ASSESSING THE IMPACTS OF EXTREME FLOODS ON AGRICULTURE IN VIETNAM: QUANG NAM CASE STUDY

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Abstract

Vietnam is situated within the tropical monsoon and typhoon zone of South-East Asia and is susceptible to extreme flood events. Since the most productive agricultural land is concentrated along the low-lying river systems, losses to agriculture resulting from extreme flooding can be significant. More than 70% of the country's population live in rural areas, many in flood prone zones, and depend upon subsistence agriculture. However, to date, there have only been a limited number of studies addressing the impact of extreme flood events on agriculture in Vietnam.

Using the Quang Nam province of central Vietnam as a case study, geographic information systems and digital elevation modeling are used to create geo-spatial inundation maps of flooded agricultural land. The mapped areas are populated with agricultural land use data and the direct costs of agricultural flood damage are calculated. Additionally, the institutional and legislative framework of Vietnam is assessed to determine whether there may be ways of streamlining systems and institutions to improve responses to extreme flooding events.

This study shows that 1:10, 1:20 and 1:100-year flood events result in inundation levels of 27%, 31% and 33% of arable land respectively. The direct crop damage incurred in the inundated regions, expressed as a percentage of total value, are 12%, 56% and 62% respectively. The study also offers recommendations to improve flood management strategies.

Acknowledgements

This research journey was a challenging experience for me. I received my education from a passive learning system where students are told to do what their teachers require. However, in New Zealand, I was required to identify problems and I was responsible for solving problems under the guidance of my supervisors. At beginning, it was broad and I was so nervous. I read not only the literature on my research area, but also consulting the media for any pieces of information they broadcasted. I desired to contribute to natural disaster management in some way and to obtain skills that will enable me to assist with the issues facing my country both today and in the future.

I am indebted to a number of people for their help with this thesis. Firstly, I wish to thank my supervisors Associate Professor John Holland and Dr Sue Cassells for their guidance and patience, and for what they have taught me, not only about science, but life. They were both consistently encouraging and supportive. In particular, I want to thank John, my big picture man for his intelligence, creative thoughts and endless enthusiasm. I'm grateful to Sue for not only her professional, relentless attention to detail and writing guidance, but also for what I learned from her as a role model outside of the academic discipline. I would not have completed this thesis without having them as my supervisors. Their help was appreciated more than they will know.

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Abbreviations

ADB	Asian Development Bank
B/C	Benefit-cost ratio
CBA	Cost-Benefit Analysis
CCFSC	Central Committee for Flood and Storm Control
CCFSCSR	Commune Committee for Flood and Storm Control and Search and Rescue
CRED	Centre for Research on the Epidemiology of Disasters
DARD	Provincial Department of Agriculture and Rural Development
DCFSCSR	District Committee for Flood and Storm Control and Search and Rescue
DEM	Digital Elevation Model
DMC	Disaster Management Centre
DMFSC	Dyke Management and Flood and Storm Control Department
DOF	Provincial Department of Finance
DONRE	Department of Natural Resources and Environment
DPI	Provincial Department of Planning and Investment
EVN	Vietnam Electricity
GDP	Gross Domestic Product
GIS	Geographic Information System
GSO	General Statistical Office
IDW	Inverse Distance Weighting
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LNDPM	Law on Natural Disaster Prevention and Mitigation
MARD	Ministry of Agriculture and Rural Development

MOD	Ministry of Defence
MOF	Ministry of Finance
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
NCSR	National Committee for Search and Rescue
OOG	Office of Government
PC	People’s Committee
PCFSCSR	Provincial Committee for Flood and Storm Control and Search and Rescue
pers.comm	Personal communication
UNDP	United Nations Development Programme
VND	Vietnam Dong (Vietnamese currency)

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Chapter 1

Introduction

1.1 Background

Flooding, storms and other natural disasters are a part of everyday life in many parts of the world and they are being reported with increasing frequency. According to the Centre for Research on the Epidemiology of Disasters (CRED, 2013a), there were 3,646 floods[1] alone reported between 1970 and 2011. Of these floods, only 8% occurred during the 1970s, however, 15%, 27% and 49% occurred during the 1980s, 1990s and 2000s, respectively. Within this 32-year period, the average annual global cost of flood damage was US$90 billion. The cost of the damage attributable to natural disasters worldwide reached more than US$360 billion in 2011 (Guha-Sapir, 2012). Such disasters leave developing countries like Vietnam particularly vulnerable as their capacity to respond is significantly lower than more developed countries (Mechler, 2003). While capital losses in the developing world might be smaller than those in developed countries, their loss and the relative impact tends to be very severe (Economic Commission for Latin America and Caribbean (ECLAC), 2003).

Vietnam has a population of approximately 86 million, with more than 70% living in rural areas and working in the agricultural sector (General Statistics Office of Vietnam (GSO), 2010). Since 2000, the agriculture sector has grown by an average of 4% per annum and now contributes more than 20% to the country's Gross Domestic Product (GDP). From being a food importing country in the 1980s, agriculture lifted Vietnam to become one of the world's largest rice exporters (by volume) from the early 2000s. This led to a reduction in poverty

[1] CRED classifies flood into coastal flood, riverine flood, flash flood and ice jam flood.

rates[2] from a rate of nearly 60% in the early 1990s to 20.7% in 2010 (World Bank, 2013).

Vietnam is an ‘S’ shaped country that covers an area of 330,000 km^2 with a coastline of approximately 3,000 km. Thousands of rivers and streams originate from mountainous areas covered with dense forests, and flow through the hilly landscape and alluvial plains before discharging into the East Sea. The biggest river systems in Vietnam are the Red River in the north and the Mekong River in the south, both of which have formed large delta plains that support intense agricultural production. Beside these two deltas, the Central coastal plain (including Quang Nam province) is the third major agricultural region of the country, with terrain characterised by a relatively narrow strip of high mountains steeply sloping towards the East Sea. The country’s climate, topography and river networks are sources of floods that not only supply nutrients to the alluvial plains, but also damage property and claim human lives annually. Vietnam, situated within the tropical monsoon and typhoon zone of South-East Asia, is considered to be among the most vulnerable countries to natural disasters (Harmeling & Eckstein, 2012; World Bank, 2010b).

Of all the extreme weather events, flooding has the most significant impact on the river deltas and coastal plains where the majority of Vietnamese population is concentrated. These areas are also cultural, political and socio-economic centres that contribute to the country’s development. Vietnamese peasants’ cultivation has been practiced in the plains for thousands of years and the fields are imbued with their sweat and tears.

[2] The 2010 poverty line in Vietnam was VND653,000/person/month (World Bank, 2013).

Vietnamese people have thousands of years' experience in dealing with flood events and three different strategies for flood prevention and mitigation for these three most populated regions of Vietnam have evolved. Dyke protection is the main approach to flood prevention and mitigation in the Red River delta, and it includes upstream forest protection, flood diversion, and reservoir control. Living with flooding is the cultural philosophy underpinning life in the Mekong delta, which includes building embankments for crop protection and permanent shelter for residents, changing crop patterns, modifying housing construction and resettlement. Finally, the key strategies for the central region are active preparedness, mitigation, and adaptation. Ways in which these strategies are implemented include drainage improvement, changing crop patterns, establishing an early warning system, building multi-purpose upstream reservoirs and supporting community preparedness measures (Prime Minister of Vietnam, 2007).

Though the flood management strategy is adapted for each region, several questions need to be answered for effective implementation of flood management policies in Vietnam. These include questions such as: what will be affected by flooding? How much will flood damage cost? What can be done before and after a flood event to minimise the impacts? Who is responsible for administration and oversight of these issues? It is not easy to find answers to these important issues, especially in an environment characterised by a high degree of uncertainty (Hien, Trung, Looijen, & Hulsbergen, 2005).

1.2 Problem statement

Despite advances in technology and the agricultural sector's vulnerability to weather, this sector depends on natural weather patterns and climate cycles for its productivity. However, the combination of rising sea-level, land degradation, and extreme events, such as storms, heavy rains and flooding, threaten agriculture production in Vietnam. Though flooding is not a new phenomenon, the increasing frequency of extreme flood events during the last two decades has raised concerns about Vietnam's susceptibility to flood damage (Ministry of Natural Resources and Environment (MONRE), 2009; World Bank, 2010b).

The traditional method of flood mapping uses complex hydraulic modelling and employs historical discharge data that are not always available. While Geographic Information Systems (GIS) technology can be used to map the extent of flooding, it can also be used for infrastructure and agricultural crop damage assessment (Samarasinghe et al., 2010; Uddin, Gurung, Giriraj, & Shrestha, 2012). Researching the impacts of flooding on agriculture using applied GIS techniques is receiving increasing attention in the scientific world. However, there has been limited application of geospatial assessment tools, including GIS, to assess the impacts of extreme flooding on agricultural land in Vietnam.

In addition, flood damage evaluation in rural areas, particularly flood damage assessments of agricultural production, are either frequently neglected or measured using simplistic approaches and rough estimates because the expected losses are typically much lower than those in urban areas (Förster, Kuhlmann, Lindenschmidt, & Bronstert, 2008). In order to understand the impact of flooding upon agriculture in central Vietnam as well as make recommendations regarding flood management, it is necessary to identify and quantify the physical and economic impacts of flood events as well as review flood management practices from an institutional perspective.

1.3 Aim and objectives

The aim of this research is to show how geospatial technologies, economic analysis techniques and institutional reform can improve decision making to reduce the vulnerability of Vietnam's agricultural sector to extreme flood events.

To achieve this aim the case study area of Quang Nam province was chosen and several objectives have been determined. They are as follows:

- Develop a rapid and accurate method to map flooding using existing data;
- Estimate the economic impact of extreme floods on agricultural production;
- Evaluate the institutional arrangements relating to flood prevention and mitigation;
- Identify opportunities to strengthen existing flood management practices.

1.4 Limitations

When calculating the direct pecuniary impact of floods on agricultural production, the study is confined to the production of the four main crops (rice, corn, beans and ‘other vegetables’) that constitute more than 70% of the value of cultivation output. No animal husbandry and indirect flood damage studies were undertaken in this research.

The flood events in this research refer to three flood classes, 1:10, 1:20 and 1:100-year floods. The impacts of small normal floods as well as floods with frequencies other than these three flood classes were beyond the scope of this research.

1.5 Contribution to research

This thesis illustrates the methods for geo-spatial inundation mapping and for assessing the economic impacts of extreme flood events on agriculture. The application of GIS technology and cost-benefit analysis will extend knowledge of the use of current technologies for flood risk management in Vietnam, which has received little attention in the past. This study provides information that will allow more accurate flood management measures to be considered to strengthen Vietnam’s flood management capacity.

The recommendations emanating from this study address leadership, the application of technical and economic analyses, and institutional arrangements to enhance and improve flood management in Vietnam. Whilst the case study is undertaken at a provincial level, the principles used in this research can be extrapolated to the national level.

1.6 Thesis structure

This thesis is comprised of eight chapters. Four of these chapters (Chapters Three to Six) are written in the form of journal articles, each of which builds upon the results of the previous chapter or chapters. Three chapters have been published, and the fourth chapter was submitted to a peer-reviewed journal. For each publication, the concept development, data collection and analyses, and the interpretation of results were all implemented by the first author and author of this PhD. Initial manuscript drafts were completed by the first author, with feedback was and guidance given by the co-authors (doctoral supervisors). Suggested changes were reviewed by the first author, who was also responsible for paper submission and emendations required by the reviewers. While they stand alone, the publications also combine to achieve the stated aim and objectives of this thesis. Each chapter then includes a background and literature review section, in order to put the research into its intended context. Thus, to avoid repetition, there is no single literature review.

The remaining chapters are presented in the following format:

Chapter 2: Study area description.

Chapter 3: Adapting GIS to map extreme floods in Vietnam (published in Applied Geography, 2013, *41*, 65-74).

Chapter 4: Calculating the cost of agricultural losses from flood events in central Vietnam (published in Natural Hazards, 2014, article first published online: 10 SEPT 2014).

Chapter 5: Institutional structures underpinning flood management in Vietnam (published in International Journal of Disaster Risk Reduction, 2014, *10*, 341–348).

Chapter 6: Strengthening flood management in the agriculture sector in Vietnam.

Chapter 7: Discussion.

Chapter 8: Conclusions and recommendations.

Chapter 2

Study area description

2.1 Introduction

Quang Nam province is located in the central region of Vietnam and covers an area of 10,408 km^2. It is bordered by Da Nang City, Thua Thien Hue province in the north, Quang Ngai province in the south, Kontum province and Lao PDR on the west and to the east, the East Sea (Figure 2.1). Land along the more than 80 km of coastline is relatively flat, with an average elevation of less than 30m. Moving in land from the west and elevation rises so that almost three quarters of the province is characterised by mountainous and highland areas. The highest point of elevation is Ngoc Linh Mountain (which Quang Nam province shares with the neighboring province of Kontum) which is more than 2500m above sea-level. Quang Nam province has 18 administrative units consisting of Tam Ky city (the capital city), Hoi An city and 16 other districts[3]. The population of the province was 1,425,395 in 2010 with more than 80% living in rural areas. The average population density for Quang Nam was only 137 people per km^2 compared with the 2010 national average of 260 people per km^2. However, the population is unevenly distributed, with the majority concentrated in the low-lying areas as can be seen from Figure 2.1.

[3] It is noted that Vietnam is divided into 63 provinces and municipalities, which are then subdivided into districts, towns and cities. Each district, town and city is continuous subdivided into communes (for districts) and wards (for city and townships).

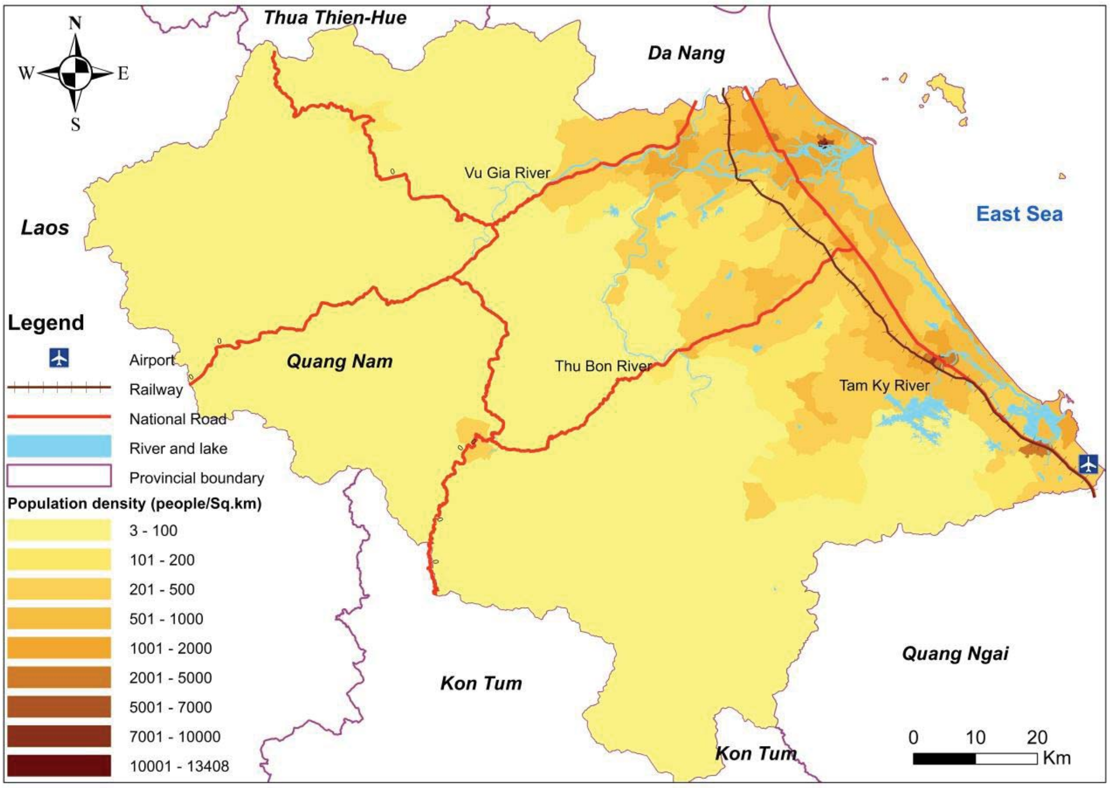
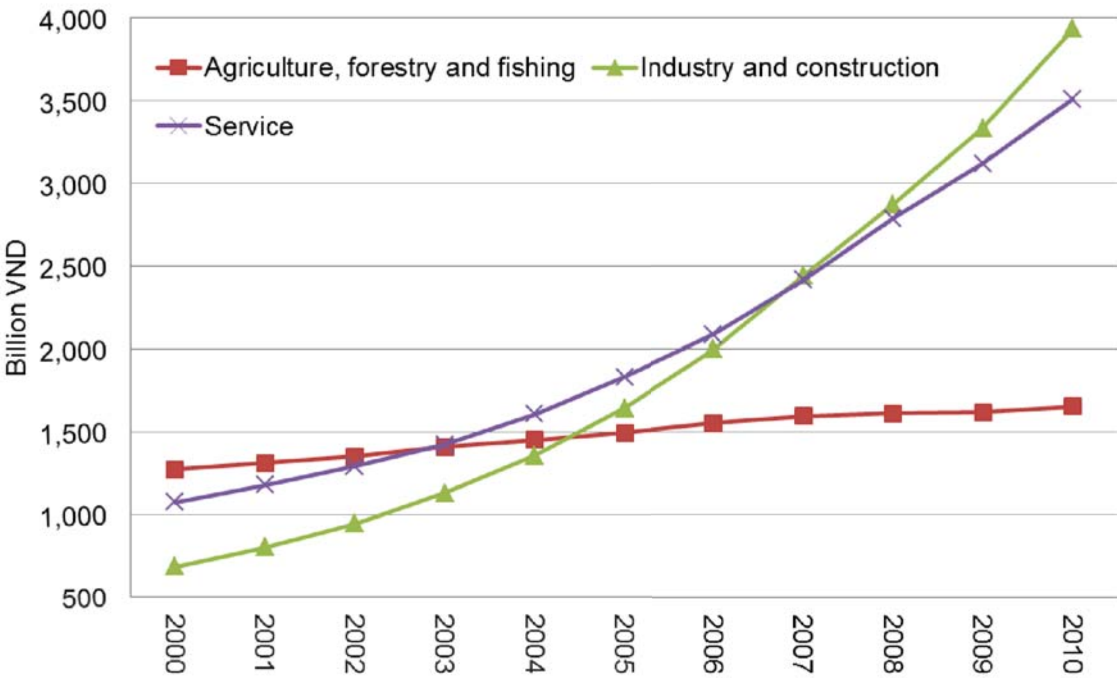


Figure 2.1. Population allocation and basic infrastructure of Quang Nam province.

