5.0	5.3	3.0	Medium –High
Salinity	3.6	3.7	3.7	1.9	Medium
Coastal erosion		3.8		2.1	Medium
Riverbank erosion		3.0		2.3	Low
Storms		5.0		2.8	Medium – High
Storms + Flood		5.8		3	High – Very high

Storms + Coastal erosion	5.4	2.8	High

Hot spot analysis

Basis for hotspot identification

The assessment team utilized the analysis presented above in conjunction with city officials to identify 'hot-spot' areas which are considered most vulnerable to the negative impacts of climate change and, as such, are priorities for action. In order to make this analysis systematic, the following criteria were considered in identifying hotspot areas:

- Areas exposed to multiple hazards;
- Areas which are less economically developed and/or have less infrastructure and lower access to basic services;
- Areas of strategic economic interest;
- Areas which provide livelihoods in specific, climate sensitive sectors (tourism, fisheries, agriculture, etc.);
- Wards which were identified as having a low adaptive capacity.

Based on the above criteria, the following hot spots were identified:

- Phuoc Hoa Block (Cua Dai ward);
- An My Block (Cam Chau ward);
- An Hoi, An Dinh blocks (Minh An ward);
- Phuoc Thang (Cam Kim).

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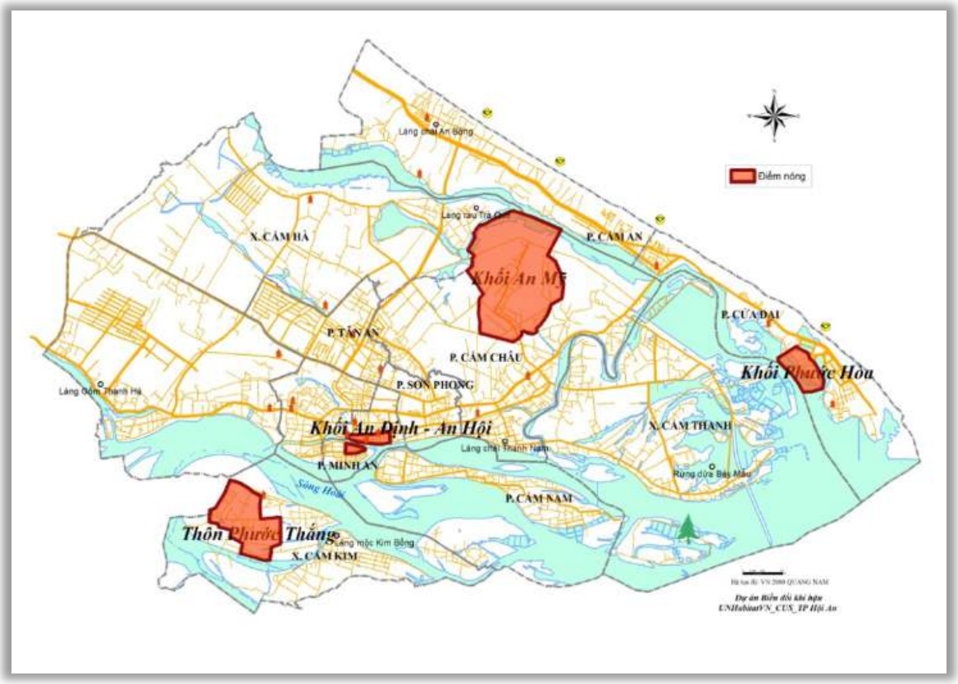
Figure 43. Location of aggregated hotspots (Source: Principal Authors)



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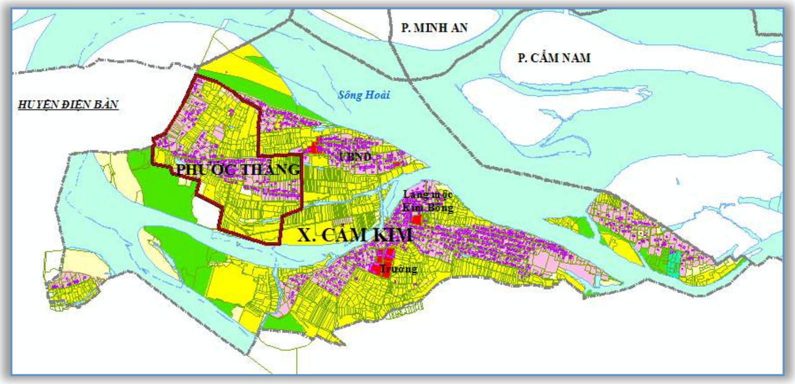
Hot spot Phuoc Thang Village - Cam Kim Commune

Phuoc Thang Village is one of the five villages of Cam Kim, located on the right bank of Thu Bon River. Phuoc Thang village has area of 1.23km², with 840 people in 198 households. The village population density in 2010 was 683 persons/km², which is lower than the average population density of the commune (943 people / km²) making it a low-density group in city. The number of inhabitants of working age is 460, accounting for 54.76 per cent of the village population.

Figure 44. Location of Phuoc Thang Village and Consultative conference of Phuoc Thang people



Phuoc Thang is an agriculture village that mainly grows rice and flowers. Fishing and handicraft work can also be found in the village. The number of agricultural workers is 187 and most of the labor force works in other areas or participates in handicraft units such as mechanical engineering, forest product processing, food processing, weaving mats, garments, etc.

