

MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF CONSTRUCTION

**HANOI ARCHITECTURAL UNIVERSITY**

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**MANAGEMENT OF DRAINAGE PLANNING  
TO MITIGATE INUNDATION  
IN THE NORTHERN COASTAL URBAN AREAS  
AND ADAPT TO CLIMATE CHANGE**

MAJOR: URBAN AND CONSTRUCTION MANAGEMENT

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**ABSTRACT FOR PHD THESIS OF  
URBAN AND CONSTRUCTION MANAGEMENT**

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At ..... on ..... 2019

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## **A. INTRODUCTION**

- **Rationale**

The topic was selected for the following reasons: (i) Climate change (CC) is in the top challenges today. According to World Bank (2011), Vietnam is one of the 5 countries that will be hardest hit by climate change and sea level rise (SLR); (ii) Eight urban areas of grade III or higher under the jurisdiction of the provincial government in the Northern Coastal Region (NCR) have been clearly suffering from the impacts of climate change such as rain, storm, SLR and the combination of rain, storm, river flood and high tide; (iii) While other coastal urban areas in the country are often flooded by tides, Quang Ninh province, with mountains and hills making up 90% of total natural area and large percentage of forest land, flood often comes from upstream area; while Thai Binh, Nam Dinh and Ninh Binh provinces with slightly slope terrain and large but diminished area of trees and water surface (detention reservoirs) are facing the inundation due to heavy rain and the ground being unable to absorb excess water; (iv) In the general urban planning proposal, the water drainage planning component has not taken into account the climate change factors and plans to mitigate inundation are still missing; (v) The absence of a system of legal documents and specific guidelines related to inundation mitigation and climate change leads to many obstacles and inconsistency in drainage planning management; (vi) Many scientific studies have proposed ways to address flooding in urban areas in the context of the climate change; however, it is still difficult to apply them in reality; (vii) Cam Pha City is selected as the study site for its diverse topography and proximity to the sea. According to the RCP 4.5 scenario in 2016, the change of precipitation in the period

2016-2035 for Quang Ninh province in general and Cam Pha City in particular would increase by 20.4%, ranking second in the whole country (only behind Hai Phong City), and sea level rise in the Mong Cai - Hon Dau area is 13 cm (8-18), respectively. It can be said that this is the area most affected by climate change within the Northern Coastal Region.

- **Research objectives**

- Evaluate the current state of drainage planning and inundation mitigation management and impacts of climate change in the Northern Coastal Region.

- Propose solutions to manage drainage planning to mitigate inundation in the Northern Coastal urban areas to adapt to climate change.

- Apply research results to Cam Pha City, contributing to improving the feasibility of the proposed solutions in practice.

- **Research subjects and scope**

Research subjects:

- Management of drainage planning to mitigate urban flooding and adapt to climate change. In which, focusing on researching issues related to surface water drainage system.

Research scope:

- Location: urban areas of grade III or higher under the jurisdiction of the provincial government in the Northern coastal region, especially Cam Pha city.

- Timeframe: Orientation to 2030.

- **Research methodology**

The thesis uses 07 main research methodologies including: Investigation and survey; Summarization and analysis; Expertise;

Inheritance; Comparison; Forecast; Mapping, chart, map overlaying, modeling (using GIS - geographic information system).

- **Scientific and practical significance of the topic**

- Scientific significance: The research results of the thesis will help concretizing and adding scientific theories to the management of drainage planning to mitigate inundation for Northern Coastal Region urban areas to adapt to climate change.

- Practical significance: + The thesis recommendations will contribute to improving the policy and mechanism in the management of drainage planning to mitigate inundation for Northern Coastal Region urban areas and can be applied in practice.

- + The thesis can be used as reference for research and training in related fields.

- **Concepts or terminologies**

The thesis uses some basic concepts and terminologies in the fields of drainage planning management, flooding, climate change, etc. in relation to the research topic.

- **Structure of the thesis**

*Introduction*

*Main content includes 3 chapters:*

*Chapter 1:* Overview of drainage planning management to mitigate inundation and climate change.

*Chapter 2:* Scientific basis for management of drainage planning to mitigate inundation for urban areas in the Northern Coastal Region to adapt to climate change.

*Chapter 3:* Solutions to management of drainage planning to mitigate inundation in the Northern Coastal Region urban areas to adapt to climate change.

*Conclusion and recommendations*

*List of references (54 documents)*

*Appendix (25 pages)*

## **B. MAIN CONTENT**

### **CHAPTER 1: OVERVIEW OF DRAINAGE PLANNING MANAGEMENT TO MITIGATE INUNDATION AND CLIMATE CHANGE**

#### **1.1. Overview of drainage planning management, inundation mitigation and climate change in some countries around the world**

*1.1.1. Overview of drainage planning management and inundation mitigation in some countries around the world:* Drainage planning management and inundation mitigation include risk assessment, flood mapping, and the application of information technology.