The provincial economy has been growing rapidly in recent years with the GDP growth rate ranging from 12% to 15% from 2005 to the present (Quang Nam Statistics Office, 2007, 2011) - 2008 and 2009 were exceptions due to the global financial crisis. The province's GDP growth in 2010 was 12.7%. The economy diversified significantly during the last ten years and industry has been the main driving force of the economy. In 2000 the industrial sector contributed 25.3% of provincial GDP but by 2010 this had risen to 40.5% of provincial GDP. Concomitantly, the contribution from agriculture, forestry and fishing decreased from 41.5% in 2000 to 21.4% of provincial GDP in 2010. In spite of this, the majority of the work force remains employed in the agricultural sector at almost 500,000 people (60% of the province's labour force). Seventy five percent of the province's cultivated agricultural land is used to produce rice and productivity has increased from more than 300,000 tonnes in 2000 to 412,000 tonnes in

2010. Despite its falling contribution to the province's GDP, agricultural output has increased significantly during the last 10 years and it remains an important economic sector in Quang Nam, especially for the poor.

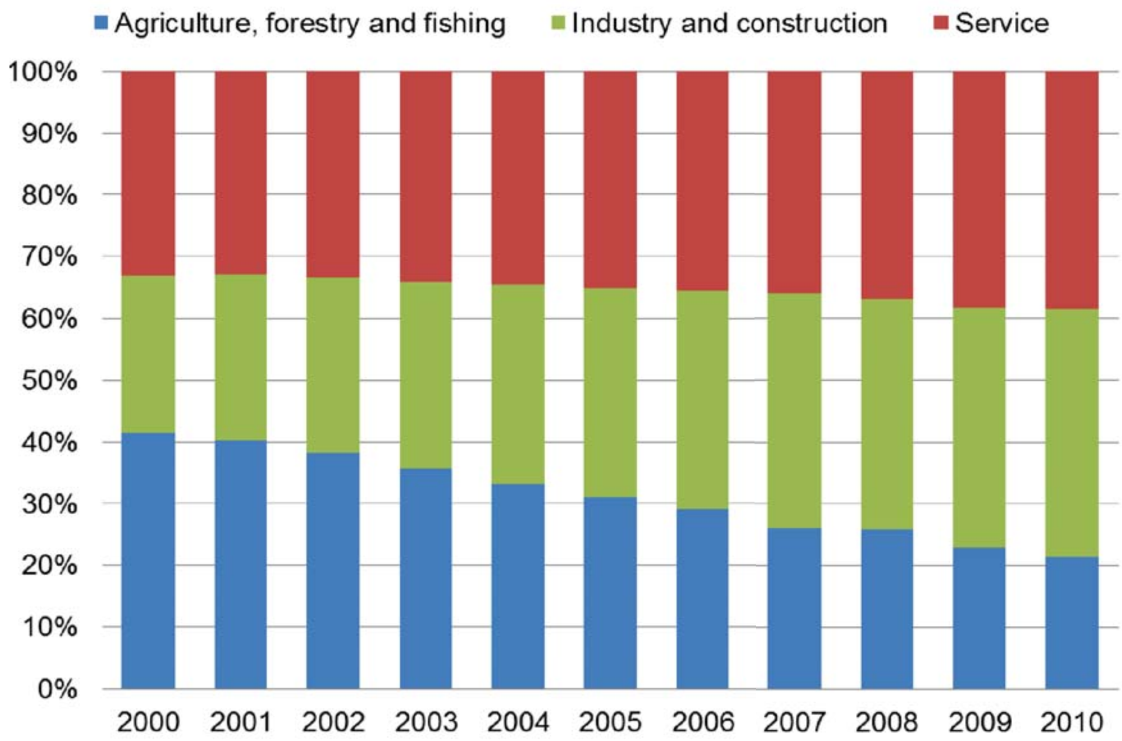
A challenging climate that experiences annual floods and storms has made the central regions (including Quang Nam) economically underdeveloped compared with other provinces in Vietnam. Despite high GDP growth rates in the last few years, Quang Nam's GDP per capita remains lower than the average for Vietnam. Figure 2.2 shows the contribution of a number of economic sectors towards real GDP in 1994 prices.



Data sourced from the Quang Nam Statistics Office, (2007, 2011).

Figure 2.2. Contribution to GDP from agriculture, industrial and service sectors (1994 prices).

It can be seen from Figure 2.2 that the contribution to Vietnam's GDP from the agricultural sector was dominant until 2003 when it was overtaken by the service sector and then industry in 2005. At that time Quang Nam province's economic development plans emphasised industrial development that grew rapidly and became the major contributor to real GDP in 2007.



Data sourced from the Quang Nam statistics office, (2007, 2011).

Figure 2.3. Sectorial contribution to GDP in Quang Nam province.

A sectorial contribution to GDP in Quang Nam for the period of 2000-2010 is presented in Figure 2.3. During 2000-2003 agriculture was the strongest contributor towards provincial GDP. In 2000 agriculture contributed 42% of GDP but had declined to 36% by 2003 and had fallen to 21% of total provincial GDP by 2010. During the period 2005-2010, Quang Nam's economy underwent significant structural transformation when the industrial and service sectors experienced marked growth and increased their contributing proportion to the province's GDP. By 2010, the contribution of industry and service in GDP reached 78.6%, in contrast, agriculture, forestry and fisheries only accounted for 21.4%, demonstrating Quang Nam's successful transition to a modern industrialised economy.

Despite its relative decline to other sectors, the agriculture sector remains pivotal in the province's socio-economic development as it provides the inputs for the thriving food processing industry and employs 60% of the workforce in the province. It also offers some major export products, such as cashews and cassava.

2.2 Quang Nam agriculture

The agricultural sector makes a significant contribution towards provincial food security and poverty reduction with rice being the most important crop and accounts for about 50% of the province's total arable area, with maize, fruit crops and annual crops making up the balance. The average yield increased significantly from 3.28 tonnes/ha and 2.61 tonnes/ha in 1997 to 5.06 tonnes/ha and 4.62 tonnes/ha respectively in 2010 and this resulted in a rise in total production from 331,000 tonnes in 1997 to 413,000 tonnes in 2010. About 85% of rice production originates from nine districts that are frequently inundated.

Agriculture in Quang Nam province is diverse as can be seen from Figure 2.4 that depicts a typical cultivated land.

Photo: *Vo Van Nghi*

Figure 2.4. Mixed maize and peanut farming in Quang Nam province.

To maximise the income from agriculture, two to three crops are sown each year with farmers taking risks by planting the crop along the river banks just before and during the flood season (Figure. 2.5).

Figure 2.5. Cultivated crops along the Vu Gia-Thu Bon river bank.

Cultivated areas like that shown in Figure 2.5 are common in Vietnam and the annual floods provide required nutrients to the soil for crops production. It is noteworthy that no flood protection infrastructure can be seen along the river banks.

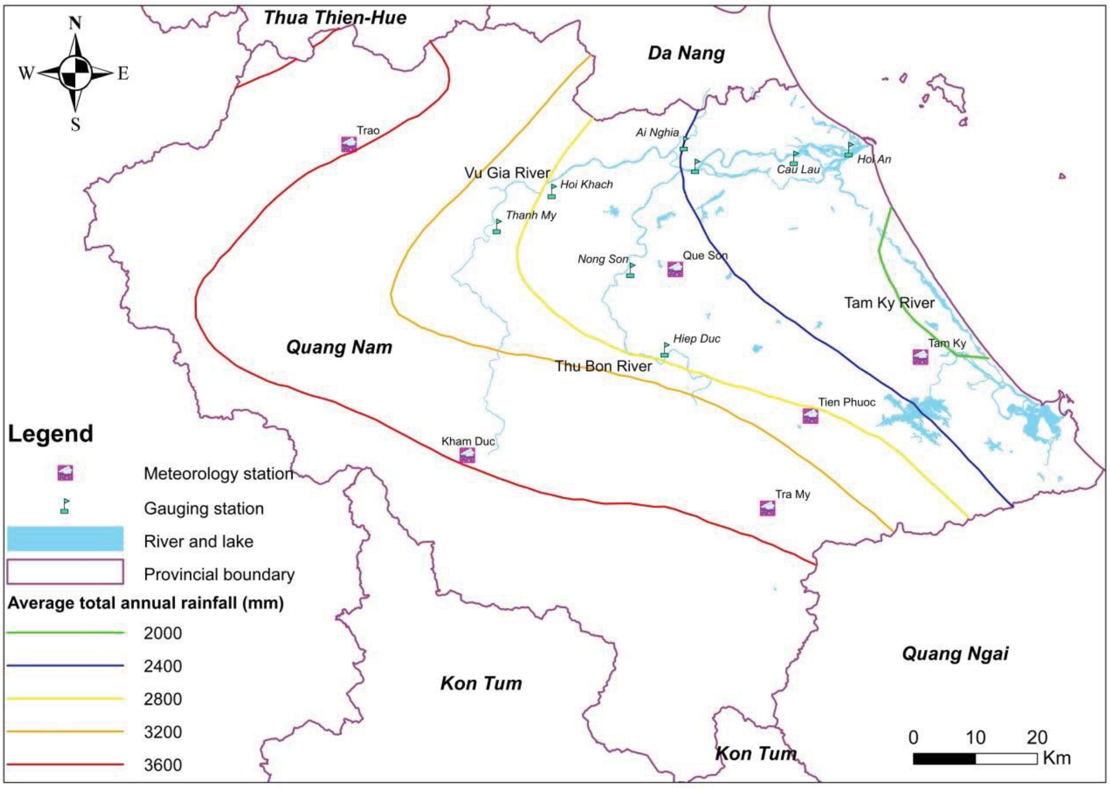
Cows, buffalos, pigs and chickens, accounted for approximately 28% of the provincial agriculture's total GDP and despite the impact of foot and mouth disease and bird flu, there were an estimated 270,000 head of cattle in 2010 (an increase of 9% from 2000) and the number of poultry was about 4 million (up 3% from 2000).

The province's prime agricultural land is situated in low lying regions where the soil is most fertile and, in terms of rice-growing, where it can take advantage of the nutrient deposits associated with annual floods that increase soil fertility. This, however, leaves prime agricultural land susceptible to extreme flooding leaving crops vulnerable to being destroyed.

2.3 Climate

Quang Nam's climate is influenced by tropical monsoon conditions and the topographical effects of the surrounding hills and sea. Annual average temperature is 25^{o}C and tends to be higher in the coastal plains and lower in the mountains. Relative humidity ranges from 80 to 90% while annual evaporation varies from approximately 1000mm in high mountainous areas to 1500mm near the coastal plain.

Quang Nam province experiences relatively high rainfall that contributes significantly to flooding. The province receives approximately 2,600mm of rainfall annually, of which, about 70% of the annual rainfall occurs during the flood season. October and November account for 40 – 50% of the annual rainfall (Figure 2.6).



Source: The Institute of Geography (2010).

Figure 2.6. Spatial distribution of average annual rainfall in Quang Nam province.

The separate or combined effect of tropical cyclones, tropical depressions and cold fronts are the main causes of heavy rain in Central Vietnam in general and in Quang Nam in particular. They mainly occur from July to December with the average rainfall of 200 to 400mm over few to five days. However, if a cyclone or tropical depression meets a cold front from the North this can result in 500 to 600mm and in even 1000mm of rainfall.

2.4 Topography and river systems

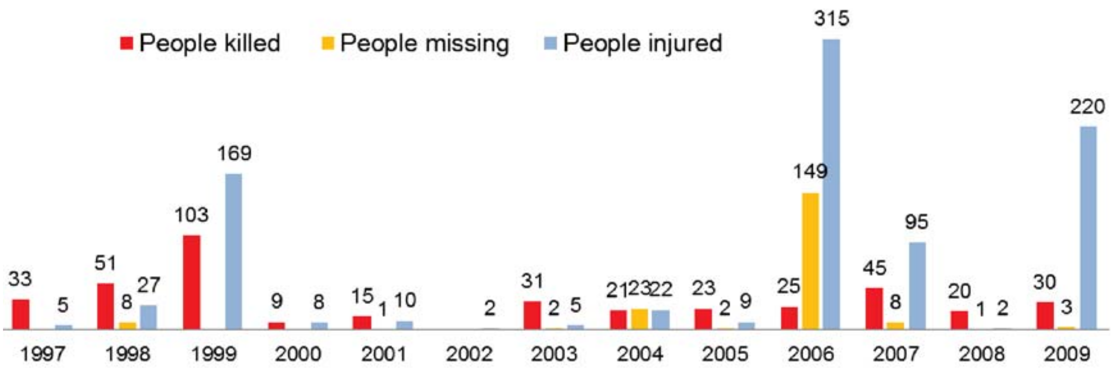
Located in the centre of Vietnam, Quang Nam is characterised by a sloping topography from West to East with many mountainous ranges, short rivers and narrow deltas. These factors, combined with high rainfall, make Quang Nam vulnerable to flood and water-related disasters. The mountainous terrain has an average elevation of 700 to 800m and it makes up more than 70% of the province's total area. Hilly and midland terrain with an average height between 100 and 200m is predominant in four districts including Tien Phuoc, Hiep Duc, Nong Son and Que Son. The rest of the districts are located within the coastal plain which is relatively flat with an average elevation of less than 30m.

The Vu Gia-Thu Bon river and the Tam Ky river are two major river systems connected by the Truong Giang river and cover much of Quang Nam province. The Vu Gia-Thu Bon river system has one of the largest river basins in central Vietnam, covering 10,350 km^2. The river system originates east of the Truong Son range in Kontum province. While the upper reaches of the river are narrow and bounded by high bluffs, the river then opens up in the middle and lower reaches as it flows through the midlands to the seas. Consequently, the downstream portions of the river are frequently inundated during the flood season.

2.5 Natural disasters in Quang Nam

Vietnam is one of the most disaster-prone countries in the world and the central region of Vietnam is at particular risk from disasters (Kellogg Brown & Root Pty. Ltd., 2009). Central Vietnam frequently suffers from extreme weather events including tropical cyclones, tropical depressions, floods, landslides, droughts, whirlwinds and salinity intrusion. Storms and floods usually occur between September and January while droughts and salinity intrusion regularly occur from March to July.

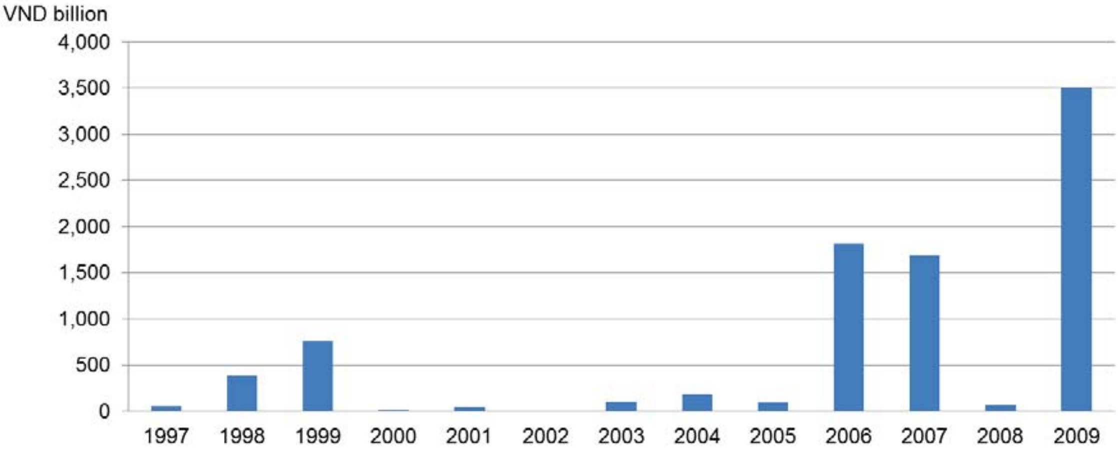
Natural disasters significantly impact the province, causing loss of life and possessions, interrupt economic and disturb human activity. According to Quy (2011), natural disasters caused an annual average loss of 6% of provincial GDP from 2003 to 2008. In a year of particularly high flooding, the resulting economic cost can reach 20% of GDP. From 1997 to 2009, more than 1500 people either died, were reported missing or were injured by natural disasters. The human casualties are presented in Figure 2.7.



Data sourced from the Central Committee for Flood and Storm Control (2012).

Figure 2.7. Casualties caused by natural disasters in Quang Nam province from 1997 to 2009.

As can be seen from Figure 2.7, the number peaked in 2006 as a consequence of the tropical cyclone Xangsane. The value of the damage caused by natural disasters is presented in Figure 2.8.



Data sourced from the Central Committee for Flood and Storm Control (2012).

Figure 2.8. Total damage caused by natural disasters from 1997 to 2009 in Quang Nam province (VND billion).