In 2010, the total rice cultivation area of the village was 28.7 hectares. Most of the crops grow during the winter-spring season (21.5 ha), as opposed to the summer (7.2 ha). Phuoc Thang has a total area of 5.19km of concrete roads and traffic density is 4.2 km / km².

The poverty rate in the village is low at around 6.7 per cent below the poverty line, however, some basic service provisions are lacking; there is minimal access to communications through phones and the internet and there is no access to piped water, with water for domestic use coming from wells. This water is subject to salinity, which negatively affects the quality and availability of drinking water. The village also lacks drainage infrastructure, which means that it lacks capacity to cope with flood waters.

Figure 45. Rice production area and its productivity in 2010

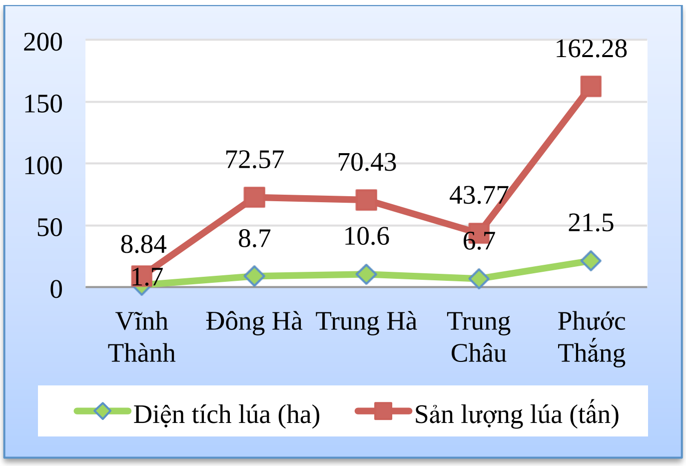
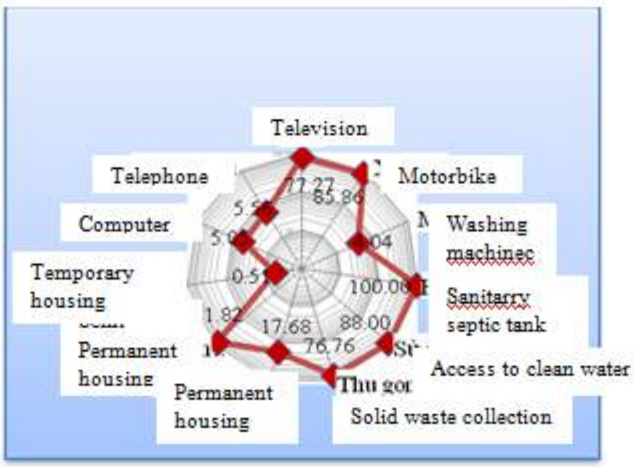


Figure 46 Rate of households accessing living means in Phuoc Thang Village (%)



The elevation of Phuoc Thang is between one to two metres above mean sea level. This means that it is highly exposed to coastal flooding, which on average happens four to five times per year and can last for up to seven days. In 2008, a flood inundated the village for more than ten days. During flood periods, students are identified as being the most vulnerable groups. Since the village is cut off from the main high school, students are forced to miss up to four weeks' of lessons per year. Sea-level rise scenarios show that the problem will become more severe in the future; the 2020 sea-level rise scenario suggests that inundations of up to four metres will be possible.

During flooding, people are almost isolated because boats are prohibited. The village has no shelters and is only equipped with historical houses with low surfaces. People living in temporary houses have to move to permanent houses during flooding, causing a lot of trouble and inconveniences.

According to climate change and sea level rise scenarios to 2020, Phuoc Thang village and most of the Cam Kim Commune are expected to be inundated under two to four metres of water. The government has implemented some measures to support the village, such as announcing flooding time in advance, providing financing to build clean water pipes etc. However, there are still additional requirements that need to be met in the village, like people having their own shelter and constructing a bridge across the river to connect Hoi An to highland areas during the flood season.

In addition to flooding, Phuoc Thang also suffered from heavily salined water, which greatly affects people's livelihoods. For example, prior to 1983, there was the possibility of growing three crops of rice per year. However, on average only one crop of rice per year can currently be grown. The poor that live away from the main road are forced to use both saline and contaminated well water when the area is flooded.

In addition to flooding and salinity impacts, PhuocThang village in particular, and Cam Kim commune in general, are subjected to river bank erosion. Riverbank erosionis not only caused by natural disasters, but also by illegal sand mining. Every day, the south ernbank of Thu Bon River between Cam Kim commune and Dien Ban district encroaches inland, causing the loss of agricultural land in PhuocThang and Trung Chau villages. One part of riverbank in Phuoc Thang village has an embankment, while the other part is still subject to erosion.

Conclusion: Phuoc Thang village in particular and Cam Kim in general suffer from the impacts of flooding, salinity and river erosion. These can seriously affect the area's economic and social infrastructure and people's living environment. Improvements and changes are required:

- improve inter-ward and inter-village roads;
- build shelter house to withstand floods;
- find solutions for converting livelihoods;
- modify the agricultural calendar and grow salt-tolerant plants to cope with salinity hazards;
- Support the water supply.