*1.1.2. Overview of the impacts of climate change in some regions of the world:* Sea level rise; temperature and precipitation change, other changes, and extreme weather.

*1.1.3. General comments:* Drainage planning management and inundation mitigation can no longer be involved with separate urban areas. Climate change, which includes increasing precipitation, is one of the main causes of inundation and flooding.

#### **1.2. Introduction about the Northern Coastal Region**

*1.2.1. Natural conditions:* heavy precipitation, diurnal tide, very diverse terrain.

*1.2.2. Economic and social conditions:* relatively high population density, industry and service sectors make up the major part of the region economy.

*1.2.3. General comments*

+ The Northern part of the region, which consists of urban areas in Quang Ninh province, has mountainous terrain and large forest area. Inundation is often caused by flash flood.

+ The Southern part, which consists of Thai Binh, Nam Dinh and Ninh Binh provinces, has slightly slope terrain, large green area and water surface (detention reservoirs). These areas are meant to absorb rainwater but are diminished, which results in inundation.

### **1.3. Current drainage system and inundation**

*1.3.1. Current drainage system:* Most urban areas use the common drainage system, which has downgraded.

*1.3.2. Current inundation in the Northern Coastal Region and causes:* Inundation is increasingly popular, for both subjective and objective reasons.

### **1.4. Current drainage planning management**

*1.4.1. Ongoing drainage projects*

All cities under the jurisdiction of the central government have specialized plans for drainage, the other urban areas have drainage plans as part of their urban planning.

*1.4.2. Current situation of the drainage planning management*

The process, from defining missions to publishing planning proposals, has not taken into account climate-change-related factors. The timeframe, duties, functions and responsibilities of each stakeholder are unclear.

*1.4.3. Current construction management in compliance with drainage planning*

The management of drainage system construction and investment is still struggling due to capital shortage; The control of ground level and connection to related projects is still inconsistent; inspection work has been decentralized.

#### *1.4.4. Current structure of managing drainage planning*

The drainage work and drainage planning is under the Central Government's administration throughout the country.

*1.4.5. Current situation of sustainable drainage, inundation mitigation and adaptation to climate change:* Currently, it is not popular.

#### *1.4.6. Some simulation tools used in drainage planning management*

The SWMM Model - Storm Water Management Model; MIKE modelling set; GIS - geographic information system.

#### *1.4.7. Community participation in drainage planning management to mitigate inundation*

The community so far has participated in only defining missions and preparing planning. There are no specific regulations on gathering public comments as part of the drainage planning management.

#### *1.4.8. General comment*

- Specialized drainage planning are only available for cities under the jurisdiction of the central government. Other remaining urban areas do not have specialized drainage planning but included in general urban planning. New technologies such as GIS, flood mapping regarding to climate change and sea level rise scenarios have not been applied in planning.

- There is a lack of legal document system and specific guidelines related to climate change and inundation mitigation, both for drainage planning management and implementation, from defining missions to publishing planning proposals.

- The management, utilization and operation of the drainage system are still included in other areas such as water supply and environment; There is no specialized committee or team to manage the sector of drainage and inundation mitigation.



- The construction in compliance with the drainage planning in each locality is under the management of different units without consistency. Determining the construction level between projects remains a problem. In particular, other factors affecting the determination of construction level have not been taken into accounts, such as climate change and sea level rise.
- The model of sustainable drainage is still alien and has virtually not been implemented in Northern Coastal Region urban areas, nor has it been integrated right from the first steps of planning.
- GIS is considered an effective simulation tool for flood mapping that takes into account climate change due to the ability to map overlaying and create thematic maps with relevant planning information.
- Community participation is still low.
- The elements related to climate change and inundation mitigation have not been mentioned in the management of drainage planning.

### **1.5. Current impacts of climate change**

#### *1.5.1. Impact of climate change in some regions in Vietnam*

Within this thesis, the author focuses on analyzing the impacts of climate change in the three coastal areas of Vietnam, meaning the Northern Region, the Central Coastal Region and the Mekong River Delta.

#### *1.5.2. Impacts of climate change in Northern Coastal Region urban areas:*

Impacts due to increasing precipitation and sea level rise; Impacts due to storms, tropical cyclones, floods; Impacts due to flash floods, mud and rock floods and landslides; Impacts due to temperature change.