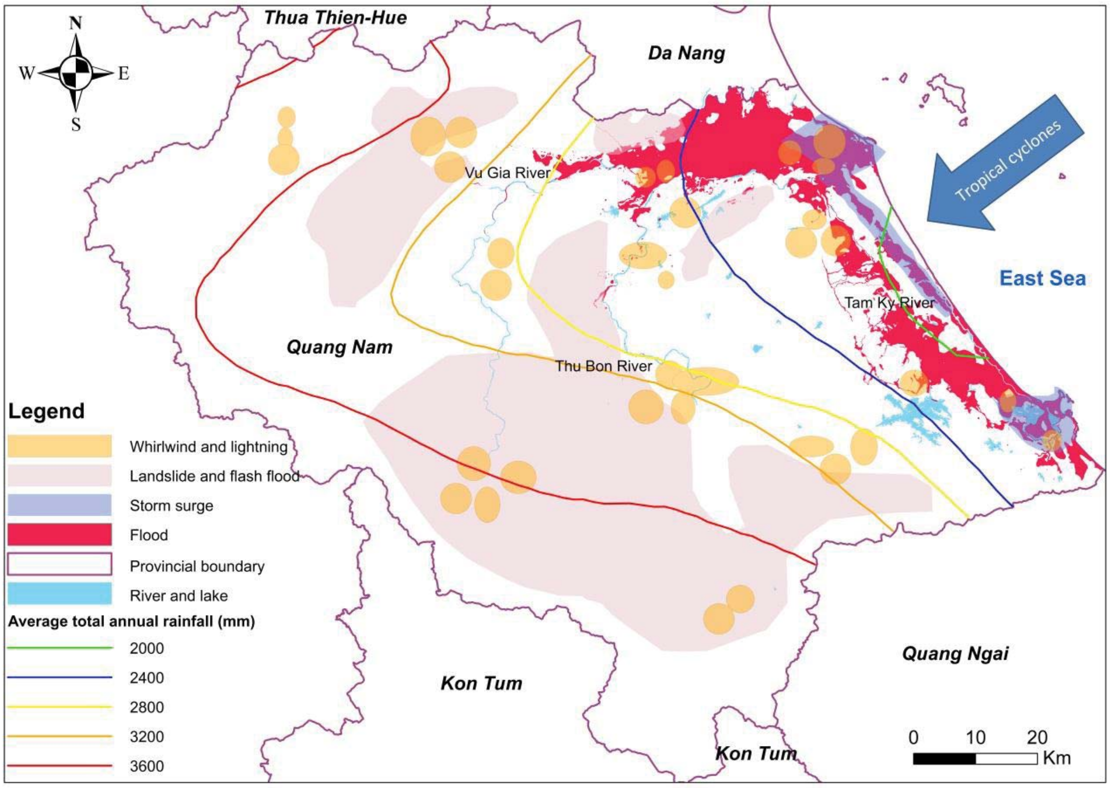
As can be seen in Table 2.1, the incidence and severity of damage and frequency of natural disasters in Quang Nam province and is source of concern to the authorities and communities alike.

Table 2.1. The most popular extreme events and affected level and location.

Type of weather extreme event	Significant impact area	Level of influence	Frequency
Flood	Plain	Very severe	High
Tropical cyclone	Province	Very severe	High
Tropical depression	Province	Severe	High
Drought	Plain and midland	Severe	High
Salinity intrusion	Plain	Severe	Medium
Northeast monsoon	Province	Medium	Medium
Flash flood, landslide	Mountain	Medium	Medium
Whirlwind, thunderstorm	Province	Medium	Medium
Southwest monsoon	Province	Medium	Medium
Fog, hail	Province	Light	Low

Source: pers.comm. Quang Nam Centre for Hydro – Meteorological Forecasting (2011); Water Resources and Flood and Storm Control Division (2011a).

The spatial distribution of the disaster types are presented in Figure 2.9.



Data sourced from the Institute of Geography (2010).

Figure 2.9. Spatial distribution of disaster types in Quang Nam province.

While the storms usually approach Quang Nam province from the East Sea, the floods and storm surge arise in the low-lying areas along the coastline. This makes the Vu Gia-Thu Bon river plain, where most agricultural production is situated, susceptible to floods and storms.

On average, Quang Nam province experiences 15 Northeast monsoons events annually from October to December. Typically, the northeast monsoons arrive in the province during the period from January to March and are followed by rains and strong winds that significantly lower air temperatures and cause damage during the crop sowing period.

Quang Nam also experiences a number of other extreme natural events including thunderstorms, lightning, whirlwind and hail. Most thunderstorms occur between April and September in the midlands and mountains. The thunderstorms have the potential to kill and injure people, as well as damage power supply, infrastructure and houses. The other events occur with low to medium frequency and have a moderate socioeconomic impact on the province.

2.6 Flooding in Quang Nam

Flooding presents the most formidable challenge to natural hazard planning and management in Quang Nam province. This is in part due to the frequency of flood events and their severity in terms of their socioeconomic impact. Flooding and typhoons are considered to be the most devastating natural events in the central region of Vietnam. The flood season normally begins in September and ends in December or January. Based on their timing, floods in Quang Nam can be categorised as early, main and late floods.

Early floods occur from September to mid-October each year and are usually small to medium in magnitude. According to the Institute of Geography (2010), around 30% of floods are early floods and occur most often in the Vu Gia-Thu Bon river system. Early floods are usually limited in duration and their extent is localised.

The most common floods are caused by heavy rains that normally occur from late October to November. The soil is often saturated from earlier flooding and its ability to absorb additional moisture is limited. Consequently, most of the rain is discharged into the river system. The combination of steep terrain, a dense river network and intense heavy rain leads to extensive flooding in Quang Nam.

The Institute of Geography (2010) observed that, typically, three to four heavy flood events occur in Quang Nam annually and account for about 40% of total flooding in the province. They occur in a short period and sometimes appear as a series of floods with a multiple peak flows, however, the inundation can extend over several days and cause disruption to daily activity and damage to infrastructure and agriculture.

Around 30% of the floods occur between December and January and are considered to be late floods. During this period, the northeast monsoons are the main cause of rain that leads to late floods. After experiencing a long rainy season, groundwater has recharged and the rain mainly contributes to surface flow. The late floods are usually low magnitude in both severity and spatial extent.

In general, the floods in the Vu Gia-Thu Bon river basin dictate the level of flooding in the province. A characteristic of flooding in the central region of Vietnam, particularly along the Thu Bon River system, is the speed with which water levels rise and fall. Inundation of the downstream reaches of rivers usually last longer due to low drainage capacity. In the upper and middle reaches of the rivers, the intensity of heavy rains combined with steep terrain and narrow riverbed leads to a rapid increase and decrease in flooding with an average frequency of 20-50cm/hour and maximum of 100-140 cm/h (Institute of Geography, 2010). In contrast with the river upstream, the river slope downstream is relatively low (Institute of Geography, 2010). In addition, the plain area is encompassed by National highway No.1, railway, sand dunes and possible high tides in the East; midland and mountain in the West; mountain and water body (lakes and lagoons) in the South; and mountain and urban areas (Da Nang, the neighboring City) in the North. The combination of these characteristics/factors make the plain comparatively closed and cause floods downstream to rise quickly but fall slowly which has the potential to significantly damage agricultural production. Normal flood duration varies from 20 to 60 hours in the middle and upstream sections of the river and to about 70 to 80 hours in the downstream section. In some circumstances, such as a series of heavy rainfall events created by a cyclone, tropical depressions or northern monsoons, flood events can last for more than six days with records showing events lasting up to as many as 13 days (Institute of Geography, 2010). Figure 2.10 shows some of the area inundated by the 2009 flood in Quang Nam province where farms and villages were submerged for 5 days and resulted in large agricultural losses. Similarity, the 2007 flood disrupted daily activity and damaged infrastructure (Figure 2.11).

Source: Water Resources and Flood and Storm Control Division of Quang Nam (2011a).

Figure 2.10. Villages isolated and farms inundated by 2009 flood in Dien Ban district.

Figure 2.11. National road No.1 at Duy Xuyen District inundated in the November 2007 flood (Photo: Vu Trung).

2.7 Conclusion

Despite rapid industrialisation and urbanisation, agriculture still plays a central role in Quang Nam's social and economic development. More than 20% of provincial GDP comes from the agricultural sector, which creates jobs for more than 60% of the total labour force. Agricultural activities also provide the raw inputs for much of the processing industry. The extreme floods have been the most challenging for the central region of Vietnam and continue to be a barrier for economic development, no more so than for the agricultural sector in Quang Nam. The flood events over the last few years which have hit Quang Nam have been unpredictable and devastating and are likely to continue in intensity in the future (World Bank, 2010b).

Enhanced understanding of possible impacts and quantifying them in monetary terms will benefit authorities as well as residents in terms of making decisions to prevent, mitigate and adapt to extreme weather events. Subsequent chapters will show how improvements is geospatial analysis to identify flood risk areas combined with economic analysis and streamlining institutional systems can improve the management of and response to, extreme flood events in Vietnam.

Chapter 3

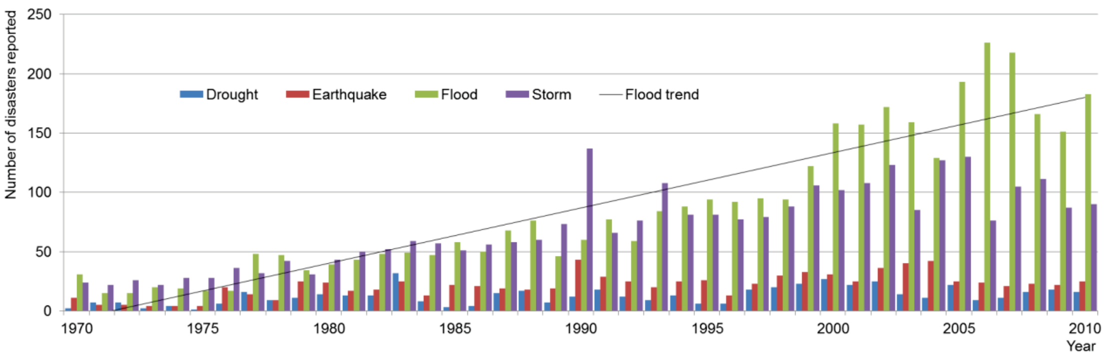
Adapting GIS to map extreme floods in Vietnam[4]

[4] Chau, V. N., Holland, J., Cassells, S., & Tuohy, M. (2013). Using GIS to map impacts upon agriculture from extreme floods in Vietnam. *Applied Geography*, 41, 65–74

Abstract - The frequency of extreme weather events has been increasing in Vietnam, with 1:10, 1:20 and 1:100 year floods all experienced in central Vietnam in the last decade. A geo-spatial model is used in a case study to assess the impacts of extreme flood events on agricultural production in the Quang Nam province of Vietnam. Eighty-six flood depth marks were interpolated by the inverse distance weighting (IDW) algorithm to generate the water surface, and a digital elevation model (DEM) was employed to create the flood inundation map. Another overlay algorithm used the flood inundation map and land use map to estimate the potential impact of floods on agricultural land. The study demonstrates the value of geographic information system (GIS) modeling, particularly when meteorological and hydrological data are limited, and remote sensing images taken during flood events are unavailable. The maps that were generated showed that the 1:10, 1:20 and 1:100 year floods led to 27%, 31% and 33%, respectively, of arable land being inundated. Wet rice was the crop most affected, with the flooded area accounting for more than 40% of the province's supply under each flood scenario. Whilst the exact loss of agricultural production will depend upon a number of factors including crop variety, stage of plant development, length of flooding period and level of inundation, this study provides valuable information for flood disaster planning, mitigation and recovery activities in Vietnam.

3.1 Introduction

Floods, tropical cyclones, droughts and other natural disasters are a part of everyday life in Asia, and no more so than in Vietnam, the world's most disaster-prone region (IFRC, 2010). Global disasters are being reported with increasing frequency (CRED, 2013a) as can be seen in Figure 3.1, which shows some 3,646 floods alone reported between 1970 and 2011. Of these floods, only eight percent occurred during the 1970s, however, 15%, 27% and 49%, respectively, occurred during the 1980s, 1990s and 2000s.



Data sourced from CRED (2013a).

Figure 3.1. Global natural disasters.

Vietnam is highly susceptible to natural disasters, especially tropical cyclones and floods and these have taken their toll on the country and its people. According to a World Bank report (2010b), natural disasters in Vietnam have taken more than 13,000 lives and cost an average one percent of Gross Domestic Product (GDP) annually for the last 20 years. The study also estimated that 59% of Vietnam's total land area and 71% of its population are susceptible to the impacts of tropical cyclones and floods. Furthermore, because of its geographical location and characteristics, Vietnam is often cited as one of the most vulnerable countries in the world to the effects of climate change (Dasgupta, Laplante, Meisner, Wheeler, & Yan, 2009; IPCC, 2007; World Bank, 2010b). Agricultural land is situated in low lying regions where the soil is most fertile and in terms of rice-growing, where it can take advantage of normal flooding, bringing nutrients that increase soil fertility. This, however, leaves prime agricultural land susceptible to extreme flooding, leaving crops vulnerable to destruction.

Extreme floods are unavoidable, but the lessons learned from past experience can be used to reduce the damage they inflict and address “the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between (natural, human-induced or man-made) hazards and vulnerable conditions” (Westen, 2010). The success of flood mitigation measures depend upon detailed knowledge of the expected frequency, character and magnitude of floods in specific areas.

Various measures, both structural and non-structural, have been undertaken to help strengthen Vietnam’s resilience to natural disasters. Thousands of kilometers of sea and river embankments and hundreds of reservoirs have been constructed or upgraded. Examples of non-structural measures include media and public education and also mitigation policy. One such policy is the Vietnam Government’s National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (Prime Minister of Vietnam, 2007), which emphasised community-based endeavours through four ‘on the spot’ initiatives: command on the spot; man-power on the spot; materials on the spot; and logistics on the spot. In this way the responsibility for both prevention and response to natural disasters are decentralised to the local community. A number of programmes and projects have been implemented, funded by central and local government, as well as international donors, all with the aim of minimising the negative impacts of extreme weather events. Despite these measures, the country still remains extremely vulnerable to damage from extreme weather events, particularly floods.

Many disciplines, including environmental planning and management, hydraulic engineering, agriculture and earth science contribute to flood simulation and assessment research and prediction studies (Abdalla, 2009). Flood risk assessment, that provides reliable information for pre-, during and post- , is the focus of current research and represents a shift from classical flood protection with an engineering focus, towards more integrated flood risk management concepts (Büchele et al., 2006). Among the assessment tools available is the flood risk map that shows the at-risk locations and determines the elements at risk, for example, the location of the population, building and civil engineering works and economic activities (Thieken, Merz, Kreibich, & Apel, 2006). A quick determination of the extended flood area during an extreme flood event provides significant information on land use and land cover types under water. This information can be used in developing a comprehensive relief effort (Y. Wang, Colby, & Mulcahy, 2002).

Integrating hydrological, meteorological and geomorphological mapping techniques can produce both qualitative and quantitative risk maps (de Moel, van Alphen, & Aerts, 2009). Results of a number studies show positive results from informative and efficient flood risk management. For example, by comparing agricultural yields in ‘more’ and ‘less’ flood-prone districts in Bangladesh, Banerjee (2010) found that areas under cultivation are more common and hence agricultural production is higher in the ‘more’ flood-prone districts and confirmed that, while floods can act as an open-access resource in supplying irrigation input to agriculture, severe inundation destroys crops. Wang, Zhong-song, Wei-hong and Peng (2010) used a flood inundation analysis method based on DEM to predict villages threatened by extreme flood events in China. Their results demonstrated that the inundation analysis method can reasonably accurately predict flood inundation and guide rescue work and villagers’ resettlement. Meanwhile, Lee and Lee (2003) analysed synthetic aperture radar (SAR) images acquired before, during, and after flood inundation in central Korea and found that the actual damage to a standing rice crop depends on the duration of inundation and the subsequent recovery efforts. However, the satellite’s optical sensors show serious limitations in during and post-flood data acquisition, due to the bad weather conditions and cloud coverage always associated with flood events (Gianinetto, Villa, & Lechi, 2006). Meanwhile, the availability of accurate data and efficient modeling tools are bounding factors for effective flood risk assessment (Abdalla & Niall, 2009).

The traditional method of flood mapping uses hydraulic modeling and employs historical discharge data to model flood frequencies and design flood flows (Hosking & Wallis, 1997; Wang et al., 2010). However, the fact that historical discharge data are not always available is a significant limitation of this approach. As an alternative, Anselmo, Galeati, Palmieri, Rossi and Todini (1996) used an integrated hydrological and hydraulic modeling approach that combined hydro-meteorological with cartographic data to evaluate extreme rainfall events and estimate probable maximum precipitation. They then used recent flood event data to calibrate a rainfall-runoff model for the upstream area, making it possible to generate flood inundation maps from simulation of the critical meteorological events. Later, Zheng and Wang (2006) used a 1-D DEM-inundation model to calculate an artificial water height surface using surface water heights of streams (available at gauging stations) and compared the artificial surface with the DEM to determine flooded and non-flooded areas. The artificial water height surface was created by interpolating surface water heights between stations. In the delineation of the extent of the flood, they superimposed the calculated surface water height layer over the DEM layer. If the location’s elevation was greater than the regular water level and below or equal to flood water levels, then the location was deemed a flooded area. The validity and accuracy of the model was then assessed by Zheng and Wang who the authors (2006) compared the modeled results with those derived from the Hydrologic Engineering Centers - River Analysis System (HEC-RAS) model, which was a widely used standard and complex 1-D hydraulic model. They then verified their model against the 1999 flood event on the lower Tar River, North Carolina and concluded that, with its simple inundation and ease of parameterisation, the 1-D DEM-inundation model is a potential alternative to the complex hydraulic model.

This study draws on the approach taken by Zheng and Wang (2006) to present a geospatial assessment of flood impacts on agricultural land in Quang Nam province, Vietnam to demonstrate how the results can inform economic assessments of natural disaster impacts and associated policy responses to mitigate extreme weather events. A case study approach has been adopted and

Quang Nam province has been chosen as it is representative of the country as a whole, both in terms of topography and its economy. The method of this study could reasonably be applied to a national study.

3.2 Study area

Quang Nam province is located in the central region (Figure 3.2) of Vietnam with a total area of 10,408km^2 and is home to 1.4 million people (Quang Nam Statistics Office, 2011).

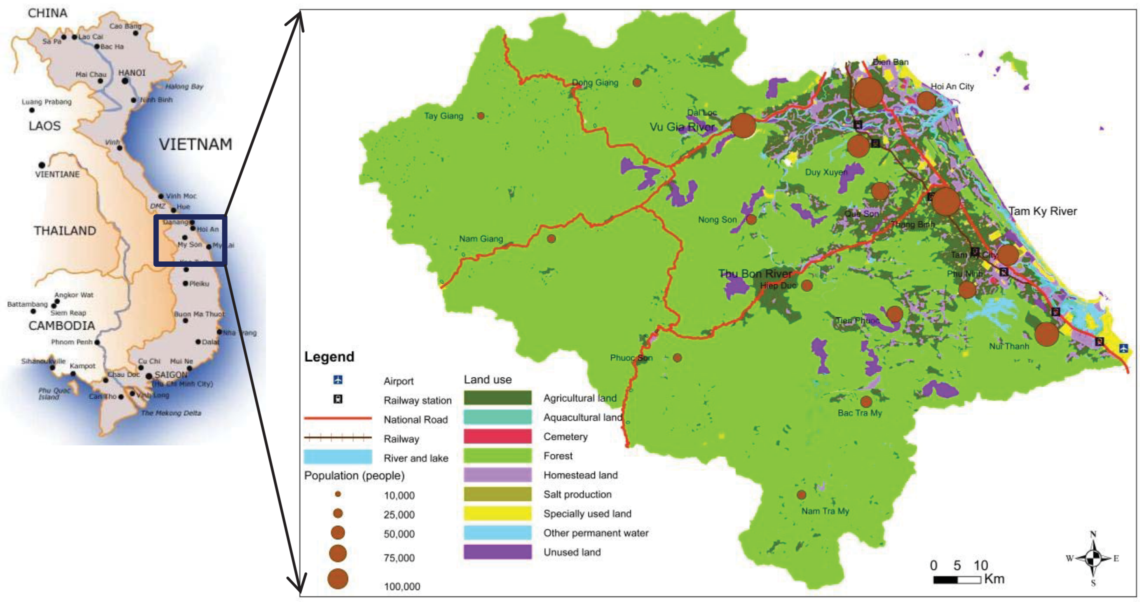


Figure 3.2. The location and land use map of the Quang Nam province in central of Vietnam.