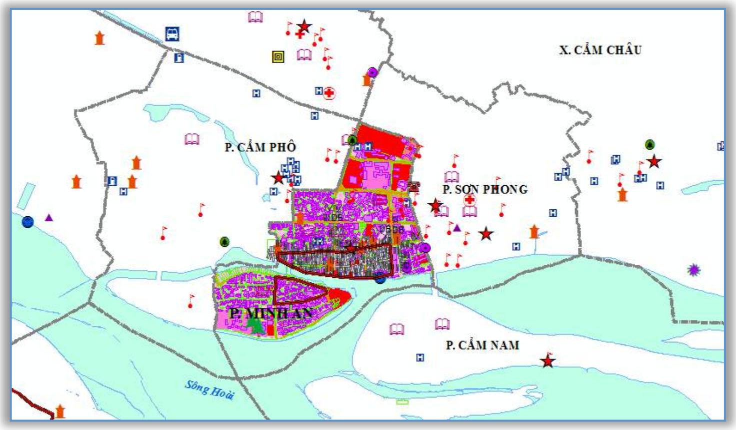
In the long run, Phuoc Thang village will require a resettlement strategy to a more stable area.

Hot spot block of An Dinh, An Hoi, Minh An Ward

Hotspot 2is the An Dinh and An Hoi neighborhood, located in Minh An Ward in central Hoi An. These areas are the cultural and commercial heart of the city. In 2007, there were almost 700 retail businesses in central Hoi An with an additional 70 restaurants and bars, many of which are located in An Hoi and Minh An.

In An Dinh, there are over 1000 relics that contribute to the cultural heritage of the city. An Dinh has 320 households, most of which work in travel services and housing sales and rentals. Hoi An market is the city's main market, located in a large area that occupies one third of the block. Varies types of infrastructure can be found, including houses, shops, churches, temples, assembly halls, bridges and ancient wells.

Figure 47. Location of hot spot An Dinh - An Hoi



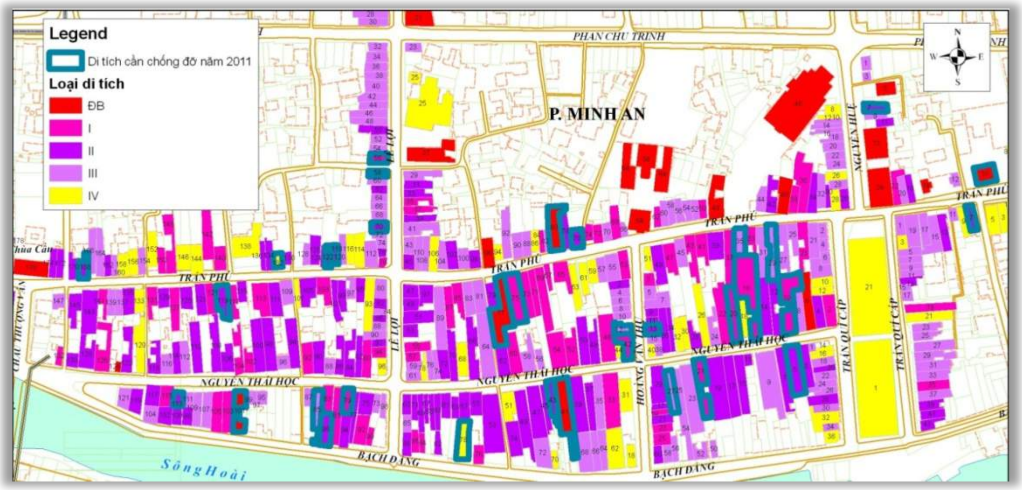
Interview household in An Dinh ancient houses. Source: Hoang Dinh Thien, Hoi An, December 2011

In 2007, Hoi An had 180 garment stores, 202 souvenir shops, art galleries and craft arts, 91 shoe shops and 207 complex department stores, most of which target tourists. Besides trade, Hoi An has about 70 restaurants and bars, accounting for 26% of total income from tourism services (2007). Most restaurants are located in the restored vestiges in An Dinh block. Poverty rates are lower in Minh An ward than in any other ward in the city and business revenues are the highest, implying that many people rely on economic activity in this area for their livelihoods.

Because the area is low-lying – An Dinh and An Hoi are entirely sub-2 metres elevation – local people have to cope with flooding, both from increased water levels from the river basin and from higher tides in the sea. In November 2011, there was a flash flood that discharged 3000 m³ of water from the Tranh River Hydropower plant and flooded the entire ward. An Hoi and Minh An experienced flood waters of up to three metres, damaging more than 1000 houses, some of which were several hundred years old.

Statistics from 2011 show that numerous households have had to be relocated: 10 households on Bach Dang road, 14 households in Nguyen Thai Hoc, 9 households in Le Loi road, 18 households in Tran Phu and 7 households in Nguyen Thi Minh Khai.

Figure 48. Map of vestiges distribution that needs protection in rainy season 2011 in Minh An
(Source:Authors)



The An Dinh area of Minh An ward lies across the Hoai River and is connected by a small foot-bridge. Here, the main incomes sources for local people are fishing, weaving and trade. This area has no drainage infrastructure, which leads to regular flooding. An Dinh and An Hoi also suffer from salinity. While piped water is available to most local people, this service is often unavailable during floods, so households have to switch to alternative water sources.