#### *1.5.3. General comments*

**Table 1.1: Evaluation of climate change's impacts in some areas in Viet Nam**

	Sea level rise	Increasing precipitation	Storm, tropical cyclone	Flood	Flash flood, mud and rock floods	Landslide	Increasing temperature
Northern area	Low (Northern Coastal Region has high risks)	Moderate ( <b>Northern Coastal Region has very high risks</b> )	High	Moderate (Northeast area and Quang Ninh province have high risks)	Moderate ( <b>Northeast area has very high risks</b> )	High (Red River Delta has low risks)	Low
Central Coastal area	Moderate	Moderate ( <b>Thua Thien Hue – Binh Dinh have very high risks</b> )	High ( <b>Thanh Hoa – Ha Tinh have very high risks</b> )	High	Low	Low ( <b>Thua Thien Hue – Quang Ngai have very high risks</b> )	Low
Mekong River Delta	<b>Very high</b>	Low	Low	<b>Very high</b>	Low	High	Moderate

*(Evaluation ranges from Low, Moderate, High to Very High)*

The Northern Coastal Region is seriously affected due to increasing precipitation (highest in the country - according to the climate change scenario RPC4.5 in the period from 2016 to 2050) and flash floods, mud and rock floods (for Quang Ninh province).

## **1.6. Other related studies**

*1.6.1. Scientific studies and theses:* Not local-specific, some theses have not taken into account the climate change factors.

*1.6.2. Drainage planning and inundation mitigation projects:* Fail to propose practical models.

### *1.6.3. Evaluation*

The thesis summarized and evaluated 3 scientific projects, 2 doctoral theses, 4 studies in the world, 3 projects - proposals - reports on:

- Drainage and inundation mitigation on a large scale (regional scale, river basin, etc.).

- Drainage and inundation mitigation for each specific locality.
- Climate change and sea level rise.
- Sustainable rainwater drainage model.

### **1.7. Thesis focused issues**

Based on the evaluation, the author chose to study and resolve some of the following issues in drainage planning management:

- Scientific basis for the management of drainage planning, inundation mitigation and climate change.
- Application of sustainable drainage model.
- The process from defining missions to publishing planning proposal for drainage planning projects to mitigate inundation and adapt to climate change.
- Solutions related to the management of drainage planning to mitigate inundation and adapt to climate change.
- Improve policy, managers' capacity and community participation.
- Application of GIS technology in flood mapping.
- Application of the thesis outcomes in drainage planning management in Cam Pha City.

## **CHAPTER 2: SCIENTIFIC BASIS FOR MANAGEMENT OF DRAINAGE PLANNING TO MITIGATE INUNDATION FOR URBAN AREAS IN THE NORTHERN COASTAL REGION TO ADAPT TO CLIMATE CHANGE**

### **2.1. Rationale for drainage planning management to mitigate inundation in Northern Coastal Region urban areas and adapt to climate change**

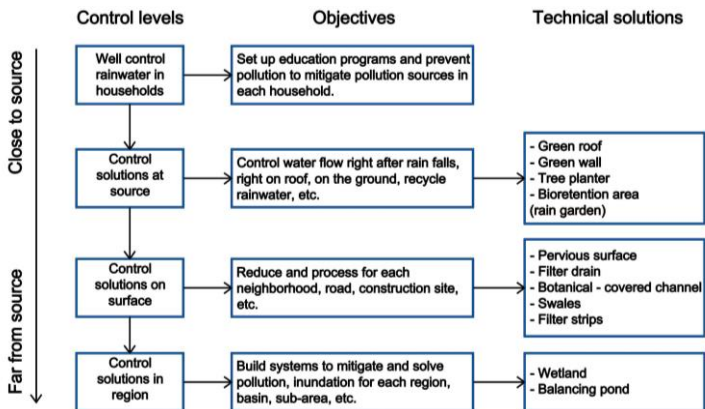
*2.1.1. Planning, drainage planning management and integrating climate change factors to mitigate inundation:* includes basic knowledge about drainage planning for urban areas, drainage planning

management for urban areas; Climate change impacts and inundation mitigation added to and mainstreamed into drainage planning proposals such as Climate Change and SLR Scenario 2016 for Vietnam, Four steps in responding to climate change, Drainage planning for inundation mitigation in urban areas.

*2.1.2. The impacts of climate change on inundation, flooding, and urban drainage systems:* Changes in inputs and margin conditions when calculating and building; increasing likelihood of destruction due to extreme climate events.

*2.1.3. GIS and its application in planning management:* Providing a systematic view and make it easy to do planning and support the decision-making process in management

*2.1.4. The model for sustainable drainage and inundation mitigation:* Introduce concepts, principles, efficiency, benefits, levels and functions of components that constitute a sustainable drainage model.



**Table 2.2: Control levels of a sustainable rainwater drainage system**

Basically, instead of quick drainage of surface runoff in urban areas through the system of canals, ditches or underground sewers, the sustainable drainage model slows down the aforementioned process with technical solutions, in which, full capacity of the natural ecosystem in storing and improving water quality is used, with the aim of bringing the most benefits to people and the living environment.