The agricultural sector is extremely important to the province with nearly all agriculture production being consumed locally (Quang Nam Statistics Office, 2011). Figure 3.2 shows that most of the province's agricultural land is located in the Vu Gia-Thu Bon River's alluvium plain. About 72% of the province is mountainous or hilly and is mostly forested. Quang Nam's climate is tropical with two distinct seasons: dry and rainy. The rainy season, from September to

December, has an average rainfall of 2,500mm and an average of 85% humidity. The dry season is from January to August with an average rainfall of 50-70mm. Quang Nam has higher rainfall than other regions, but precipitation is unevenly distributed, with approximately 2,000mm annually in the coastal area and some 3,000-4,000mm in the upland area (Ho & Umitsu, 2011). This combination of topography and rainfall means the province is prone to flooding during the rainy season. Water-related disasters, and floods in particular, cause widespread devastation in Quang Nam province. The annual cost attributed to natural disasters damage averages around 6.26% of the province's GDP, but can be as high as 20% of the provincial GDP in years of extreme floods (Institute of Geography, 2010).

According to the Quang Nam Statistics Office (2011), the province's economy has been growing rapidly in recent years, with the annual GDP growth rate varying between 12% and 15% since 2005. The economy of the province has become more diversified during the last 10 years, with industry becoming the main driving force of the local economy. In 2000, industry contributed 25.3% of the province's GDP and by 2010 its contribution had risen to 40.5% of GDP. Conversely, the combined contribution of agriculture, forestry and fisheries to the GDP of the province decreased from 41.5% in 2000 to 21.4% in 2010. However, 60% of the work force (500,000 people) is still employed in the agricultural sector where 75% of agricultural land is planted in rice. Productivity of this commodity has increased from just over 300,000 tonnes in 2000 to 412,000 tonnes in 2010. Despite the declining contribution of agriculture as a percentage of the province's GDP, the value of agricultural output has increased significantly since 2000 and the sector remains important to the economy of Quang Nam.

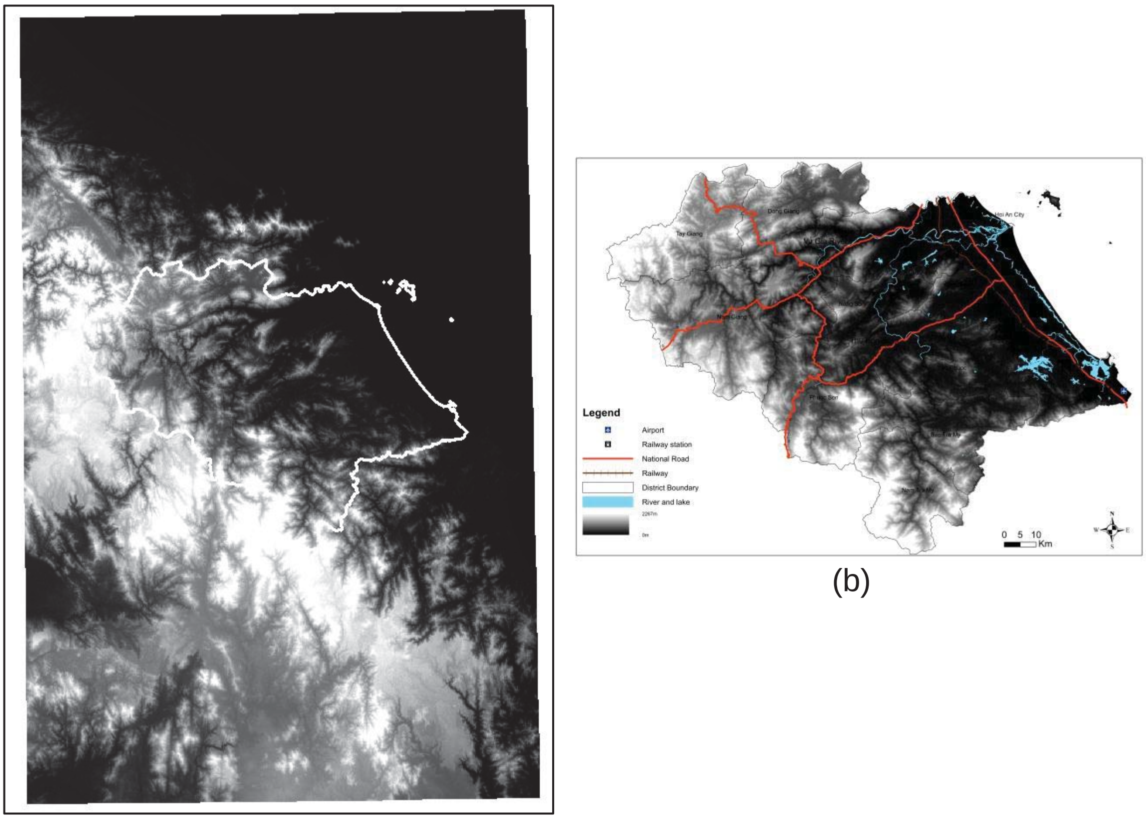
Several studies utilised different methods to undertake mapping of the flood extended area of the Vu Gia-Thu Bon river system. The Institute of Geography (2010), using a hydraulic model (MIKE11 GIS), found that about 64,000, 65,000 and 73,000ha will be inundated by 1:10, 1:20 and 1:100-year floods, respectively. Meanwhile, Ho & Umitsu (2011) developed a method based on a geomorphological approach utilising the Shuttle Topographic Mission (SRTM) and the LANDSAT Enhanced Thematic Mapper Plus (ETM +). Their results showed that 43.34% of this plain was associated with a high or very high flood hazard likelihood (Ho & Umitsu, 2011). Neither of these studies focused their investigation specifically on the level of flood inundation on agricultural land.

3.3 Data used

DEM data with geographic latitude and longitude coordinates on a one arc-second (approximately 30 m) grid of the Quang Nam province (Figure 3.3) was extracted from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) (ASTER GDEM[5]) version 2 (V.2). ASTER GDEM V.2 production involved automated processing of the entire 1.5-million-scene ASTER archive, including stereo-correlation to produce 1,264,118 individual scene-based ASTER DEMs, cloud masking to remove cloudy pixels, stacking all cloud-screened DEMs, removing residual bad values and outliers, averaging selected data to create final pixel values, and then correcting residual anomalies before partitioning the data into 1°-by-1° tiles

[5] The ASTER GDEM is a product of cooperation between The Ministry of Economy, Trade and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA). It's free to users via electronic download from the Earth Remote Sensing Data Analysis Centre (ERSDAC) of Japan and NASA's Land Processes Distributed Active Archive Center (LP DAAC).

(METI and NASA, 2011). Compared with ASTER GDEM version 1 (V.1), the characteristics of ASTER GDEM V.2 have improved significantly. The elevation offset reduces to -0.7m from -6m (V.1), the voids decrease and the artifacts mostly disappear (Tachikawa, Hato, Kaku, & Iwasaki, 2011). Despite the advanced technology applied to generate the GDEM, it generally maps the tops of dense land covers rather than just bare earth and it may contain vertical errors. Consequently, underestimation of areas affected by flooding in built-up and forested areas is possible using these data. To construct the Quang Nam DEM, six adjacent tiles were downloaded from LP DAAC and imported to ArcMap and merged into a single DEM. The DEM was clipped to the provincial boundary to produce the DEM of Quang Nam as shown in Figure 3.3(b).



(b)

(a)

Figure 3.3. Six adjacent DEM tiles (a) from ASTER GDEM V2 were clipped to create the 30 metre resolution DEM of Quang Nam province (b).

There are no flood protection standards for Vietnam's Central Region (Institute of Water Resources Planning, 2011), however, the development of a national strategic water resources management plan was approved by the Prime Minister (2009) and this included flood management planning and the protection of agricultural land from 1:10 to 1:20-year floods. In its 2011 report, the Water Resources Planning Institute suggested using a 1:10-year flood standard for agricultural flood protection activities. In addition, a 1:100-year flood standard has become universally adopted to describe a reasonable flood protection level. This study used three flood scenarios, 1:10, 1:20 and 1:100-year floods to assess the impacts of floods on agriculture for Quang Nam province. The Institute of Geography (2010) and the Water Resources Planning Institute (2011) analysed the highest annual water levels recorded from 1976 to 2009 at Cau Lau station, which is located in the centre of the floodplain, to simulate flood frequency for the Vu Gia-Thu Bon river system. Their results (Table 3.1) concluded that the 1:10, 1:20 and 1:100-year floods are compatible with the floods that occurred in 2004, 2009 and 2007, respectively.

Table 3.1. The flood frequencies calculated at the Cau Lau gauging station.

Year	H_{max} (cm)	Return period (year)	Flooded area (km^2)
2004	459	10	64,150
2009	529	20	65,365
2007	539	100	73,460

Sources: The Institute of Geography (2010) and the Water Resources Planning Institute (2011).

The flood depth marks from 1996 to 2010 were collected immediately after floods, during flood impact assessments by local and central government agencies. The government established a series of flood level markers in the Vu Gia-Thu Bon river system. The flood level markers are normally poles or gauges on the sides of buildings. Eighty-six flood depth markers (Figure 3.4), which were spaced along the rivers and floodplain area, were analysed for this study and were provided by the Disaster Management Center of the Ministry of Agriculture and Rural Development and Quang Nam's Department of Water Resource and Flood and Storm Control. Each flood depth marker has a number, code, location (longitude, latitude, place-names), time recorded, flood depth and sources of flood.

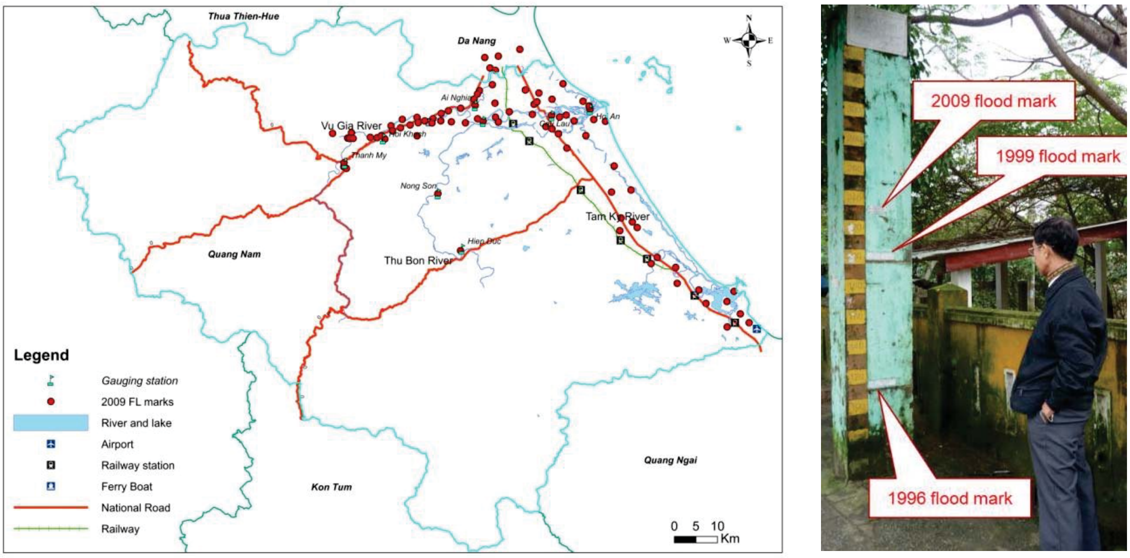


Figure 3.4. The location of the measured flood depth markers (left) and a typical flood depth marker (right) in the Vu Gia-Thu Bon river system.

The land use map of Quang Nam province (Figure 3.2) was provided by Quang Nam's Department of Environment and Natural Resources to the Vietnam Denmark Collaborative Project P1-08 Vie: Impacts of Climate Change in Mid-central Vietnam. The land use map was created by interpreting 2005 Landsat satellite data at a scale of 1:100,000 which is available for public use at the "Assessing effects of and responses to climate change on environment and socio-economic development in mid-Central Vietnam" project (Institute of Geography, 2011). The risk of using this map is two-fold, one being that it is potentially out of date (2005), and the second is lack of detail for annual crops.

Despite this, there is currently no other readily available data that portrays these land cover classes at this resolution.

In addition, base maps showing administration units, transportation systems and rivers were extracted from a topographic map of the five central provinces (Department of Survey and Mapping Vietnam, Ministry of Natural Resources and Environment). This is data was also available from the previously mentioned project of the Institute of Geography (2011). The inundation maps created from the flood depth markers and DEM were overlaid on the land use map to assess the impact of 1:10, 1:20 and 1:100-year floods on agricultural land in the Quang Nam province. All spatial analyses were implemented in ArcGIS 10 (Environmental Systems Research Institute Inc., Redlands, CA, USA) and the results are presented in section 3.5.

Other data used in this study were secondary sources from reports, surveys and projects from Quang Nam province and Central Government agencies and research institutes. The data include both geospatial data and socio-economic data. Since this study was not concerned with change detection, it was assumed that the land use and topography have remained unchanged since the data was gathered.

3.4 Method

This study used the GIS technology to map the extent of flooding and measure the impact on agricultural land. The process is outlined in Figure 3.5 showing how the GIS data are constructed from the base data and the spatial analysis method that is applied to evaluate the degree of impact in the case study area.

i. Posting flood depth markers in compatible with ArcGIS format.

ii. Using inverse distance weighting (IDW) algorithm to generate water height surface from flood depth marks. The result of this interpolation is the artificial water height surface.

iii. Using Map Algebra to calculate the inundated areas by taking the water height surface minus the DEM. The result of this algorithm is a map show locations' values. Positive values are flooded area; negative values show the non-flooded area.

iv. Identifying the inundation levels by reclassify the inundation map into 0-0.5, 0.5-1, 1-2, 2-3, 3-4 and >4m levels, then using structured query language (SQL) algorithm to extract those classes to create inundation map in raster format.

v. Using "raster to polygon" conversion tool to convert the raster inundation map into polygon format. The result of this step produces the inundated map in polygon format.

vi. Using the inundated map in polygon format clips the land use map to generate the land use affected by inundation.

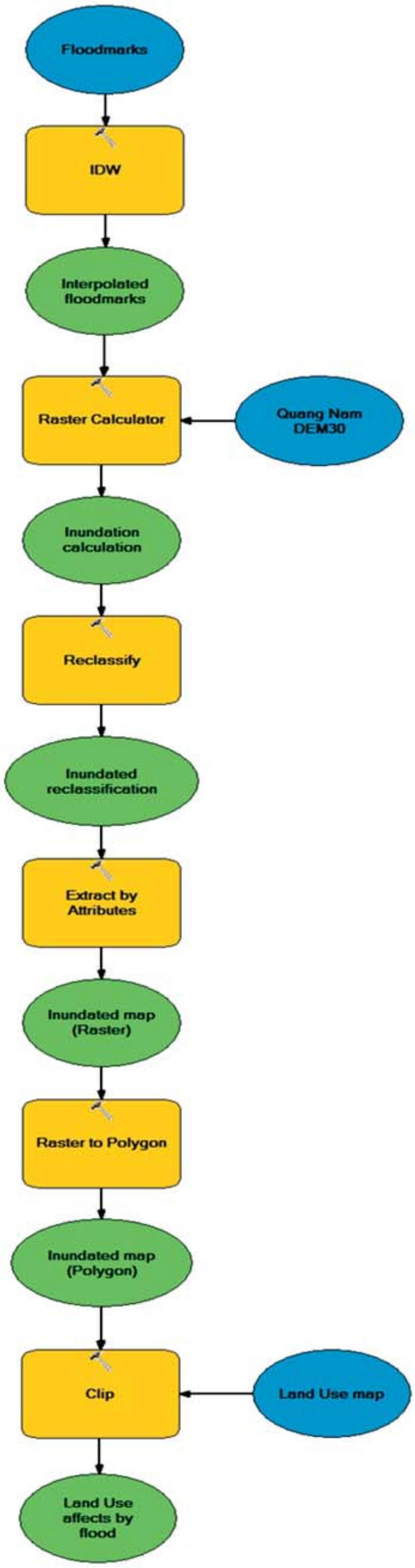


Figure 3.5. The ArcGIS model created to automate processes for the output of land use maps affect by floods.

The flood depth markers were posted during site visits immediately post flood and then interpolated to model the flood surface area. A two-step process was used: first, ArcCatalog is used to convert flood depth marks from the longitude and latitude format to feature class, which is compatible with ArcGIS format. The flood depth marks were then interpolated by the inverse distance weighting (IDW) algorithm to generate the water height surface. Secondly, inundated areas are identified by taking the water height surface minus the DEM which is considered a platform to evaluate the level of inundation. The positive values from this operation were used to create a map of the inundated areas.

The inundated agricultural land was identified by overlaying the flood extension layer over the agricultural land use layer provided by Quang Nam's Department of Environment and Natural Resources. It should be noted that the study excluded flash floods that may have occurred in elevated and isolated areas.

3.5 Results

This study assessed the impact of 1:10, 1:20 and 1:100-year floods on agricultural land use in the Quang Nam province. Whilst results of agricultural impacts are presented for each of three flood scenarios, the inundation maps for the 1:100-year flood scenario only, are presented in this paper. The inundation maps of the 1:10 and 1:20-year flood scenarios can be found in Appendix A. The map of the predicted inundation for a 1:100-year flood event in the Quang Nam province is presented in Figure 3.6.