Figure 49. An Dinh - An Hoi with risk of flood and salinity 2020 (Source:Authors)

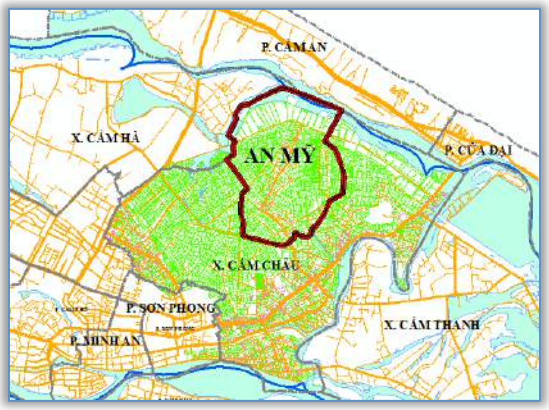
Conclusion: The An Dinh - An Hoi block is home to many old houses and historical sites with cultural and historical values and is the hub for trade and tourism and city services. The area is regular inundated and has suffered huge property losses during flooding. Solutions to be implemented include the evacuation of assets, management mechanisms and the protection and maintenance of reasonable historical responses to flooding. In the long term, in order to cope with flooding, the An Dinh - An Hoi block requires a strategy and plan for flood drainage.

Hot spot An My block, Cam Chau ward

The Cam Chau ward consists of 6 blocks: Truong Le, Son Pho I, Son Pho II, An My, Thanh Tay and Thanh Nam. An My is the largest village neighbourhood in Cam Chau with an area of 1149 km² and a total population of 993 people in 251 households. The population density is low compared to the rest of the city at 939 persons per km². Agriculture and eco-tourism are the main livelihoods of the city. 51.8 per cent of households depend primarily on agriculture for their livelihood.

Cam Chau Ward is famous for its rice fields and for being an eco-tourism point in the city. An My is the agriculture block, having 130 farming households out of 251. The agricultural labor force consists of 237 people, accounting for 33.19% of employees of working age.

Figure 50. Location of An My block



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Consultative community conference in An My. Source: Bui Nguyen Trung, Hoi An, December 2011

Figure 51. Rice total area and its productivity 2010

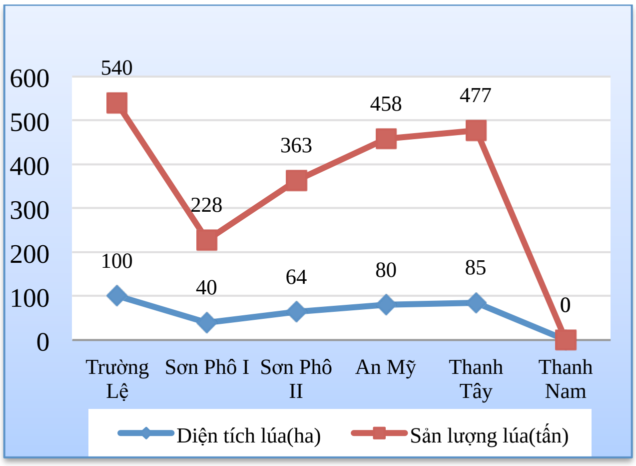
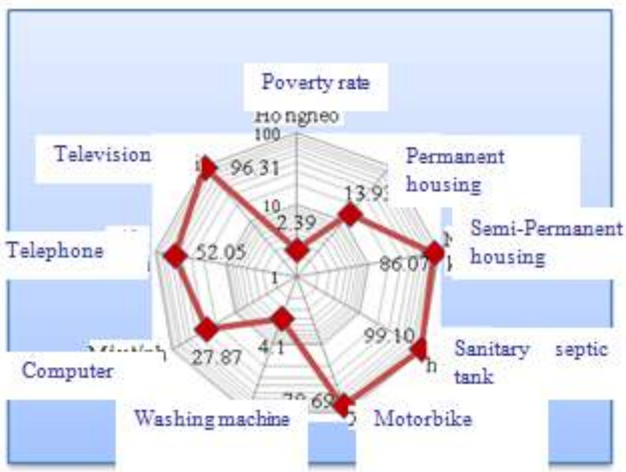


Figure 52. Rate of poor households and accessibility to living means (%)