*2.1.5. The organizational structure for drainage planning management:* requirements and principles in management.

*2.1.6. Community participation in the management of drainage planning and inundation mitigation:* roles, possible areas of participation and effectiveness.

## **2.2. Legal basis for urban drainage planning management**

*2.2.1. Legal documents on drainage planning management:* Urban Planning Law (No. 01/VBHN-VPQH); Construction Law (No. 50/2014/QH13); Law on Environmental Protection (No. 55/2014/QH13); Law on Water Resources (No. 17/2012/QH13).

*2.2.2. By-law document on drainage planning management:* Decree 44/2015/ND-CP; Decree No. 80/2014/ND-CP; Decree 37/2010/ND-CP; Circular 12/2016/TT-BXD.

*2.2.3. System of standards and regulations on drainage planning management:* QCVN 07-2:2016/BXD; QCXDVN 01:2008/BXD; TCVN 7957:2008

*2.2.4. Approved planning projects related to drainage planning in Northern Coastal Region urban areas:* The part on drainage planning research has been quite sufficient while the part on the impacts of climate change and sustainable drainage solution is still missing.

## **2.3. International and Vietnam experiences in drainage planning management to mitigate inundation and adapt to climate change**

2.4.1. *Experience in Vietnam:* Solutions to manage drainage and flooding in Vinh City - Nghe An Province; Quy Nhon City; Ecopark urban area, Hung Yen - Surface rainwater management system.

2.4.2. *International experience:* Bangkok, Thailand - Flood control center; Japan; England and Wales - Managing surface runoff; US - Sustainable drainage model at George Washington University

### **CHAPTER 3: SOLUTIONS TO MANAGEMENT OF DRAINAGE PLANNING TO MITIGATE INUNDATION IN THE NORTHERN COASTAL REGION URBAN AREAS TO ADAPT TO CLIMATE CHANGE**

#### **3.1. Viewpoints, objectives and principles applied to the management of drainage planning to mitigate inundation for Northern Coastal Region urban areas to adapt to climate change**

##### *3.1.1. Viewpoints*

(i) Drainage Planning Management to mitigate inundation is associated with forecasting inundation and assessing the impacts of climate change. (ii) Using sustainable drainage planning model as an additional solution to inundation mitigation in drainage planning management. (iii) Using advanced science technology in drainage system construction and planning management. (iv) Establish “Committee on Drainage Planning Management and Inundation Mitigation for the Northern Coastal Region” to address related issues. (v) The community must participate in the management of drainage planning to mitigate inundation and adapt to climate change.

##### *3.1.2. Objectives*

(i) Integrating climate change factors and sustainable drainage model in drainage planning management. (ii) Proposing new solutions in the management of drainage system construction. (iii) Applying GIS in inundation mapping, taking into account climate change factors. (iv) Enhancing managers’ capacity in drainage planning; strengthening the relationship and coordination among localities in the region as well as

direct management agencies. (v) Defining clearly the community participation in drainage planning management.

### *3.1.3. Principles*

(i) In compliance with Decision No. 589/QĐ-TTg dated April 6, 2016 on approving the revised development orientations for urban and industrial park drainage system in Viet Nam to 2025 and vision to 2050. (ii) Maximize the use of detention reservoirs. (iii) Given the reality, make the best of the current renovated drainage system. For new areas, the construction of the drainage system as a shared, completely separate and semi-separate one as well as the application of a sustainable drainage system must be based on each urban area's specific condition. (iv) The formulation, appraisal and approval of drainage planning must comply with and inherit from relevant planning that had been approved by the authorities, in accordance with the existing legal procedures. (v) The construction management must proceed from long-term planning projects and construction phases, at the same time, taking into account the economic, technical and sanitary factors to ensure the optimization of human resources and finance. (vi) Proposed management models must be practical and suitable with the context of the region as well as each locality; The management structure model must match its roles, functions, duties and authorities assigned by the Government; there must be sufficient qualified personnel to promptly solve problems arising during implementation, investment and construction.

## **3.2. Proposed solutions for drainage planning management to mitigate inundation and adapt to climate change**

### *3.2.1. The sustainable drainage management model solution*

Help solving the hydrological impacts due to increasing precipitation in the Northern Coastal urban areas.