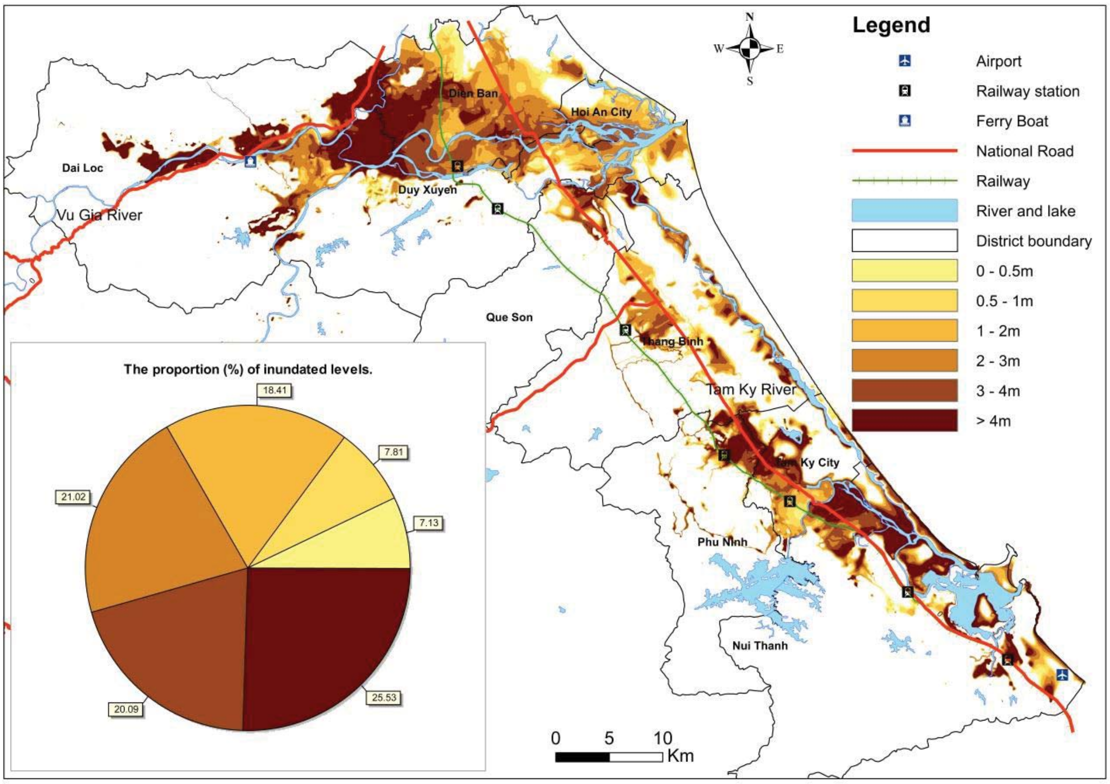


Figure 3.6. Predicted inundation of Quang Nam province resulting from a 1:100-year flood event.

From this map it can be seen that inundation occurs in the low lying areas of the two main river systems, Vu Gia-Thu Bon and Tam Ky River systems and affects nine districts, namely, Dai Loc, Dien Ban, Duy Xuyen, Hoi An, Thang Binh, Phu Ninh, Que Son, Nui Thanh and Tam Ky. In order to evaluate the impact of flooding on agricultural land, the submerged area was classified into six depth ranges (0 – 0.5m, 0.5 – 1m, 1 – 2m, 2 – 3m, 3 – 4m and greater than 4m), which are identified in Figure 3.6.

The model predicts the areas of inundation for the 1:10, 1:20 and 1;100-year flood scenarios and these are presented in Figure 3.7. The total inundation area includes the cumulative area of all depths including those above 4m. Whilst it may appear from Figure 3.7 that the 1:100-year flood has a lesser area of inundation than the 1:10 and 1:20-year floods for depths up to 4m, this is simply a reflection of the topography of area. Once the total area of inundation is accounted for, the 1:100 year flood clearly covers the greatest area.

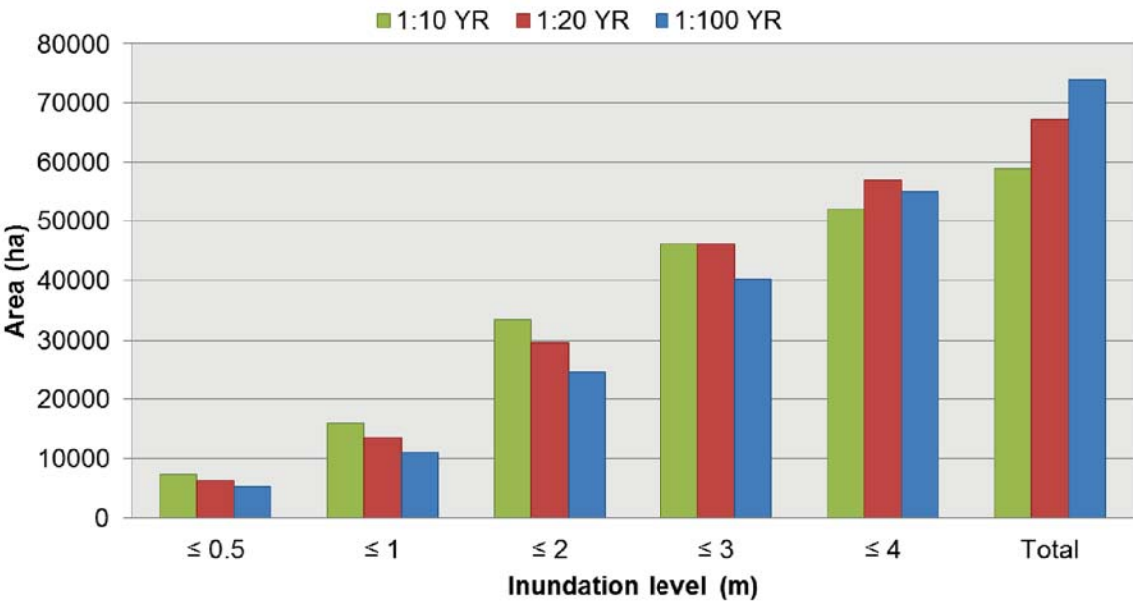


Figure 3.7. The predicted cumulative area of inundation in Quang Nam province resulting from the three flood scenarios.

It can be seen from Figure 3.7 that the model predicts for 1:100-year flood scenarios that up to a depth of one metre 11,000ha will be flooded. A further 13,600ha will be flooded at a depth of one to two metres making the total area flooded up to two metres, 24,600ha. Quang Nam province covers an area of 1.04 million hectares. The model predicts that a 1:10-year flood event would submerge 58,905ha, which represents 5.7% of the province. The total affected area increases to 6.5% (67,267ha) and 7.1% (73,835ha) of the total area of the province for 1:20 and 1:100-year flood events, respectively. The Dien Ban district would be worst affected with a predicted 81% of its total area submerged by a 1:100-year flood. Tidal effects would exacerbate the drainage process and, in the long term, a predicted sea level rise of up to 30cm by 2050 (Ministry of Natural Resources and Environment, 2009) and 59cm by the end of this century would add to the impact of the disaster (IPCC, 2007).

Among the inundated land uses, the model estimates that agricultural land would be the land use type most impacted by each flood scenario. The impact of a 1:100-year flood event on different land uses is shown in Figure 3.8.

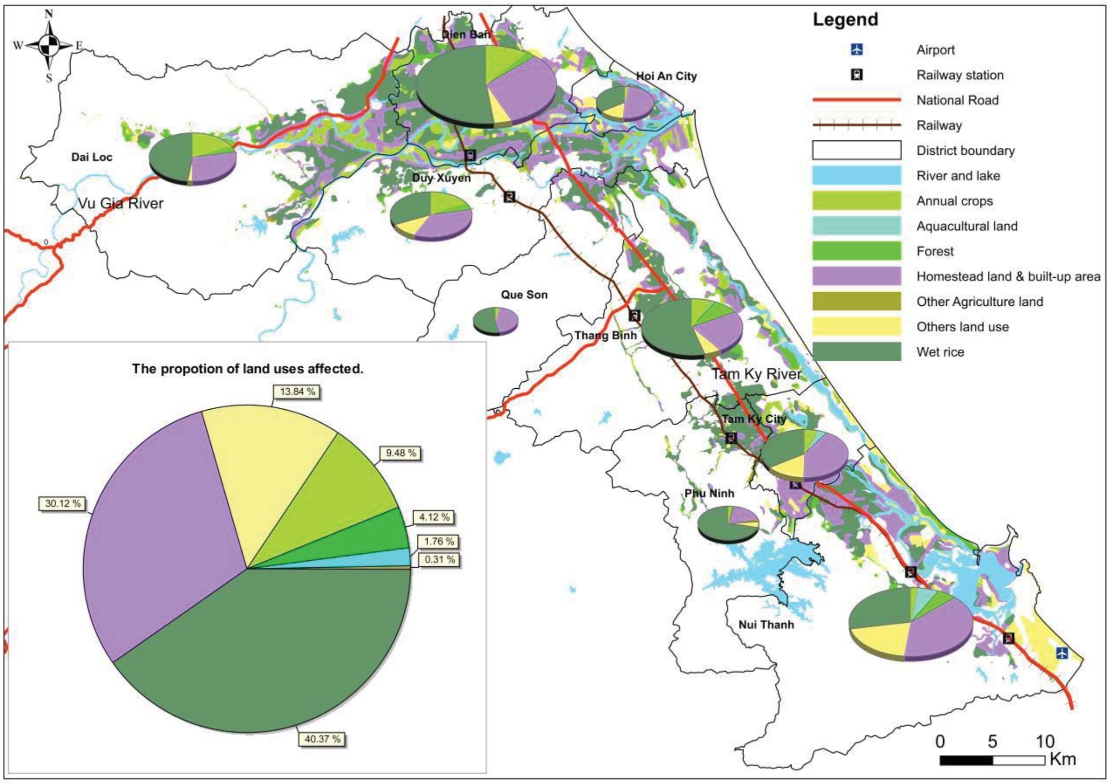


Figure 3.8. Different land uses in Quang Nam province's districts affected by the 1:100-year flood.

Overall, each of the flood scenarios would lead to just more than 50% of the inundated area being agricultural land. The second largest affected land use type is the homestead land and built-up area (30.12% for 1:100 year flood) and approximately 14% (for 1:100 year flood) of the inundated area comes under other land uses, including industrial and commercial land.

Typically, a district has more than 80% of its agricultural land in rice fields, with grasslands for animal grazing and perennial fruit production contributing only a small proportion of agricultural land. An estimation of agricultural land in Quang

Nam that would be inundated under the three flooding scenarios is presented in Table 3.2.

Table 3.2. Estimated areas of agricultural land in Quang Nam province affected by flood scenarios.

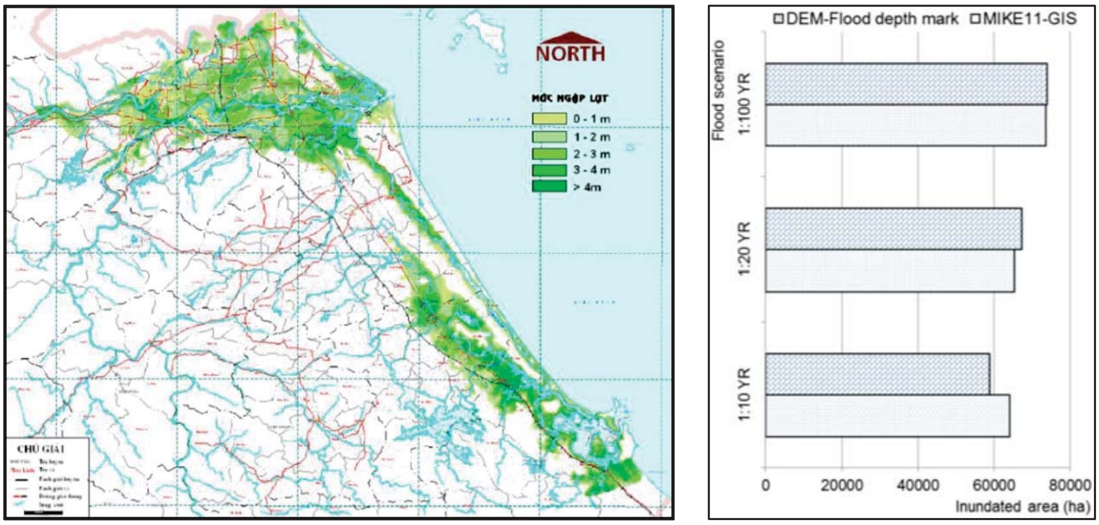
	Total area (ha)	Flooded area (ha)			Flooded area (%)			% of total provincial agricultural land		
Flood scenario		***1:10***	***1:20***	***1:100***	***1:10***	***1:20***	***1:100***	***1:10***	***1:20***	***1:100***
Annual crops[a]	30,803	5,263	6,367	6,999	9	9	9	17	21	23
Wet rice	56,445	24,496	27,275	29,815	42	41	40	43	48	53
Other agriculture	23,710	158	204	229	0	0	0	1	1	1
Sub total	110,958	29,917	33,846	37,043	50.8	50.3	50.2	27	30.5	33.4
Total flooded area		58,905	67,267	73,835						

a. Annual crops are predominately by corn, beans, peanut, cassava, sweet potatoes and other vegetables.

The model calculates the larger affected area for the more severe flooding scenario. The predicted flooded agricultural areas for the 1:10, 1:20 and 1:100-year flood event scenarios are estimated to be 29,917, 33,846 and 37,043ha, respectively, which accounts for 27%, 30.5% and 33.4%, respectively, of the total agricultural area in Quang Nam. Wet rice is the crop most affected. The agricultural land submerged by more than 3m increases significantly as flooding intensity rises, from 20% (1:10-year flood) to 47% (1:100-year flood). While rice crops are vulnerable to long periods of inundation, they are better able to recover from this than annual crops such as maize, sweet potatoes, sesame, beans and other vegetables which are more sensitive to the effects of the inundation. For example, the maize yield would be reduced by 18%, 22%, and 32% if it were inundated for longer than 24, 48 or 72 hours, respectively (Joe, 2001). It is also noted that the deeper inundated areas would probably take a longer time to dry out, thereby exacerbating the impact of the floods.

3.6 Discussion

The geo-spatial modeling technique applied to generate the inundation maps in this study (see Figure 3.6) produced similar results to maps created by the Institute of Geography (2010) using a hydraulic model (Figure 3.9(a)). The spatial allocation of water depth from this study (as shown in Figure 3.6) differed slightly from that of the Institute of Geography (2010) (see Figure 3.9 (a)) whose DEM was constructed from a 1:25,000 scale contour map. However, the total inundation area corresponds well in both studies as shown in Figure 3.9(b).



(a) (b)

Figure 3.9. (a) 1:100-year flood map created by the Institute of Geography (2010) using hydraulic model MIKE11 GIS and (b) total areas of inundation in Quang Nam province.

The inundation map for this study also compares well with Figure 11, the flood hazard map, of Ho & Umitsu (2011), but seems to conflict in some part with Figure 12 (The MODIS rapid response flood inundation maps provided by Dartmouth Flood Observatory (DFO)), in the Ho and Umitsu (Ho & Umitsu, 2011) study. The 2009 flood in Vu Gia-Thu Bon started on 27th Sep and ended on 3rd Oct; the flood levels fluctuated day by day. Meanwhile the 2009 flood inundation map provided by DFO to Ho and Umitsu was derived from MODIS imagery, however, it is unclear at which stage or the exact date the flood inundation map refers to; it may have been before or after the flood peak which was used in this study. This outcome bears testimony to the usefulness of the flood mapping method used here, when meteorological and hydrological data are limited and where remote sensing images are unavailable to support decisions made during and immediately following extreme flood events. In emergency situations, the combination of interpolated flood depth markers and the DEM taken in short periods can be used to predict flood extended areas, which provides useful information for decision-makers to respond appropriately to real flood hazards. This study used 30m DEM resolution, which was the best DEM resolution available in Quang Nam; the results could be more accurate if using higher DEM resolutions (Charrier & Li, 2012) and if a higher density of flood depth markers were available.

The results from this study highlight the areas susceptible to the flood scenarios. The reported loss and damage is consistent with reported data from the Quang Nam People's Committee (2005, 2008, 2010). Both present a similar trend in which the 2007 flood (1:100-year flood) caused the greatest damage on agriculture, followed by the 2009 flood (1:20-year flood). Despite the area inundated by a 1:100-year flood being less than 1:20 and 1:10-year floods at most of the inundation levels, 26% of the area affected by the 1:100-year flood would be submerged to more than four metres and it results in the total area inundated being greater than the other two flood scenarios (Figure 3.7). The area of rice production affected increased from 24,496ha (1:10-year flood) to 27,275ha (1:20-year flood) and 29,815ha (1:100-year flood). The total area inundated may be under or overestimated, depending on the method employed. This is illustrated by Lastra, Fernández, Díez-Herrero, & Marquínez (2008), who used three different methods resulting in three different outcomes for the total flooded surface area.

Despite advice from government authorities and the huge effort from farmers, including shifting crops and modifying the planting season, agriculture in Quang Nam province is still highly vulnerable to floods. For example, storm No. 9 landed directly on Quang Nam in September 2009 followed by a flood, which resulted in the total destruction of approximately 3,500 ha of the summer-autumn rice crop and more than 7,600 ha of other annual crops. In addition, almost 350,000 poultry and 1,500 cattle were destroyed and planting of the winter-spring crops was delayed for 15 days (Quang Nam People’s Committee, 2010). Furthermore, during floods the yield and quality of harvested crops may be affected as a result of inadequate post-harvest processing, such as crop drying and storage. Farming in Quang Nam is characterised by small household farms where most of the harvest and post-harvest activities use manual labour and rely upon natural conditions, such as sunshine to dry the rice. The produce is then packaged and stored in households, which are also vulnerable to flooding. Post-harvest and storage measures need to be taken into consideration, particularly in the more deeply inundated areas.

Whilst Quang Nam’s agriculture is slowly diversifying, it remains heavily reliant on crop production. Foot and mouth disease amongst cattle and avian influenza outbreaks amongst poultry in recent years have further emphasised the importance of crop production in the composition of Quang Nam’s agriculture.

Compounding this is the fact that production processes are heavily reliant on natural conditions, therefore, the ability to recover from natural disasters is low. This has made the agricultural sector more vulnerable to natural disasters than any other sector in Quang Nam province. The identified flood hazard zones will provide valuable information for farmers and decision makers to respond to flood hazards during the flood season and prioritise the livelihood of those living in the flooding zone.