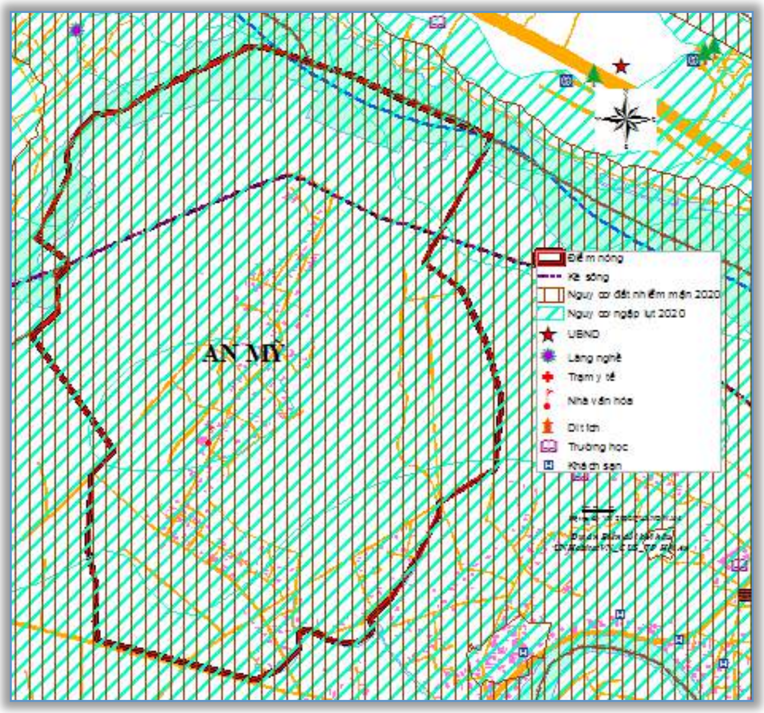


An My is sub-two metres in elevation, and large parts of the area are below one meter. This means that flooding is a regular occurrence in the rainy season, especially in September and October. In 2009, the flooding was three metres deep and affected five out of the six neighborhood blocks in the ward. The effect of this is that local livelihoods – which primarily consist of agriculture and aquaculture – are damaged because rice crops flood and hardware is damaged. In the dry season, irrigation infrastructure also becomes less effective in this area due to salinity.

A salinity prevention dike was builtin1973fromThanh Tay toTra Que, however the dike is low and the water coconut trees have been cleared and replaced by shrimp ponds. The area is subjected to salinity of water and soil due to spillover of sea water. Surface water cannot be used for irrigation due to salinity and contamination. The summer-autumn crop yield in 2010 was reduced by 50 per cent due to salinity and frost.

The local government has been supporting numerous people in the community by creating evacuation points for natural disasters, improving mortgage lending and housing for the poor, providing seeds to the community and assisting in career changes for people that relocate. People in An My also aspire to reinforce the salinity prevention dike and plant trees that can prevent salinity, which will ease the impacts on agriculture and livelihood of the people. In addition, a wastewater treatment plant is being built in Cam Thanh in order to solve the wastewater issues found in Cam Chau. Figure 52 is a map that forecasts the risk of inundation and salinity under scenarios of climate change and sea level rise in 2020. It shows that An My block will be inundated under three to four metres of water and the water will be affected by salt.

Figure 53. Risk of inundation and salinity in An My 2020



Conclusion: An My block is the lowest area in the city and it is heavily affected by flooding. In the long run, a part of the area will be permanently inundated. In order to survive, An My block needs to modify the livelihood of its people and change its agricultural habits. Thereafter, it will require the implementation of proper resettlement.

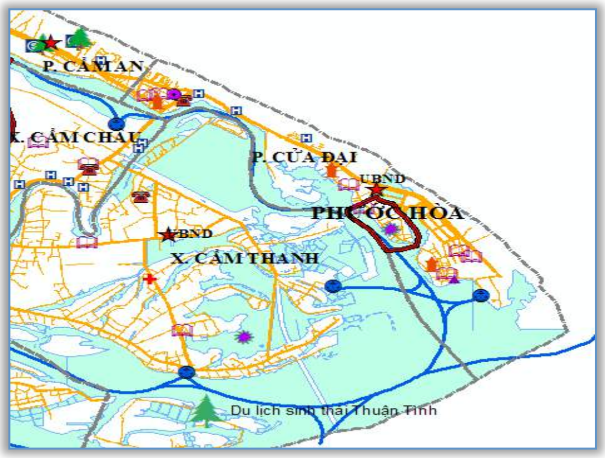
Hot spot Phuoc Hoa block - Cua Dai ward

The Cua Dai ward is home to five blocks: Tan Phuoc, Phuoc Trach, Phuoc Hoa, Phuoc Thinh and Phuoc Hai. Phuoc Ha has around 240 households and people depend primarily on the tourism trade (50 per cent), fisheries (30 per cent) and other industries (20 per cent).

The Cua Dai ward is located between the Co Co river and the sea and is strongly affected by climate change and rising sea levels. The most severe disasters such as storms, flooding, salinity, coastal erosion, riverbank erosion and coastal estuarine sedimentation all take place here. Although the terrain is quite high compared to the city (coastal area: two to three metres high, area next to Cam An: four metres high and inner area of Co Co river: one to two metres high), flooding inundates the west and the south areas when inundation depth is not high and flood drainage is faster than in the city. Coastal erosion occurs at a rapid rate because pine forests that prevent erosion have been replaced by new resorts. An An ward officer said that in the past seven years, the sea has encroached 120 to 150 metres into the land. Althought here is a sea dike, erosion is still a serious issue and has caused damage to the embankment.

In the area, the Phuoc Hoa block is the poorest ward. People mainly earn their living by fishing, hence are completely dependent on the weather. Wind storms and flooding affects the lives and livelihoods of people. During the rainy season, they cannot go fishing and have no additional source of income

Figure 54. Location of Phuoc Hoa block and Cua Dai ward



Consultative conference with Phuoc Hoa people. Source: Bui Nguyen Trung, Hoi An, December 2011

Phuoc Ha faces inundation due to its low elevation, but the most urgent challenge facing it is river bank erosion and salinity. There is no access to piped drinking water in Phuoc Ha, which means that all households rely on 10 metre wells for their water. Riverbank erosion also damages aquaculture and reduces the size of land plots which people can use for homes and livelihoods.