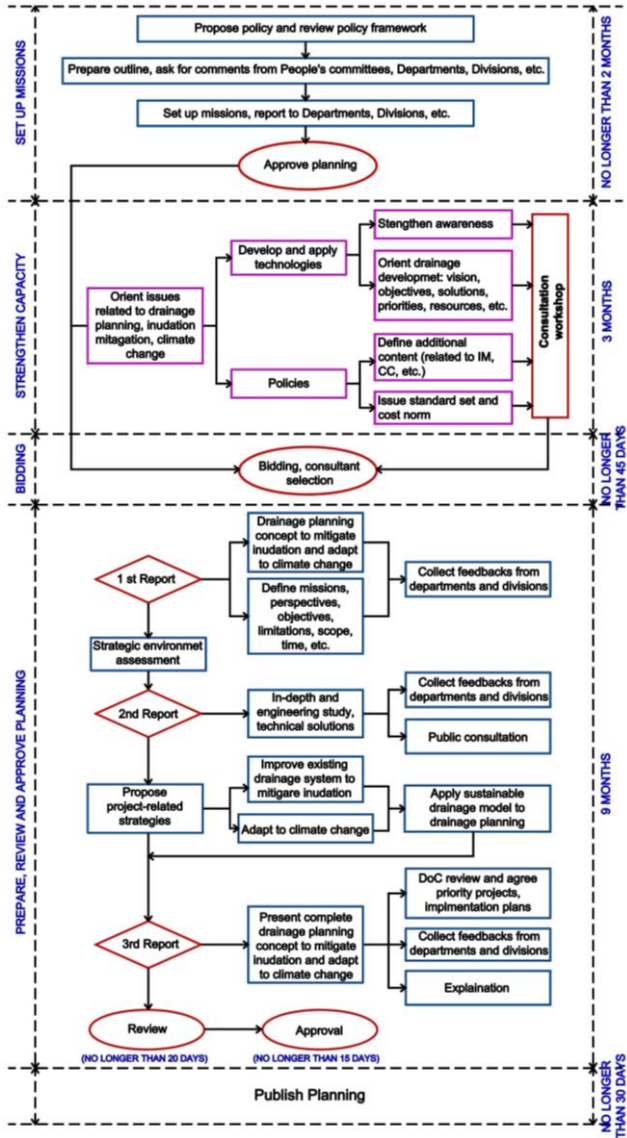
- a. Applying the sustainable drainage model to the road network
- b. Integrating the sustainable drainage model into the functions of using civil land.

**Table 3.1: The management of sustainable drainage model construction by functions of using civil land**

Land use											
No		Green area		Public land		Living area					Land for schools and other non-civil purposes
		Urban area	Living unit	Urban area	Living unit	Semi-detached houses	Apartment	Complex buildings	Villas	Villages	
<b>Control solutions at source</b>											
1	Green roof			X	X		X	X	X		X
2	Green wall			X	X		X	X			X
3	Underground water tank			X	X	X	X	X	X	X	X
4	Tree planter	X	X	X	X		X		X		X
5	Bioretention area (rain garden)		X	X	X		X	X	X		X
<b>Control solutions on surface</b>											
6	Pervious surface	X	X	X	X		X	X	X	X	X
7	Filter drain		X								
8	Swales	X									
9	Botanical-covered channel	X									
10	Filter strips	X	X								
<b>Control solutions in region</b>											
11	Wetland	X									
12	Balancing pond	X									

*3.2.2. Solutions for the process from establishing mission to publishing planning for drainage planning project to mitigate inundation and adapt to climate change*





**Table 3.1: Solutions for the process from setting up missions to publishing planning for drainage project to mitigate inundation and adapt to climate change**

### **3.3. Proposed solutions that are related to drainage planning management to mitigate inundation and adapt to climate change**

*3.3.1. Drainage management by regions and river basins:* For the main drainage axes of the region and for key irrigation works such as upstream reservoirs, spillways and drainage pumping stations.

*3.3.2. Management and development of buffer zones to protect coastal and riverside urban areas:* Cooperate with the Ministry of Natural Resources and Environment to develop plan to protect and plant new watershed forest systems to reduce the likelihood of flash flood and landslide, affecting the downstream urban drainage system (**Solution specifically for Quang Ninh area**).

*3.3.3. Management and development of lake systems:* Lakes in the region and sub-regions; Detention reservoirs in urban areas (**Solution dedicated to Thai Binh, Nam Dinh and Ninh Binh provinces**).

*3.3.4. Management of ground level:* Factors such as tide level, inundation level rise due to storm, sea level rise, etc. should be considered as well.

*3.3.5. Use of new construction materials:* Materials that are resistant to heavy rain, high corrosion, to build sustainable drainage models, etc.

### **3.4. Proposals for additional legal documents, improving managers' capacity and community participation**

*3.4.1. Addition to the Vietnam Construction Standards - Construction planning (QCXDVN 01:2008):* Proposing some elements on adaptation to climate change, the application of the sustainable drainage planning model, etc. to spatial planning and technical preparation planning.