3.7 Conclusion

This study presented an overview of flood hazard mapping and GIS technology to measure the potential impact of extreme flood events on agricultural land in the Quang Nam province of Vietnam. The model used here demonstrated satisfactory performance in predicting flood inundation, compared to the result of the complex hydraulic model MIKE11-GIS and its impact on agricultural land, the results of which could enable more effective disaster planning, preparedness, mitigation and recovery processes. The methodology employed to map and estimate the agricultural land affected by flooding has demonstrated the simplicity and usefulness of the model, particularly when meteorological and hydrological data are limited and where remote sensing images are unavailable.

This study found that 27%, 31% and 33% respectively, of Quang Nam’s arable area is estimated to be at risk from 1:10, 1:20 and 1:100-year flood scenarios. Wet rice would be the crop most affected, with more than 40% of Quang Nam’s wet rice production land submerged in all three flood scenarios, with the Dien Ban district most affected. The actual percentage of production loss will depend on a number of factors, including crop variety, stage of plant development, and length of flooding period and level of inundation. Quantification and valuation of these impacts will provide further useful information for policy makers, investors and farmers. Further research will be undertaken to extend the results of this study to estimate the likely economic losses incurred by the agricultural sector in Quang Nam province as a result of extreme flood events.

Using these results in conjunction with field observations, statistics and flood legislation in the Quang Nam province, a number of recommendations can be made. First, there needs to be a review of short and long term corrective procedures which address appropriate non-structural measures, as current flood prevention and mitigation are based heavily on structural measures alone. Second, the lack of appropriate mining and forest management to date has caused large quantities of suspended sediment to flow downstream reducing the drainage capacity of the Vu Gia-Thu Bon River. This has contributed to increased flooding of valuable agricultural land, therefore, it is recommended that effort be directed toward achieving sustainable natural resource management, particularly in forestry and mining. Third, in the flood risk areas there is a need for risk classification based on flood inundation levels, coupled with provision of appropriate action guidelines at each risk level. Of particular importance is the need to increase both the number of technical staff and other resourcing to respond to the flood hazards. Finally, data on hydrology, agricultural land use and infrastructure needs to be regularly upgraded and free access to information provided, with the aim of improving awareness of likely flood impacts and the action that needs to be taken, prior to, during and immediately following flood events.

Chapter 4

Calculating the cost of agricultural losses from flood events in central Vietnam[6]

[6] Chau, V.N, Cassells, S., & Holland, J. (2014). Economic impact upon agricultural production from extreme flood events in Quang Nam, central Vietnam. Natural Hazards, Article first published online: 10 SEPT 2014 | DOI:10.1007/s11069-014-1395-x

Abstract - Quang Nam province, central Vietnam is situated within the tropical monsoon and typhoon zone of South-East Asia and is susceptible to extreme floods. Historical water level data from 1976 to 2009 for the Vu Gia-Thu Bon river system have been used to simulate flood frequency, concluding that the floods experienced in 2004, 2009 and 2007 were congruent with 1:10, 1:20 and 1:100-year floods, respectively, all occurring within the last decade (Institute of Geography, 2010; Water Resources Planning Institute, 2011). Since the most productive agricultural land is concentrated along the low-lying sections of river systems, losses to agriculture in extreme flooding can be significant.

Using *ex-post* data, this study estimates the direct damage to agricultural production caused by three flood classes, 1:10, 1:20 and 1:100-year floods in Quang Nam. Utilising geo-spatial inundation maps together with the timing of the floods with respect to crop rotation, calculation is made of flood-depth susceptibility rates for the four main crop types. These susceptibility rates are then applied to calculate the damage value and also the percentage loss in value for the four crop types under the three flood classes. Benefit-cost ratios were calculated under 'with' and 'without' extreme flood events. In addition, both scenario and sensitivity analyses were conducted.

The estimated value of direct losses to the four main crops for a 1:10, 1:20 and 1:100-year flood are approximately VND22 billion, VND115 billion and VND147 billion, respectively. These represent a percentage loss in value in the inundated areas for 1:10, 1:20 and 1:100-year floods, of 12%, 56% and 62%, respectively. Benefit-cost ratios, already very low for subsistence farmers, are

further eroded in years of extreme floods, with many farmers experiencing a net loss. This study will help to inform flood management decision makers in central Vietnam.

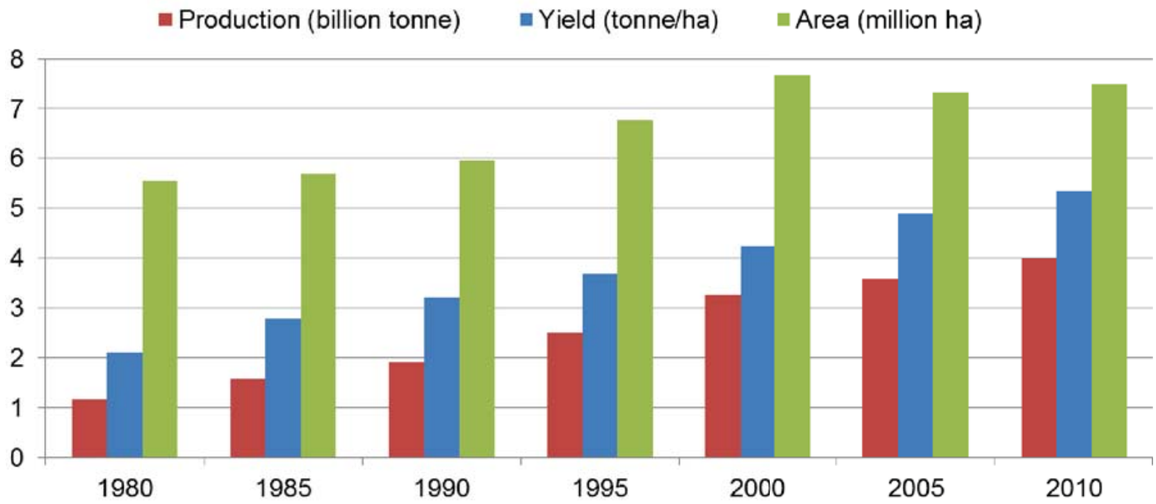
4.1 Introduction

Natural disasters are being reported with increasing frequency across the globe (CRED, 2013a). Such disasters leave developing countries like Vietnam particularly vulnerable as their capacity to respond is so much less than developed countries (Mechler, 2003). The total damage caused by floods in Vietnam was estimated at USD3.7 billion from 1990 – 2013, of which 62% occurred in the last decade (2004 – 2013) (CRED, 2013a). Subsistence farmers who rely upon agriculture as their main source of income are most vulnerable to extreme floods and which have the potential to significantly reduce their production, exacerbating their poverty (Biltonen, 2001).

The focus of this study is Quang Nam province, central Vietnam, 10,408km^2 in area and home to 1.4 million people, more than 80% of whom live in rural areas (GSO, 2011). The per capita Gross Domestic Product (GDP) of Quang Nam province is relatively low, around VND11.22 million (US$560) in 2010 and ranked 48th out of the 63 provinces in Vietnam (GSO, 2011). Annual rainfall for the province averages 2,600mm, with 2,500mm of this falling during the rainy season from September to December. Quang Nam is situated within the tropical monsoon and typhoon zone of South-East Asia and as such is susceptible to extreme flood events. The most productive agricultural land is concentrated along the low-lying sections of river systems and is vulnerable to flooding. While the annual cost attributed to natural disaster damage averages around 6.3% of the province's GDP, this can be as high as 20% of GDP in years of extreme floods (Institute of Geography, 2011b).

The Institute of Geography (2010) and the Water Resources Planning Institute (2011) for Vietnam have analysed the historical discharge and water level data from 1976 to 2009 for the Vu Gia-Thu Bon river system (the main river system in Quang Nam). Of the 34 years of data collected, the five highest water levels were recorded in the last 12 years of data (1998 – 2009). When using the data to simulate flood frequency, they concluded that the floods experienced in this river system in 2004, 2009 and 2007 were congruent with 1:10, 1:20 and 1:100-year floods, respectively, all occurring within the last decade.

Since the 1990s, Vietnam has made the transition from being a net importer of rice to becoming one of the world's largest exporters of rice. Vietnamese farmers have been highly successful at increasing food production since the economic reforms (the reformation or Doi moi) of 1986, the goal of which was to create a market economy (though maintaining some degree of government control). The yield per hectare of crops in general, and rice in particular, more than doubled during the 30-year period to 2010, as is shown in Figure 4.1.



Data sourced from the General Statistics Office of Vietnam (2012) & Pham (2011).

Figure 4.1. Trends in rice production, yield/ha and total area for Vietnam (1980-2010).

It can be seen in Figure 4.1 that the amount of land used for rice production has also increased since the 1980s. Both the increased area given to rice production and the increased yield per hectare, due to improved seed varieties and irrigation, and increased use of fertiliser has led to increased production. However, overall production is threatened by factors such as increased urbanisation on productive land, environmental degradation and more particularly, natural disasters (Ward, Pauw, van Buuren, & Marfai, 2013; Wilby & Keenan, 2012).

In more recent years the focus of flood management has moved beyond structural mitigation measures such as dams and flood-ways, toward a “more adaptive and integrated” approach (Ward et al., 2013, p. 519). Flood risk management is defined by Simonović and Carson (2003) as a broad spectrum of water resource activities aimed at reducing the potentially harmful impact of floods on people, economic activities and the environment, and by Samuels and Gouldby (2009, p. 16) as “continuous and holistic societal analysis, assessment and mitigation of flood risk". Simonović (1999) identified three flood management stages: the planning stage, the flood emergency management stage, and the post-flood recovery stage. Activities associated with each stage are reliant upon results of risk assessment, and in particular on economic assessment of the impact of floods (Duttaa, Herathb, & Musiake, 2003; Li, Wu, Dai, & Xu 2012).

For a time, flood damage evaluation of agricultural production was either neglected or accounted for using over-simplified approaches and rough estimates because expected losses were relatively insignificant in comparison to those in urban areas (Brémond, Grelot, & Agenais, 2013; Förster et al., 2008; Merz, Kreibich, Schwarze, & Thieken, 2010). It is now widely recognised as being necessary to provide economic flood damage information to help decision making in efforts to mitigate the impact of floods (Okuyama, 2007; Merz, Kreibich, et al., 2010; Penning-Rowsell, Yanyan, Watkinson, Jiang, & Thorne, 2013; Brémond et al., 2013). Estimation of potential flood damage provides important information for the assessment of support needed in the short-term and policy development in the long-term for flood control planning, land use planning, and allocation of resources for recovery and reconstruction (Duttaa et al., 2003; Downton & Pielke, 2005; Merz, Kreibich, et al., 2010). It could also serve to avoid some of the controversies highlighted by Changnon (2003) that have arisen over government relief payments for natural disasters. Further, flood damage evaluation is critical when determining the economic efficiency of adopting an intervention strategy against flood damage (Brémond et al., 2013; Messner et al., 2007). A large number of studies have been conducted which provide some level of economic analysis of flood damage specifically to agriculture and an excellent review of many of these has been executed by Brémond et al. (2013).

While the damage estimation method is selected based on the scale and objective of study, data availability and flood damage categories (Brémond et al., 2013; Messner et al., 2007; Meyer et al., 2013), the full cost of extreme floods include both tangible and intangible costs (Changnon, 2003; Downton & Pielke, 2005; Penning-Rowsell & Parker, 1987; Parker, Green, & Thompson, 1987; Smith & Ward, 1998). Intangible costs, however, are difficult to both identify and quantify due to lack of data availability and insufficient knowledge of full disaster damage (Meyer et al., 2013). Downton and Pielke (2005) identified three particular reasons that made accounting for the cost of disasters inherently complicated. First, disasters have both direct and indirect costs and benefits. Direct flood costs may include the destruction of crops and livestock, while floodwater inundation may result in indirect costs, such as interruptions in transportation, trading activities and consumption, and a temporary increase in unemployment (Okuyama, 2007). One indirect benefits may be the supply of nutrients resulting in an increase in soil fertility. Second, “disaster’s losses are a function of the spatial and temporal scale that the analyst chooses as the focus of a particular loss analysis” (Downton & Pielke, 2005, p. 212). Widespread damage can cause a decrease in food supply, inflating commodity prices and compounding the problem of estimating the economic loss associated with crops that never went to market. Third, many losses incurred as a result of natural disasters are intangible, such as psychological damage and impacts on health (Duttaa et al., 2003), which are extremely difficult to measure (Meyer et al., 2013). Agricultural flood damage categories are summarised in Table 4.1.

Table 4.1. Agricultural flood damage categories.

Form of loss		Primary	Secondary
Tangible	Direct	– Crop loss – Yield reduction – Livestock fatalities – Damage to perennial plant material – Damage to buildings – Damage to machinery – Damage to stored inputs – Damage to infrastructure (e.g. irrigation system and road)	– Loss of added value due to the loss of yield in the first years after replanting perennial plant material (orchard, vineyard) – Reseeding grass loss of livestock products (e.g. milk & egg) – Loss of added value due to unavailability of production factors (machinery, inputs etc.) – Cost of relocation or premature sales of livestock – Cost of additional food for livestock – Cost of restoration
	Indirect	– Disruption of traffic and agricultural trade – Delay or cancellation of supply from the flooded area (inputs, machinery, etc.)	– Loss of added value outside the flooded area due to business interruption of assets in the flooded area – Loss of added value outside the flooded area due to damage to infrastructure
Intangible		– Health, psychological damage to famers – Reduce confidence and investment in the agricultural production	

Source: Adapted from Parker, Green and Thompson (1987, p. 2), Smith and Ward (1998, p. 35) and Brémond, Grelot and Agenais (2013, p. 2496).

A number of methods to estimate the cost of agricultural flood damage have been developed and reported (Brémond et al., 2013; Messner et al., 2007; Meyer et al., 2013; Morris & Brewin, 2013; Pantaleoni, Engel, & Johannsen, 2007). Brémond et al. (2013), the most comprehensive review, described 42 studies on economic evaluation of flood damage to agriculture, reviewing 26 of these in detail. The studies either used or looked to create damage functions for *ex-ante* appraisal, and while a few took an experimental approach, most were based on *ex-post* analysis of past events.

Messner et al. (2007) reviewed and categorised existing methods in European countries, providing guidance for quantification and evaluation of flood damage. The European guidelines introduce a set of recommended steps for direct and tangible flood damage evaluation, beginning with the objective and the area under investigation, through to ascertaining the damage categories under consideration, gathering the information and available data, determining the method, and finally calculating the damage. In addition, the inclusion of uncertainties needs to be reflected in the results.

Recently, an evaluation of the impact of a one-off extreme flood event upon agriculture in Somerset, England was undertaken by Morris and Brewin (2013). They conducted a survey of farmers four weeks after the onset of the flooding. The data collection focused on type of impact, farming system and land use to estimate the impacts of seasonal flooding, as well as to understand how farmers coped with the effects of the flooding upon their farm businesses. The results showed that the damage cost of floods to agricultural production can be substantial, depending on timing and the ways that farmers coped with the flooding.

In a simulation method, Kotera and Nawata (2007) conducted an experiment to explore the connection between yield reduction and inundation for rice growth stages. Three factors, including start date, duration and depth of submergence were used to determine yield reduction. The results showed that yield losses vary, not only by flood characteristics, such as duration and water depth level, but also the growth stage of the crop. For example, the yield loss of rice that was inundated in the early vegetative stage was greater than plants inundated during the reproductive stage.

Banerjee (2010) used rice and jute productivity data to estimate the short and long-term impacts of extreme floods on agricultural productivity in Bangladesh. The short-term impact was assessed by comparing average annual yield rates in ‘normal’ flood years with those in ‘extreme’ flood years. The long-term impact was analysed by comparing the area under cultivation and the agricultural productivity in ‘more’ and ‘less’ flood-prone districts over a 20-year period.

Penning-Rowsell et al. (2013) used a depth-loss rate relationship to assess flood damage on land use categories (including residential, agriculture, industry, business and infrastructure) in the Taihu Basin, China. They established the depth-loss rate by asset categories and flood depth based on an existing flood loss rate or susceptibility, which was a percentage of the pre-flood property value at varying flood depths, and associated flood damage data from past floods. They tested their model using 1999 flood data and found that their damage loss differed only slightly from the widely accepted records of loss issued by the Taihu Basin Authority.

A number of studies, from both local and international institutions have been undertaken to study flood hazards in Quang Nam province (Cologne University of Applied Sciences 2013; Ho & Umitsu 2011; Institute of Geography 2012; Institute of Water Resources Planning 2011), however, none of these studies have quantified the impact on agricultural production of extreme flood events. This study aims to fill that gap by conducting an economic assessment, restricted to flood damage incurred by three flood classes (1:10, 1:20 and 1:100-year floods) on agricultural production in Quang Nam province. Estimated are the direct tangible economic losses from these three flood classes on the four main crop types grown in the province. The main crop types have been identified and grouped as: rice, corn (maize), beans (predominantly long beans, haricot beans, green beans, soybeans and black beans) and ‘other vegetables’ (including garlic, chillies, water spinach, kohlrabi, aubergines, various Chinese cabbage and leafy green salad vegetables). The analysis utilises geo-spatial inundation maps developed in Chapter Three that portray the extent of the flooding upon agricultural land by the three flood classes. Using *ex-post* data, including the timing of the extreme floods with respect to crop rotation, a damage function is used to estimate the resulting damage and evaluate the economic efficiency of agricultural production under these three extreme flood scenarios without further mitigation.

4.2 Data used

The floods of 2004, 2009 and 2007, congruent with 1:10, 1:20 and 1:100-year floods respectively, form the basis of this study. In order to estimate the flood damage costs to agriculture, the submersion results generated by the inundation mapping in Chapter Three (Chau et al., 2013) are used in conjunction with 2010 economic data (described later in this section) collected during a field trip to Quang Nam province from November 2011 to February 2012. Data were collected from the Quang Nam Statistics Office[7] and from semi-structured interviews at the provincial level with officers of the Department of Natural Resources and Environment and the Department of Agriculture and Rural Development (DARD). At DARD interviews and discussion took place in both the Agricultural Extension and the Agricultural Planning divisions and also

[7] Including both the agriculture statistics division and the meteorology division.

the Flood and Storm Control division. At the district level, interviews were conducted with officers at each of nine districts' Agricultural Division[8].