Under scenarios of climate change and rising sea level for 2020, large residential area of Phuoc Hoa will be inundated. Figure 54 shows a forecast of flooding and salinity in Phuoc Hoa, Cua Dai

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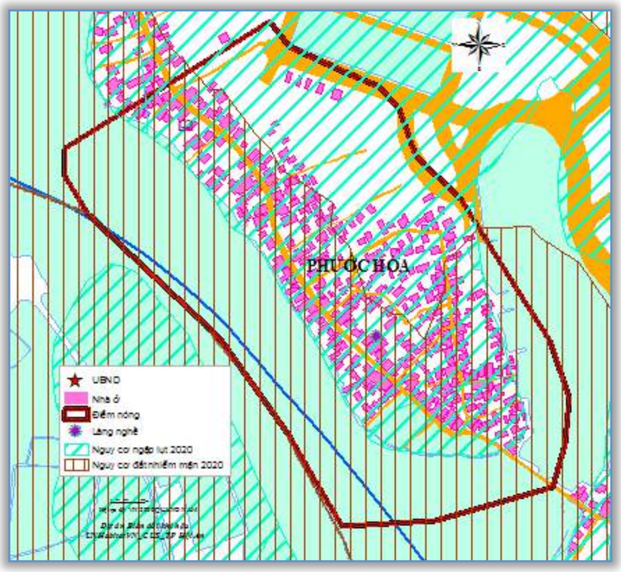
Figure 55. Forecast of flooding and salinity in Phuoc Hoa, Cua Dai



Conclusion: Phuoc Hoa block is located on a coastal estuary, which is a dynamic area that suffers from the strong impacts of disasters, storms and coastal erosion. This block requires comprehensive solutions to combat coastal erosion from deforestation and the destruction of infrastructure. Contamination and salinity is concern, along with public health issues. There is a need to strengthen dikes and embankments, repair roads and install water pipes for access to clean water.

In summary, due to differences in geographical and natural conditions, there are different combination of hazards in each hot spot with various scale and intensity. They all have a direct influence on the livelihoods of local communities. Each hot spot needs to be separately addressed in the development strategy of socio-economic planning.

6. CONCLUSION AND RECOMMENDATIONS

Conclusion

Due to its location, Hoi An city is strongly affected by climate change and its effects: sea level rise, large upstream rainfall, temperature increases and unusual weather events in the coastal downstream region. Typical natural hazards in Hoi An include floods, hurricanes, tornados, salinity; coastal and river erosion, sedimentation of coastal estuaries, lightning, fog, sand moving and drought. Of all the mentioned natural hazards, those with the most impact to the area are floods, hurricanes, tornados, salinity and coastal and river erosion.

Floods

Flooding is the natural hazard that results in the some significant impacts to Hoi An. It is thought that with time, an entire portion of Hoi An will be permanently covered in water due to flooding.

Causes: Long-lasting rain; upstream floods; tides and rising sea level; upstream flash floods upstream (A Vuong-Tranh II River); flood drainage from the Co Co river; coastal sedimentation; and narrowing drainage surface of the Thu Bon river in Cua Dai.

Conditions: Low geographic positioning of many communes and wards (including the Old Square).

Forecasted results of flood: According to climate change scenarios applied for Hoi An, the following consequences are forecasted for the region:

- In 2020, floods are projected to occur in: Cam An, Chau Chau, Cam Nam, Cam Pho, Cua Dai, Minh An, Son Phong, Tan An, Thanh Ha, Cam Ha, Cam Kim, Cam Thanh. The flooding area is projected to be 2912 ha (not including river area), accounting for 63 per cent of covered under one to four metres of water. Forty hectares are expected to be permanently flooding, accounting for 0.86 per cent of the city (not including river).
- In 2050, floods are expected to cover 2946 hectares (not include river), covering 63.7 per cent of the city area under one to four metres of water. Fifty-two hectares are expected to be permanently flooding, accounting for 1.1 per cent of the city (not including river).
- In 2100, floods are expected to cover 3204 hectares (not include river), covering 69.3per cent of the city area under one to four metres of water. Four hundred forty-two hectares are expected to be permanently flooding, accounting for 9.6 per cent of the city (not including river).

Note that over time, the flooded area does not increase significantly, but the depth of flooding does.

Current adaptability: Hoi An has a high adaptability to flooding. There is a steering committee that oversees flood prevention for the entire city and every ward and commune. Measures such as preventive policies, food stocks for households, information systems and support to overcome damage exist. Moreover, there are resettlement projects for displaced individuals during flooding. However, technology is not up-to-date (no GIS), nor is infrastructure (roads, drainage systems and waste). Furthermore, there is limited financing from the city to the wards and households.

Therefore: Climate change and rising sea levels will be important factors that will permanently the city via flooding:a flooded area of 443 hectares is predicted for 2100and there will be increasing flood hazards. Other impacts that will affect Hoi An include sedimentation in Cua Dai, the filing of Co Co with flood drainage. The construction of the A Vuong - Tranh River hydropower dam will also cause severe impacts.

Salinity

Saline intrusion into surface water, soil and groundwater is becoming more significant in terms of scale and consequences, notably its effects on agricultural crops, livestock and water supply.