*3.4.2. Solutions to improve managers' capacity in drainage planning to mitigate inundation and adapt to climate change*

a. For drainage management at regional and river basin scope: “Committee on Drainage Planning Management and Inundation Mitigation for the Northern Coastal Region” should be established.

b. For urban drainage planning management scale: An Urban Development and Technical Infrastructure Division should be established under the Department of Construction while the Training Management Division of the City should be put in place to train and retrain drainage planning management officials.

*3.4.3. Solutions for the application of the geographic information system (GIS) in flood mapping:* Developing the GIS database system; Operating the system, including data sharing.

*3.4.4. Solutions for the community participation in the management of drainage planning:*

a. Role of the government and community.

b. The community participation in drainage planning and construction management in accordance with drainage planning: setting out possible steps where the community can participate in to ensure the project has the best quality and is practical.

### **3.5. Applying some outcomes to drainage planning management to mitigate inundation in Cam Pha City**

*3.5.1. About Cam Pha City:* It is a grade II city under the jurisdiction of Quang Ninh provincial government, affected by the hydrological regime of Mong Duong river with many small streams, steep slopes and the diurnal tide.

*3.5.2. Characteristics of drainage systems and the inundation status in Cam Pha City:* Shared drainage systems, often blocked by waste, rock and mud, etc. In some areas, the bed level of the sewage is lower than the sea level rise at high tide.

### 3.5.3. *The current status of planning management in Cam Pha City:*

Comply with the General Construction Planning Scheme of Cam Pha City to 2030, vision to 2050 and beyond 2050.

### 3.5.4. *Redefining construction ground level taking into account climate change factors*

a. Basis of calculation:  $H_{\text{build}} = H_{P\%}^{\text{max}} + H_{\text{sl}} + H_{\text{cc}} + a$

b. Redefine construction foundation elevation taking into account climate change factors: For Cam Pha - Cua Ong civil areas, the minimum construction control height is + 3.7m; For industrial parks and areas along the sea, the minimum ground level must be + 3.9m; Existing residential areas in the downtown of the city that has ground level below +3.7m should be referred to project owners to find solutions.

### 3.5.5. *Application of GIS technology in inundation mapping integrated with climate change*

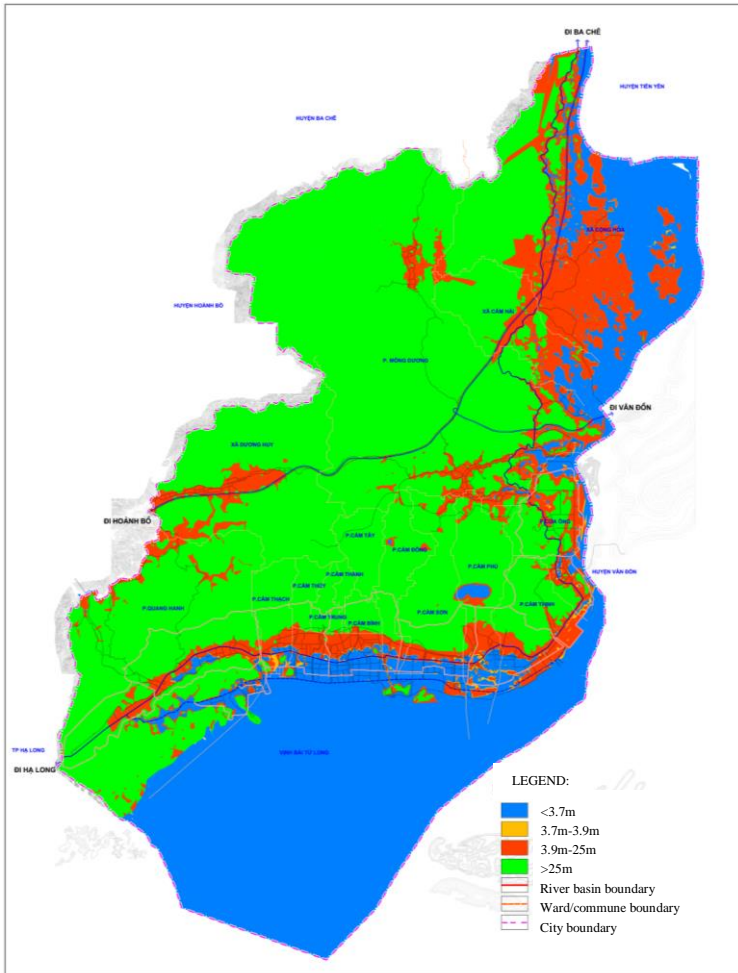
a. Software selection:

b. Results:

\*Inundation mapping for Cam Pha City (Figure 3.2)