In Chapter Three inundation maps were generated using the geographic information system, flood depth marks from the floods of 2004, 2009 and 2007 respectively, and a digital elevation model. The agricultural land affected by these inundations was identified by overlaying the flood inundation maps over the agricultural land use map for the province. The map of the agricultural land predicted to be affected by a 1:100-year flood event (like that which occurred in 2007) in Quang Nam province is presented in Figure 4.2.

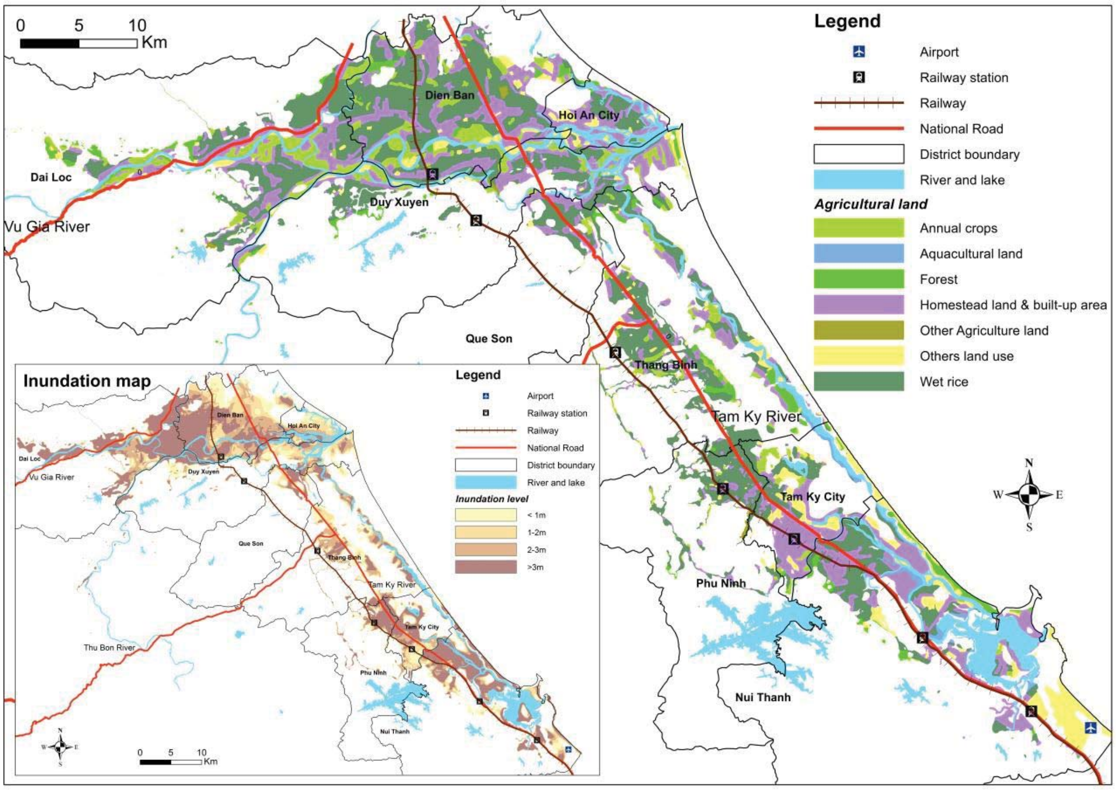


Figure 4.2. Predicted inundation of agricultural land in Quang Nam province, Vietnam, resulting from a 1:100-year flood event.

[8] In all some 36 interviews and discussions took place.

Figure 4.2 shows the areas of wet rice production, other agricultural land, aquaculture, and forest land predicted to be inundated by a 1:100-year flood. The model estimated that agricultural land would be the land use type most impacted by each of the three flood classes. The inundated agricultural areas for 1:10, 1:20 and 1:100-year flood events are estimated to be 29,920ha, 33,850ha and 37,000ha, respectively, which account for 27%, 30.5% and 33.4% of the total agricultural area in Quang Nam, respectively. Wet rice (the main crop) was identified as being the most affected crop, with more than 40% of the total wet rice growing area being inundated under each of the three flood classes. Corn, beans and ‘other vegetables’ accounted for less than 10% of the total flooded area, while grazing land and perennial fruit production comprised only a very small proportion of flooded land.

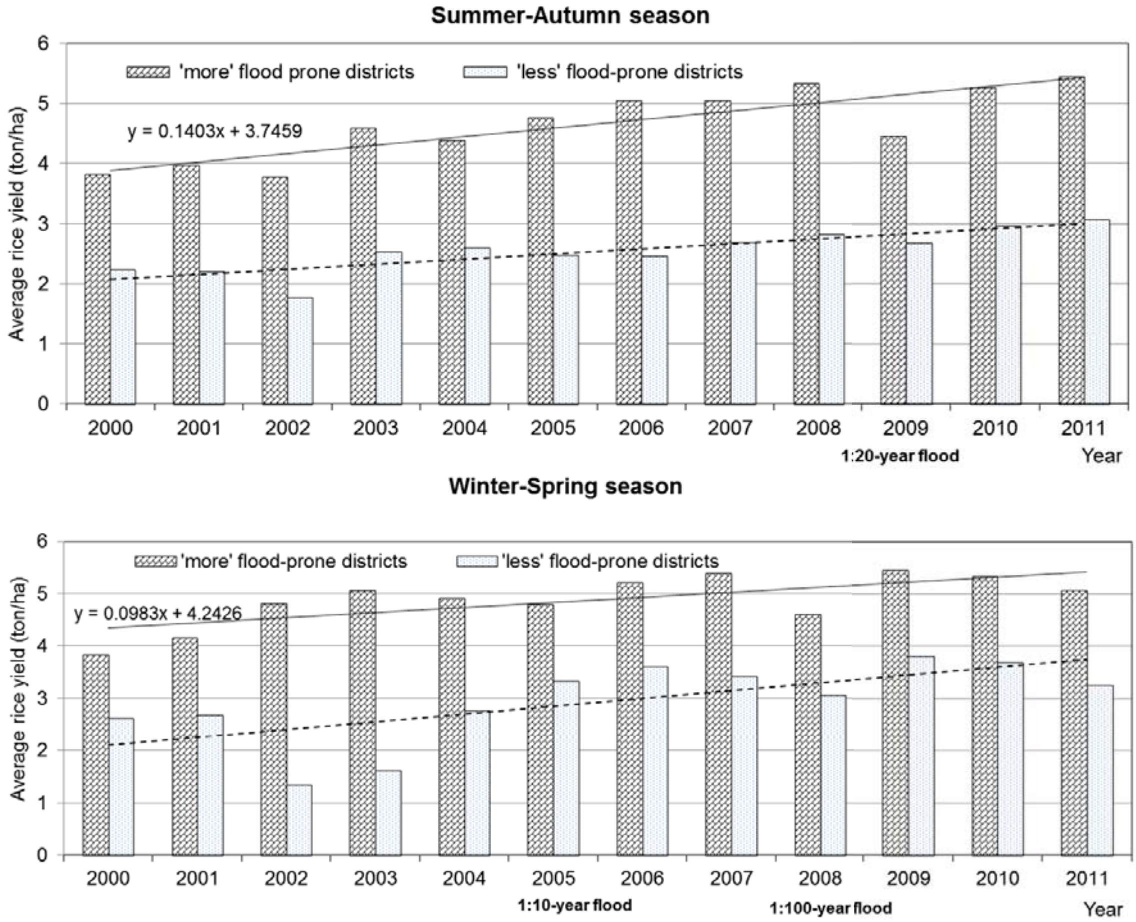
Nine districts affected by the floods, namely Dai Loc, Dien Ban, Duy Xuyen, Hoi An, Thang Binh, Phu Ninh, Que Son, Nui Thanh and Tam Ky were grouped into the ‘more’ flood-prone districts. The remaining administration districts were identified as the ‘less’ flood-prone districts, and in general were not affected by flood water inundation. In this study only the ‘more’ flood-prone group of districts is used in the analysis.

In Quang Nam, rice, corn, beans and ‘other vegetables’ production is carried out on small irrigated family farms utilising family labour. Farm sizes are typically less than 0.2ha in the low-lying areas (pers. comm. Agricultural Extension Centre, 2011). Farming families consume a considerable proportion of the farm output, with the remainder being sold or bartered locally. There is no official classification between skilled and unskilled labour in agricultural production in the province (Quang Nam Statistics Office, 2011), so it is assumed that the same wage rate is paid to all labour.

Crop production costs and revenue data were adapted both from the Quang Nam Statistical Yearbook 2010 (Quang Nam Statistics Office, 2011) and data collected via interviews with DARD and the Districts' Agricultural Divisions. Cost data included input costs for seeds, fertiliser (urea, superphosphate, KCL, lime), agrochemicals (e.g. pesticides), tractor hire, bags and boxes for packaging, transportation, labour costs for seedbed and land preparation, sowing, agrochemical and fertilizer application, irrigation maintenance, weed and pest control, harvesting, threshing, drying, packaging, delivering to market and in addition, cooperative charges (pers. comm. Agricultural Extension Centre, 2011; pers. comm. Agricultural Divisions of Dai Loc, Dien ban, Duy Xuyen and Nong Son Districts, 2011)[9]. All costs are calculated on a per hectare basis as are benefits from output yields. These farm gate input and output prices are used to calculate the costs and benefits of primary agricultural production (rice, corn, beans and 'other vegetables') both in a 'normal' growing year without an extreme flood event and then agricultural production as impacted by the three flood classes.

Average crop yields were obtained from the Quang Nam Statistic Yearbook for 2010 (Quang Nam Statistics Office, 2011). The average seasonal rice yields for both the 'more' flood-prone and the 'less' flood-prone districts for the period 2000 to 2011 are shown in Figure 4.3.

[9] Details of this data can be seen in the appendix B.



Data sourced from the Quang Nam Statistics Office (2011).

Figure 4.3. Average annual rice yields/ha and trends in the 'more' flood-prone and 'less' flood-prone districts of Quang Nam province, 2000-2011.

Figure 4.3 shows the average yield (tonne) per hectare of the summer-autumn and the winter-spring rice crops, with differentiation made between the 'more' flood-prone and 'less' flood-prone districts. Trend lines (regression lines of best-fit) for both crop season yields have been included. Yields increased on average by a rate of 3.8% per season for the summer-autumn crop and by 3.0% for the winter-spring rice crop. Rice crop yields per hectare have been increasing for a number of reasons. These include the use of improved varieties of rice which have increased yields, more effective irrigation and also increased use of fertiliser. It is important to note that the 2004 and 2007 floods affected the winter-spring rice crops, which were harvested in April of the following year.

Therefore, it is the 2005 and 2008 rice yields which are impacted by the floods, as can be seen in Figure 4.3.

Traditionally there were three annual rice crops grown in Quang Nam: a summer-autumn, winter-spring and a spring-summer rice crop. However, the Government decided that the spring-summer rice crop was to be eliminated completely from 2005 on, since it was the crop most often seriously affected by frequent flooding and so was the one least profitable. Since the spring-summer rice crop rotation is no longer grown in the province, it was not considered in this study.

4.3 Method

A two-step method is used to determine the value of damage to agricultural production from 1:10, 1:20 and 1:100-year flood events. First, *ex-post* data is used to populate a damage function which incorporates susceptibility rates for the four main crop types from which the direct tangible losses to agricultural production experienced under the three flood classes are estimated. The damage function and the susceptibility rates are described in detail in following subsection. Second, benefit-cost ratios are calculated for each of the four main crop types under different scenarios for the three flood classes in order to compare the situation for farmers under the ‘without’ and the ‘with’ extreme flood scenarios. The second step requires a one year analysis timeframe since all costs (and benefits) are incurred (and realised) within each crop season, which is less than one year. In addition, there is no capital equipment used, with planting and harvesting done by hand. If a tractor is used, it is usually hired (pers. comm. Agricultural Extension Centre, 2011; pers. comm. Agricultural Divisions of Dai Loc, Dien Ban, Duy Xuyen and Nong Son Districts, 2011).

Damage function and susceptibility rates

Flood damage to agricultural production is dependent upon a number of variables, including type of crop, the crop's development stage, inundation depth and duration of inundation (Hansen, 1987; Messner et al., 2007; Peltonen-Sainio et al., 2010; Read Sturgess and Associates, 2000; van Aalst, Cannon, & Burton, 2008). Where available, damage predictions can be estimated based on 'real flood damage data' from previous flood events. Alternatively, predictions can be made by using depth-damage functions derived from past inundation characteristics and land-use data (Messner et al., 2007). With regard to flood damage to agriculture, the damage function method estimates crop damage based on the relationship between inundation depth, duration of inundation and crop development stages (Hansen, 1987; Messner et al., 2007; Penning-Rowsell et al., 2013).

Since the required level of historical flood damage data is not available for Quang Nam, this study has utilised the damage function method. However, some assumptions were necessary and these will be detailed later in this section. To calculate damage to the four main crop types, the generalised simple damage function reported in Messner, et al., (2007) was used:

$$Damage_{total} = \sum_{i=1}^{n}\sum_{j=1}^{m} D_{i,j} \quad = \sum_{i=1}^{n}\sum_{j=1}^{m}\left(value_{i,j} \times susceptibility_{i,j}\right) \ (1)$$

Where:

i = category of crops at risk (n crops possible. In this study, there are four crop types: rice, corn, beans and 'other vegetables');

j = inundation depth (m inundation levels possible. In this study, four inundation levels are used: <1m, 1-2m, 2-3m and >3m);

D_{ij} = damage for crop i at inundation depth j;

$value_{ij}$ = yield per ha for crop i (based on previous year) x inundated area (at depth j) x crop sale price

$susceptibility_{i,j} = f\left(E_{i,j}, F_k\right)$ (2) measured as a percentage of crop yield (for rice and corn) and of replanted area (for beans and 'other vegetables')

E_{ij} = characteristic of crop i under inundation level j of flood class k;

F_k = inundation characteristics of flood class k (In this study there are three flood classes, k = 1:10, 1:20, 1:100-year flood).

The susceptibility rate for each crop and each flood class (1:10, 1:20, 1:100-year floods) was estimated based historical data from the 2004, 2009 and 2007 floods, respectively. For rice and corn the susceptibility rate reflects the loss of crop yield based on historical yields using the difference between the average crop yields in the year of extreme flood with that of the previous year. For the extreme flood year, average crop yields from the nine 'more' flood-prone districts were calculated and separated according to four inundation levels, namely <1m, 1-2m, 2-3m and >3m. The crop losses for each district populating a particular inundation level were collected for each flood class. These yield losses were then averaged to obtain an estimate of the yield loss associated with that inundation level, and expressed as a percentage of crop yields. These percentages are the susceptibility rates. For beans and ‘other vegetables’ the susceptibility rates reflect the percentage of the affected area that required replanting, again separated according to the four inundation levels. These two different approaches to susceptibility rates used here stem from the fact that $E_{i,j}$ (of which susceptibility is a function), in this study represents the timing of the flood relative to the timing of the crop rotation (which for rice and corn impacts crop yield and for beans and ‘other vegetables’ results in some areas requiring replanting).

Based on the inundation mapping and data collected during in-country interviews, estimation was made of the area of inundation for each of the four main crops at each of the four inundation levels. These results are presented in Table 4.2 for each of the flood classes.

Table 4.2. The predicted area (ha) of each crop affected at the four inundation levels for the three flood classes.

Flood	Crop	Area affected by inundation level				Total area
		< 1m	*1-2m*	*2-3m*	*>3m*	
1:10 YR	Rice	6,620	7,586	4,929	5,361	24,496
	Corn	659	583	501	285	2,028
	Beans	307	376	257	104	1,044
	Vegetables	483	846	550	348	2,227
	Total	*8,069*	*9,391*	*6,237*	*6,098*	*29,795*
1:20 YR	Rice	5,367	6,808	6,628	8,472	27,275
	Corn	610	563	488	413	2,074
	Beans	420	371	378	268	1,437
	Vegetables	881	618	645	723	2,867
	Total	*7,279*	*8,359*	*8,138*	*9,876*	*33,653*
1:100 YR	Rice	4,021	5,778	6,159	13,857	29,815
	Corn	359	603	603	531	2,095
	Beans	388	351	426	672	1,837
	Vegetables	913	690	630	884	3,118
	Total	*5,681*	*7,422*	*7,818*	*15,944*	*36,865*

Note: These totals differ from those given in the 'Data used' section as they were figures for all agricultural production whereas these are the areas affected for the four main crop types.

Table 4.2 shows that for a 1:20-year flood, 8,472ha (31%) of the total affected rice growing area is inundated by more than three metres of water. For a 1:100-year flood this affected area increases to close to half (13,857ha or 46.5%) of the flooded rice crops being inundated by more than three metres of water.

The susceptibility rates of the crops to flooding, at each inundation depth, were determined based on the reduction in yields (for rice and corn) in the year of the extreme flood from the previous year, and the percentage of replanted area (for beans and 'other vegetables') for the 2004, 2009 and 2007 floods. The results, expressed as a percentages, are shown in Table 4.3.

Table 4.3. Susceptibility rates in yield (rice and corn) and replanted area (beans and vegetables) as a resulting of flooding (%).

Inundation depth *(m)*	**1:10-year (2004)**				**1:20-year (2009)**				**1:100-year (2007)**			
	Rice	*Corn*	*Beans*	*Vegetables*	*Rice*	*Corn*	*Beans*	*Vegetables*	*Rice*	*Corn*	*Beans*	*Vegetables*
<1	0	0	10	10	0	0	0	20	0	0	10	20
1-2	0	1	20	20	7	0	0	30	7	3	30	40
2-3	3	3	50	40	15	0	0	50	16	6	50	60
>3	6	5	70	60	29	0	0	70	23	11	70	80

In the case of a 1:100-year flood, 30% of beans inundated by 1-2metres have to be replanted. As seen in Table 4.3, the highest rate of rice yield loss, measured against the previous year was for an inundation of more than three metres in 2009 when the summer-autumn crop was inundated prior to harvest. It is worth noting that this is for a 1:20-year flood, evidence that it is the timing of the flood that is the critical factor.