Causes, conditions and salinity mechanism:

River flow decreases during the dry season, resulting in lower water levels. In addition, the A Vuong - Tranh II river hydropower dam interrupts upstream water flows, resulting in insufficient water flow during the dry season. Hence, tides and sea level rise intrude into the land, resulting in water salinity in Hoi An.

- **Groundwater**: Groundwater is affected by sea level rise and river water, resulting in salinity in the water container layer.
- **Land**: Tides and sea level flow into low-lying areas, causing salinity. Surface land in dry weather absorbs saline groundwater via a capillary system, turning the soil saline. In 2020, it is forecased that the total area of saline land and groundwater will be 2700ha/ 4622.12ha (covering 50 per cent of the city area)

Current adaptability: *The adaptability of the community and government to salinity is weak.* Salinity has recently been recognized as an increasing hazard, therefore there has not yet been any action on the part of the community or the government.

Therefore: Human impacts such as building dams to prevent water flow and the exploitation of groundwater are important causes of urban salinity. However, in the long run, climate change and sea level rise are thought to be responsible for salinity.

Coastal erosion

Coastal erosion and sedimentation of estuaries are issues which affect the entire eight km coastline of Hoi An. They are caused by the impact of deforestation for the development of seaside tourism infrastructure, which in turn threaten the stability of embankments in the Cua Dai region.

Causes, conditions and scale of coastal erosion: Sand is the main component found in a beach and is sensitive to wave effects. During storms and changing tides, waves can destroy the coastal sea area. The deforestation of protected forests for the development of resorts without shore protection measures is major cause of coastal erosion found from Cam An to Cua Dai.

Current adaptability: *The adaptability of the community and government to coastal erosion is medium.* In spite of having embankment solutions to replace protected forests, the solutions are still not in-sync with institutional policies or management apparatus and suffer from weak coordination and ineffective implementation.

Therefore: Serious coastal erosion in Hoi An is caused by the deforestation of protected forests for the development of resorts, without accounting for solutions to protect the coast. As time goes by, climate change and sea level rise will increase the impact of waves - the main cause of coastal erosion hazards in Hoi An.

River erosion

Riverbank erosion is found in the estuary due to weak geological structure. Along the riverbanks of Hoi An, the intensity of this increases from unplanned mining activities related to the extraction of river sand. Riverbank erosion leads to loss of farmland, threatening housing and construction work, particularly in the areas of Cam Kim, Cam Nam, Thanh Ha, Cam Thanh, Cua Dai.

Current adaptability: *The adaptability of the community and government to river erosion is medium*. Hoi An is used to copying with river erosion, having already invested in technology related to embankment in key areas, such as the Old Quarter. However, investments made are modest and additional issues, such as unplanned sand mining activities occur due to limited policy implementation and lack of coordination.

Therefore: Sand mining activities and the impacts of hydropower activities are the main causes of river erosion in Hoi An. In addition, climate change impacts and rising sea levels increase flooding, further impacting river erosion of the Thu Bon and De Vong Rivers.

Storms

Hurricanes are natural disasters that are very difficult to forecast. In Hoi An, they appear in between the months of September and November, causing multiple effects such as heavy rains, rising sea levels and strong winds. These, in turn, create large waves that destroy river banks and various types of infrastructure, such as housing and impact trees and power line systems. They also impact forest resources, affect the cultivation of rice and flowers, and affect other economic activities such as fishing, especially in the coastal wards of Cam An, Cua Dai and Cham Island. The increase in frequency and intensity of storms in recent years shows a relationship between the latter and the symptoms of climate change.

Current adaptability: *The adaptability of the community and government to storms is high*. As mentioned, Hoi An has a steering committee that oversees flood prevention for the entire city and every ward and commune. Measures such as preventive policies, food stocks for households, information systems and support to overcome damage exist.

Vulnerability, sensitivity, adaptability to disasters

- Of all the natural hazards, flooding has the most significant consequences for Hoi An, even though the adaptability of the community and government to the impacts is quite high.

- Storms cause severe impacts, especially in the wards of Cua Dai and Cam An. However, the adaptability of the community and the government is high, so the vulnerability is in the medium to high level.
- The presence of large storms is normally accompanied by flooding. Storms and flooding combined can cause serious damage, especially during events of "storms, flooding due to storms and inundation from upstream flow". Although the adaptability of the community and the government is high, the possibility of damage is in the high-very high level.
- Although the impacts of salinity are rated to be moderate, the community's response to the issues is weak. Solutions have not been developed yet, hence the actual potential impacts are quite significant.
- Coastal erosion effects are rated as average for Cua Dai and Cam An wards. However, the ability to cope (resilience) is low, so the impacts on city and communities are very significant.
- The impacts of riverbank erosion are considered to be of small consequence. The community is used to responding to these types of disasters. Preventative measures have been applied, so potential impacts on the city are low.

Overall, Hoi An city has the highest adaptability to flooding and the weakest adaptability to salinity. The technological capacities and financial capabilities of the city are weak and policy elements of the local government are considered dominant. The city has prepared for climate change adaptation.