\*Compare with the inundation mapping, taking into account climate change factors, using topographical map overlapping, based on the boundaries of wards and communes, the spatial development orientation diagram, etc., the author put forward the areas that are likely to suffer from inundation. Proceeding from which, the following comment is raised: The area of Cong Hoa commune, Cam Hai commune and Cua Ong ward has large flooded areas (20% -33%) and have no land reserved for urban construction; The development of urban areas towards the south is reasonable; It is proposed that the

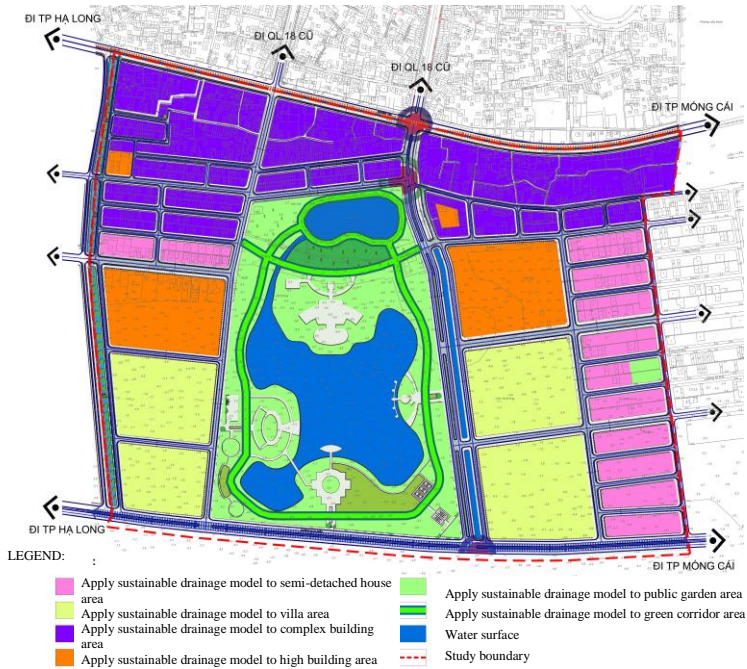
minimum level of polder is raised from +3.5 to +3.9m to mitigate inundation.



**Figure 3.2: Inundation map that takes into account climate change for Cam Pha City according to the Climate Change Scenario (2016) RPC4.5 to 2050**  
 3.5.6. *Some solutions for technical issues, design and construction according to planning*

- a. General solutions
- b. For the southern area of the city
- c. For suburban areas
- d. For coastal areas and land reclamation
- e. Application of sustainable drainage model

### 3.5.7. Application of sustainable drainage model for new urban area in Cam Trung ward, Cam Pha city



- Figure 3.3: Chart for the application of sustainable drainage system for the new urban areas in Cam Trung ward, Cam Pha city**
- a. Construction and control of rainwater at households
  - b. Control solutions at source: Applying the sustainable drainage model to areas of semi-attached houses, villas and high buildings.

c. Control solutions on surface: Applying the sustainable drainage model to complex areas.

d. Control solutions in region: Applying the sustainable drainage model to public gardens and green corridors.

### **3.6. Discuss some research outcomes**

#### *3.6.1. Compare with outcomes of other pieces of research*

The author has proposed a flexible plan for drainage system management by applying additional solutions such as the application of sustainable drainage models to reduce the pressure on traditional drainage systems. This process consists of two parts:

+ The object is traditional drainage system:

- Proposing solutions related to traditional drainage planning to mitigate inundation adapting to climate change. (Section 3.3)

- Using the climate change and sea level rise in 2016, applying GIS technology to flood mapping, redefining the construction core for urban areas. (Section 3.4.3)

+ The object is sustainable drainage model: in order to solve the issue of flow expected to increase in the future, proposing measures to retain water, slow down the surface runoff. This solution is not only in the scope of water drainage planning but also in combination with transportation system, land use functions, landscape architecture, etc. (Section 3.2.1)

In order to put the proposals into practice, the author has supplemented some contents as follows:

- Integrating the contents of climate change into the process from establishing missions to publishing proposal for drainage plan to mitigate inundation. (Section 3.2.2)

- Supplementing Vietnam Construction Standards - Construction planning (QCXDVN 01:2008). (Section 3.4.1)

- Proposing solutions to improve drainage planning management capacity. (Section 3.4.2)

*3.6.2. Discuss the applicability of sustainable drainage model for other urban areas:* The thesis provides some remarkable notes to apply the sustainable drainage system to other urban areas.

*3.6.3. Discuss the importance of community participation in drainage planning management:* The role of community is very important from establishing and managing plan to implementing construction following the planning.

## **C. CONCLUSIONS AND RECOMMENDATIONS**

### **CONCLUSIONS**

The thesis has clarified some points as follows:

- The Northern Coastal Region is the most affected area in terms of increasing precipitation (ranking at number 1 position of the whole nation in the 2016 Climate Change Scenario), which is the main cause of urban inundation. Therefore, it is proposed to apply a sustainable drainage model for this area to help solving the hydrological impacts due to highly increasing precipitation.