Recommendations

Orientation for Hoi An climate change adaptation

Policies, institutions and coordination (system, implementation, cooperation)

1. The Hoi An eco-city sustainable development vision is based on strategic responses and adaptation to climate change. Therefore, it is necessary to mainstream Hoi An's climate change adaptation programs into the climate change response strategy of Quang Nam province and the National Strategy on Climate Change.
2. It is important to incorporate elements of climate change into the socio-economic development plan and the construction master plan of Hoi An (not yet verified), with special attention paid to permanent flooding in low or saline areas. In addition, proper sector planning is required, as well as the revision and integration of the 13 plans among 37 plans/projects listed in the Hoi An Eco city development plan
3. A strategic response to climate change must be directed and implemented at all levels from households to wards/communes, cities and provinces in the overall national strategy of climate change. The response must include various adaptation forms (finance and investment, technology and infrastructure, human resources and information, institutions and coordination). Furthermore, they must be comprehensive for fields such as infrastructure and planning, natural resources and eco environment.

4. In addition to storm and flood response policies, there should also be additional policies to cope with other disasters like salinity and policies to attract enterprises to respond to climate change.
5. Mechanisms are required to manage urban development in accordance with approved plans and climate change response action plans, giving investment priorities for the most vulnerable areas and communities.
6. It is important to prioritize the implementation of projects responding to issues affecting river dikes, sea dikes, roads, bridges, community housing to prevent flooding, projects to combat salinity, protection of forests, saline forests. Projects that ensure riverbed stability and channel dredging and improvement of flood discharge capacity for the Thu Bon River and Co Co Rivers are important. Infrastructure projects need to be carefully assessed on the impacts of flooding, salinity, erosion or environmental degradation.
7. Studies are required to propose strategies and economic restructuring plans for cities and wards. The plans need to focus on developing strengths and opportunities and transforming difficulties into opportunities. Other priorities include the implementation of projects which respond to climate change and prevent disasters, contributing to the transformation of livelihoods (seeds, livestock and agricultural production), especially for areas that are subjected to flooding and salinity.

Finance and investment

The vulnerability assessment has shown that finance and technology are the two weakest aspects in the adaptive capacity of the city. It is proposed that, as a world heritage city, Hoi An positions itself to take advantage of any funding available from the state budget, city budget, international cooperation or through the participation of enterprises. Hoi An should develop an investment plan for the city to respond to climate change and prevent disasters. Results of this assessment should be used for climate change response action plans at all levels from hotspots, wards/communes to city and provincial levels (river basins).

Human resources and information

1. The city must pro-actively develop a plan to raise awarenesss in the community to actively respond to climate change and transform the challenges of the latter into opportunities for improvement of living conditions and community development.
2. Results from flood, salinity model impact assessments for specific groups as well as adaptability are good basis for city departments to adjust industry plans, prepare for climate change adaptation plans for each sector, increase adaptability in weak sectors and revise the impacts of climate change on socio-economic development projects. It is necessary to revise 24 projects (not include 13 planning projects) out of a total 37 eco-city projects of the assessment

Technology and infrastructure

Investment in technology for climate change forecasting, early warning and disaster management and promoting the application of green technology, clean technology and information technology to increase adaptability to climate change is necessary.

Orientation for disaster reduction solutions in Hoi An city

1. Develop an early warning and monitoring system, especially for storms and flooding; Calculate the water balance and flood drainage capacity for Hoi An in case the Co Co river gate is closed and identify appropriate solutions;
2. Develop a safe flood discharge process, preventing downstream flooding due to flood discharge from upstream hydropower (A Vuong-Song Tranh II);
3. Conduct a study to identify stable shorelines and determine the optimal cross-drainage side of Thu Bon River. Analyze the process of sedimentation of coastal estuaries and the corresponding solutions to prevent flooding in Hoi An.
4. Integrate urban infrastructure issues in flood forecasting models, develop and provide flood forecasting maps to Hoi An city for disaster management;
5. Assess quantity and quality of ground water for water supply of Hoi An city;
6. Conduct a survey to forecast saline intrusion of surface water, ground water and soil, and assess their impact on the socio-economic development of Hoi An;
7. Develop a plan for the effective use of surface water and groundwater of Hoi An; apply holistic solutions (for example reforestation, reinforcing embankment, or construction of a soft dike) to prevent coastal erosion in the city;
8. Calculate the quantity of rivers and mining and widen the Thu Bon river channels with stable discharge flow to ensure flood drainage and stabilization of the river bank.

UN-Habitat's Cities and Climate Change Initiative promotes enhanced climate change mitigation and adaptation in developing country cities. This document is an initial output of the Cities and Climate Change Initiative activities in Hoi An, Viet Nam. This full report has its abridged version that can be accessed online: http://unhabitat.org/books/hoi-an-viet-nam-climate-change-vulnerability-assessment/

The report titled: "Hoi An, Vietnam – Climate Change Vulnerability Assessment" is funded under the framework of One UN Initiative in Viet Nam in 2011, and the Cities and Climate Change Initiative.

Starting with a brief background of the city, this report addresses Hoi An's climate change situation from a climate risk perspective that focuses on hazards, vulnerabilities, and the adaptive capacities of the city. Following the insights gained from clarifying the climate change challenges, the report proposes the key sectors for climate change adaptation and mitigation measures in Hoi An. It finally recommends four solutions for improving capacity of Hoi An to adapt to climate change: (1) policy, institutional and coordination; (2) finance and investment; (3) human resources and information; (4) technology and infrastructure.