- In the North of Northern Coastal Region, including the urban areas of Mong Cai, Uong Bi, Cam Pha and Ha Long with steep terrain, large proportion of forest land, flash floods often occur on the occasion of heavy rain. It is proposed to manage the development of buffer zones to protect coastal and riverside urban areas, especially cooperating with the Ministry of Natural Resources and Environment to develop a plan to protect and plant watershed forest systems in order to prevent flash floods and landslides from affecting drainage systems in downstream urban areas.

- In the South of Northern Coastal Region, including the urban areas of Thai Binh, Nam Dinh, Ninh Binh and Tam Diep with steep terrain, a large proportion of green trees and water surfaces (detention reservoirs) with the role of retaining and absorbing water in case of rain, which help reducing inundation. It is proposed to manage and



develop a system of detention reservoirs in the region, sub-regions and urban areas.

The proposed content considered to be new contributions including:

**1. Proposing solutions related to the management of drainage planning to mitigate inundation and adapt to climate change:**

Compared to previous research, the thesis does not only study water management at the scale of individual urban area but also at large-scale with connection features, such as drainage by regions and river basins, including the proposal of establishing “*Committee for management of drainage planning, mitigation of coastal inundation for the Northern Coastal Region*” to help improving management capacity; Managing the development of buffer zones to protect coastal and riverside urban areas; Managing and developing the system of detention reservoirs; Controlling ground level; Using new construction materials.

**2. Applying and operating GIS systems, flood mapping:** Based on evaluating pros and cons of some simulation tools applied in management of water drainage planning and selection of software, the thesis has applied geographic information system - GIS to flood mapping with taking climate change factors for Cam Pha City in the climate change scenario (2016) RPC 4.5 toward 2050 into consideration. Then, the percentage of inundation for wards and communes will be identified. Based on the method of topographic map overlaying and spatial development orientation diagrams, it is reasonable to reaffirm that the development of sea encroachment urban toward the South. It is proposed to raise the minimum level of polder in Cam Pha City from +3.5m to +3.9m to mitigate inundation and to develop mechanism for organizing, managing and sharing GIS data among stakeholders.

**3. Supplementing and completing the process from establishing missions to publishing the planning proposal for drainage plan to mitigate inundation and to adapt to climate change:** Based on the overall evaluation, the thesis presents theoretical and legal issues related to the process of developing drainage plan. Accordingly, the specific proposals will be delivered and integrated with climate change, as well as clearly indicated time and missions, functions, responsibilities of executing and agencies and of review and approval agencies.

**4. Concretizing the sustainable rainwater management solutions, locating the study area in New urban area in Cam Trung ward, Cam Pha city:** Based on the scientific basis of sustainable rainwater drainage model, the thesis proposes to supplement the sustainable drainage model following road network and the functions of using civil land. This model will be applied specifically to the New urban area in Cam Trung ward, Cam Pha city, such as controlling rainwater at households applied to semi-detached houses, villas, apartments, complex houses, public gardens and green corridor areas.

## **RECOMMENDATIONS**

1. Proposing the Ministry of Construction to

- Consider reporting to the Government, issuing a system of documents to supplement content related to inundation and climate change.

- Report to the Government on allowing to establish the Regional drainage management model; restructure the Division of Technical infrastructure under Department of Construction and Division of Urban management of the city

2. Proposing to Cam Pha City

3. Proposing to resident community

## **LIST OF THE AUTHOR'S PUBLISHED PAPERS RELATED TO THE THESIS**

1. Ngo Huy Thanh, *Hành lang pháp lý trong quản lý quy hoạch thoát nước (Legal Framework in drainage planning management)*. Planning Magazine, Ministry of Construction, Issues 89 + 90 of 2017.

2. Ngo Huy Thanh, *Ngo Huy Thanh, Ứng dụng hệ thống thoát nước mưa đô thị bền vững nhằm giảm thiểu ngập úng, thích ứng với biến đổi khí hậu cho các đô thị Vùng duyên hải Bắc Bộ (Application of sustainable urban rainwater drainage system to mitigate inundation to adapt to climate change for Northern Coastal Region)*, Planning Magazine, Ministry of Construction, Issue 93 in 2018.

3. Ngo Huy Thanh, *Bài học kinh nghiệm trong quản lý thoát nước nhằm giảm thiểu ngập úng thích ứng với biến đổi khí hậu tại một số đô thị trên thế giới (Experience lessons in drainage management in order to mitigate inundation to adapt to climate change in some urban areas in the world)*, Planning Magazine, Ministry of Construction, Issue 94, 2018.