Assumptions made

The flood season in Quang Nam province is separated into early (August to September), main (October to November) and late flooding (December to January). The Provincial Committee for Flood and Storm Control note that, in conditions of no further rain immediately following a flood and with normal tides, the receding of the flood waters vary between one and six days, depending upon the level of inundation. An inundation of less than one metre is likely to have receded completely within one and a half days, causing no damage to either rice or corn, however, beans and vegetable crops may be affected. An inundation of one to two metres typically recedes within two days, two to three metres in three days, and more than three metres takes between three and six days to recede. No information was available regarding the duration of inundation and any associated damage impact, therefore, these durations of floodwater inundation are noted here, but are not used when calculating the damage function. The calendar for the flood seasons and the growing months for the four main crop types are presented in Table 4.4.

Table 4.4. The calendar for the main crop production and the flood seasons in Quang Nam province (2010).

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Winter-Spring Rice	■	■	■	■								■
Summer-Autumn Rice						■	■	■	■			
Corn	■									■	■	■
Beans	■	■									■	■
Other Vegetables	■	■	■	■	■	■	■	■	■	■	■	■
Flood season	■							■	■	■	■	■
Main flood period										■	■	

The past floods used in this study as representative of 1:10, 1:20 and 1:100-year floods occurred during 23 – 28 Nov 2004, 27 Sep – 3 Oct 2009 and 9 – 15 November 2007, respectively. As can be seen from Table 4.4, the 1:20-year flood (2009) occurred when the summer-autumn rice crop was ready for harvest. The 1:10-year flood (2004) and 1:100-year flood (2007) both occurred as the winter-spring rice crop was planted (although planting data from 2010, shown in Table 4.4 begins at the end of November). This meant the damage from the 2004 and 2007 floods was reflected in crop losses for the years following, as the winter-spring rice crop was planted in November 2004 and 2007 but was harvested the following April in each case (2005 and 2008). This is clear to see evident in the Figure 4.3 yields of the winter-spring season for the 'more' flood-prone districts. As will be seen later, the timing of these flood events are critical for their impact, regarding yield loss or replanting required.

Scenario and sensitivity analyses for the benefit-cost ratios

Since both the timing of the extreme flood in relation to crop growing cycles and the severity of that flood (as reflected in this study by the susceptibility rates) are uncertain, scenario analyses were performed to estimate the crop yield losses for each of the three flood classes. The most significant impact on the level of loss to agriculture is the timing of the floods, particularly the timing relative to the growing cycle of the rice crops, which are the staple crops in Quang Nam. According to Kotera and Nawata (2007) rice submerged at the end of the growth phase is subject to significant yield loss, as are rice plants inundated immediately following transplanting in the field. Three scenarios were developed by varying the timing of the flood event for each flood class, and were identified as pessimistic, likely and optimistic scenarios. These scenarios were created in consultation with DARD (pers. comm. Water Resources and Flood and Storm Control Division, 2011b). The baseline used for both the scenario and sensitivity analyses was the 2010 crop yields and prices.

The likely scenario for each of the 1:10, 1:20 and 1:100-year floods is that which occurred in 2004, 2009 and 2007, respectively. Therefore, the susceptibility rates calculated from these historical floods are combined with the 2010 crop yields for the likely scenarios.

For the pessimistic scenario, it was assumed that the extreme flood event would occur at the end of September, destroying the summer-autumn rice crop, just as it is ready for harvest. The crop calendar shows that ‘other vegetables’ is the other crop type affected at this time. The susceptibility rates for rice and ‘other vegetables' for each of the inundation levels will be increased by 30% to reflect the yield reduction (rice) and the replanting required ('other vegetables') for the worst-case scenario for each flood class[10]. Corn and beans are not affected in the pessimistic scenario as they are not in the ground at this time.

The assumption for the optimistic scenario is that flooding will occur during the main flood period, between early October and late November, after the summer-autumn rice has been harvested. In this scenario, the flood level both rises and recedes quickly as a result of low tides and no further rainfall. There is no rice crop planted at this time and it is possible for corn, beans and 'other vegetables' to be replanted. It is assumed that the flood cost damage to the crops, which are young and highly vulnerable to inundation, is the cost of replanting. To reflect this, the susceptibility rates for each inundation level will be decreased by 10% for the optimistic scenario (pers. comm. Water Resources and Flood and Storm Control Division, 2011b, 2011c).

Sensitivity analyses are performed to estimate the impact on the benefit-cost ratio for each flood class as a result of changes in the product price, yield and labour costs. Variation in product prices are considered from -30% (where the quality of the output is degraded by the flood) to +50% (where food shortages during the flood season have pushed the prices up)[11]. Variations in yield from -30% (impact of disease) to +30% (when taking advantage of technology[12]) were

[10] An increase of 30% is used since in Table 2 an inundation depth of >3m for the 2009 flood shows a susceptibility rate for rice of 29%, and for 'other vegetables' of 70%, so the more conservative option has been assumed for the worst-case.

[11] In rare situations (for example in remote areas) the price of rice can be double the usual price (pers comm. District Agricultural Officer).

[12] In 2010 the rice yield for the US was roughly 7.5 tonne/ha (FAO, 2012), some 40% higher than Vietnam's rice yield. Since the US is one of the most technologically advanced rice producing countries, this study has assumed that a 30% increase in yield would be possible. In

considered. Changes in labour costs (which are most often returned to the farmers themselves as income) were also considered since this is the most significant cost to the small scale farmer, where all work is done manually. A range of between -30% (where farmers help each other (and any employees) out, for no payment, in difficult periods or periods of unemployment) and +50% (the actual cost observed in 2012 during data collection in the field) of the labour cost, per person per day, was also considered in this sensitivity analysis.

4.4 Results

4.4.1 Estimates of direct damage to agriculture

The per hectare yields, total costs and benefits (for 2010 yields and 2010 prices) for four the main crops in years ‘without’ extreme flood events are calculated and are presented in Table 4.5. Costs are separated into labour costs and non-labour costs.

Table 4.5. Yields, economic benefits, costs and benefit-cost ratios for the major crops in the ‘without’ flood scenario (VND thousands, in 2010 prices).

Crops	Yield (tonnes/ha)	Benefits per ha (VND 1000’s)	Costs per ha (VND 1000’s)			B/C
			total costs	*labour costs*	*non-labour costs*	
Winter-Spring Rice	5.33	25,628	21,296	10,500	10,796	1.20
Summer-Autumn Rice	5.26	25,310	21,296	10,500	10,796	1.19
Corn	4.94	23,430	16,797	5,880	10,917	1.39
Beans	1.16	24,360	14,323	4,680	9,643	1.70
Vegetables	13.00	43,680	19,770	10,800	8,970	2.21

Note: Non-labour costs include seed/planting materials, fertilisers, agrochemical, transportation, tractor, bags and packaging, cooperative charge and irrigation maintenance.

addition, the average annual rice yields in the ‘more’ flood-prone districts increased 25% and 10% in the 2000-2005 and 2005-2011 periods, respectively (see Figure 4.3).

Labour costs have been separately identified in Table 4.5 as these are a significant part of the total cost of agricultural production in Quang Nam. For rice growers, for example, labour costs are roughly half their total costs (pers. comm. Agricultural Extension Centre, 2011; pers. comm. Agricultural Divisions of Dai Loc, Dien Ban, Duy Xuyen and Nong Son districts). It can be seen from Table 4.5 that the benefit-cost ratios (B/C) for rice production in ‘normal’ years is not particularly high, with an approximate 1.2 VND benefit for every 1 VND spent. The benefits per hectare for beans and ‘other vegetables’ are considerably higher, at 1.7 times and 2.21 times their costs, respectively. This would explain why farmers are willing to risk planting beans and ‘other vegetables’ during the major flood period. However, these crops are only planted where the soil and land elevation are suitable (pers. comm. Agricultural Extension Centre, 2011).

Next, the costs and benefits (in 2010 prices) are calculated for the ‘with’ flood scenario for each of the three flood classes. The estimates of these, for rice only, are presented in Table 4.6.

Table 4.6. The total damage (loss) to rice production (VND billion in 2010 prices) and the benefit-cost ratios for the three flood classes.

Flood	Depth level (m)	Area (ha)	Total cost	Total benefit	Total damage	B/C
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
1:10-year (2004)	< 1	6620	141	157	0.00	1.11
	1-2	7586	162	179	0.00	1.11
	2-3	4929	105	113	3.45	1.08
	>3	5361	114	119	7.81	1.04
	Total	*24496*	*522*	*568*	*11.26*	*1.09*
1:20-year (2009)	< 1	5367	114	138	0.00	1.20
	1-2	6808	145	162	12.77	1.12
	2-3	6628	141	145	24.89	1.03
	>3	8472	180	155	62.29	0.86
	Total	*27275*	*581*	*599*	*99.94*	*1.03*
1:100-year (2007)	< 1	4021	86	104	0.00	1.22
	1-2	5778	123	139	10.56	1.13
	2-3	6159	131	133	26.08	1.02
	>3	13857	295	275	84.08	0.93
	Total	*29815*	*635*	*651*	*120.73*	*1.03*

Note: Total damage (rice) = susceptibility rate x previous year's yield/ha x area inundated (at that level, *m*) x price (2010)

As expected, the 1:100-year (2007) flood caused the greatest total damage (loss) to rice production in Quang Nam province at VND120.7 billion, since it inundated the greatest area and it impacted the larger yielding winter-spring rice crop. However, the B/C is equally low for the 1:20 and 1:100-year floods[13]. The reason for this is due to the timing of the 1:20-year flood (occurring in 2009) which came at a worse time, affecting the summer-autumn rice crop just prior to harvest so that the crop was seriously damaged. For individual rice producers, however, whose rice crop is inundated by more than three metres during a 1:20 or 1:100-year flood event, their costs outweigh their benefits (B/C < 1). Similar

[13] For the province as a whole, benefits just outweigh costs for both these floods as well as for the 1:10-year flood.

calculations were conducted for corn, beans and ‘other vegetables’ and these are presented, along with rice, in Table 4.7.

Table 4.7. Total loss of income for the four main crop types over the three flood classes (VND billion).

Flood	Rice	Corn	Beans	Vegetables	Total	B/C
1:10 (2004)	11.3	0.7	2.4	7.1	21.5	1.17
1:20 (2009)	99.9	0.0	0.0	14.6	114.5	1.11
1:100 (2007)	120.7	2.6	6.5	17.0	146.9	1.12

As expected, the 1:100-year (2007) flood caused the most damage to agriculture in the province at VND146.9 billion. The B/C is lowest for the 1:20-year flood since rice (the crop damaged most significantly by the 2009 flood) accounted for 87% of the total damage to agricultural production caused by this event. Therefore, it is the timing of the floods that is most critical to the damage caused to agricultural production. In terms of the percentage loss in value for the four crop types, losses in the inundated areas of 12%, 56% and 62% are experienced for 1:10, 1:20 and 1:100-year floods, respectively.

4.4.2 Scenario and sensitivity analyses

Scenario and sensitivity analyses were used to further estimate the total damage to agricultural production under the three flood classes (using 2010 yields and prices). The estimated losses for the four crop types under each of the pessimistic, likely and optimistic scenarios are presented in Table 4.8.

Table 4.8. Estimation of the total crop loss value (using 2010 yields) due to extreme flood events under pessimistic, likely and optimistic scenarios (VND billion in 2010 prices).

Flood	Rice	Corn	Beans	Vegetables	Total	B/C
Pessimistic scenario						
1:10-year	15.9	0.0	0.0	55.3	71.2	1.05
1:20-year	128.3	0.0	0.0	73.2	201.5	0.86
1:100-year	155.4	0.0	0.0	81.1	236.4	0.85
Likely scenario						
1:10-year	12.2	0.9	2.4	7.1	22.7	1.26
1:20-year	100.0	0.0	0.0	14.6	114.6	1.11
1:100-year	118.0	2.9	6.5	17.0	144.5	1.10
Optimistic scenario						
1:10-year	0.0	5.0	1.6	4.7	11.2	1.52
1:20-year	0.0	5.8	2.8	10.0	18.5	1.41
1:100-year	0.0	7.1	5.1	13.6	25.8	1.32

The likely scenario for the 1:10, 1:20 and 1:100-year floods are losses of VND22.7 billion, VND114.6 billion and VND144.5 billion, respectively. However, it can be seen in Table 4.8 that under a pessimistic scenario, where the flood events occur in late September, destroying the summer-autumn rice crop and much of the 'other vegetables', the value of the losses could be as high as VND71.2 billion, VND201.5 billion and VND236.4, which would represent percentage losses in the inundated areas of 41%, 98% and 100% for 1;10, 1:20 and 1:100-year floods, respectively.

Rice is the driver of agricultural production in the province, therefore, a relatively small amount of damage to the rice yield could change the B/C for agricultural production as a whole, from a situation of net benefit to one of net loss. The results of the likely and optimistic scenarios confirm that even in the case of an extreme flood, beans and 'other vegetables' remain cost-effective compared to other crops in Quang Nam's agriculture.

The sensitivity analyses initially involved independently varying the product prices, yields, and labour costs (for all four crop types simultaneously under the three flood classes). The results show that while a 20% fall in the price of each of the four crops will still yield a B/C over one for a 1:10-year flood, for a 1:20 or 1:100-year flood, a 12% and a 13% (respectively) fall in price would result in the costs outweighing the benefits. A similar trend also occurs for the crop yields[14]. With regard to labour cost, for any year experiencing a 1:20 or 1:100-year floods, if there is an increase in labour cost of 24% and 23%, respectively, the costs would outweigh the benefits. However, for a 1:10-year flood, labour costs could increase by more than 56% before resulting in a B/C of less than one.

Finally, B/C ratios are calculated when there is simultaneously a change in all product prices as well as labour costs; and then it is repeated for a change in all product prices as well as crop yields. The results for a 1:100-year flood are presented in Table 4.9.

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[14] A reduction in crop yields of more than 27%, 12% and 13% would result in a B/C < 1.0 for a 1:10, 1:20 and 1:100-year flood events, respectively.

Table 4.9. B/C ratios for a 1:100-year flood as a result of simultaneous changes in product prices and either labour costs or, crop yields (for all crops).

1:100 YR		Percentage change in all product prices								
		-30	-20	-10	**0**	10	20	30	40	50
Percentage change in labour costs	-30	1.01	1.10	1.20	1.29	1.39	1.48	1.58	1.67	1.77
	-20	0.95	1.04	1.13	1.22	1.31	1.40	1.49	1.58	1.67
	-10	0.90	0.99	1.08	1.16	1.25	1.33	1.42	1.50	1.59
	0	0.86	0.94	1.02	**1.10**	1.19	1.27	1.35	1.43	1.51
	10	0.82	0.90	0.98	1.05	1.13	1.21	1.29	1.36	1.44
	20	0.78	0.86	0.93	1.01	1.08	1.16	1.23	1.30	1.38
	30	0.75	0.82	0.89	0.96	1.04	1.11	1.18	1.25	1.32
	40	0.72	0.79	0.86	0.93	0.99	1.06	1.13	1.20	1.27
	50	0.69	0.76	0.82	0.89	0.95	1.02	1.09	1.15	1.22
Percentage change in crops yields	-30	0.69	0.75	0.80	0.86	0.92	0.97	1.03	1.09	1.15
	-20	0.75	0.81	0.88	0.94	1.01	1.07	1.14	1.20	1.27
	-10	0.80	0.88	0.95	1.02	1.10	1.17	1.24	1.32	1.39
	0	0.86	0.94	1.02	**1.10**	1.19	1.27	1.35	1.43	1.51
	10	0.92	1.01	1.10	1.19	1.28	1.37	1.45	1.54	1.63
	20	0.97	1.07	1.17	1.27	1.37	1.46	1.56	1.66	1.76
	30	1.03	1.14	1.24	1.35	1.45	1.56	1.67	1.77	1.88

The shaded area in Table 4.9, shows the simultaneous changes required to move from net benefits to net losses. For example, for a 1:100-year flood, a 10% decrease in product prices accompanied by a 10% increase in labour costs means that costs outweigh benefits. Similarly, if both yields and product prices simultaneously fall by 10%, costs will outweigh benefits. These results are for the four main crop types as a whole, although individual farmers could be affected to a greater (or lesser) degree depending on the level of inundation on their own land in each flood scenario.

4.5 Discussion

When comparing the results of this study (based on 2010 prices) with the actual reported losses to agricultural production in Quang Nam province for the corresponding years, the comparisons for two flood classes are favourable. In this study, the estimated loss from flood damage for a 1:10-year flood (that occurred in 2004, where the loss is realised in 2005) was VND22 billion as compared with the reported damage bill of VND21 billion from the Quang Nam People's Committee (2005) and the Central Committee for Flood and Storm Control's (CCFSC) disaster database (2012). The estimated loss of 1:100-year flood (occurring in 2007, where the loss realised in 2008) was VND146.9 billion, which represents a 62% loss in value for the four main crops in the inundated area. However, under a pessimistic scenario this estimate rose to VND236.4 billion (a 100% loss in crop value), if flooding occurred at the end September, before the summer-autumn rice harvest. The total damage of the 2007 flood was reported at VND1500 billion, 8% of which was damage to crops, that is approximately VND120 billion (Quang Nam People's Committee, 2008). This is less than this study's actual estimates and the 'pessimistic' estimates using 2010 prices.

The total reported damage for the 2009 flood, by the Quang Nam People's Committee (2010) and recorded in the CCFSC disaster database (2012) was VND3,500 billion, of which, VND1,400 billion was agricultural damage. However, the Vietnamese Prime Minister (2012) stated that the 2009 natural disaster damage reports were deliberately excessive in order to claim higher relief payments from the central government in 2009. Therefore, direct comparison with estimates from this study cannot easily be made. To provide a more realistic estimate of agricultural production loss, the results of the pessimistic scenario in this study (with the estimation of damage at VND201.5 billion) could be used as a 'maximum' flood damage estimate for a 1:20-year flood. In the same report, the Prime Minister (2012) also revealed that there were no natural disaster damage assessment criteria in Vietnam, which highlights a gap in the knowledge of post- natural disaster recovery. In addition, the agricultural flood area could be categorised into zones based on this CBA results for planners, farmers, policy makers and other stakeholders' reference. For example, the rice plantation should be restricted in the >3m inundation zone of a 1:100-year flood as the rice production costs outweigh the benefits, however, the flood prevention measures may be considered for the beans and other vegetables plantation zones as their B/C ratios are relatively high.

Whilst return on investment for rice is less than for other crops (with a B/C of around 1.2 in the 'without' flood scenario), rice remains the most important crop in Quang Nam province. This is because rice is the staple crop on which farmers are extremely reliant, and as such, does not experience the fluctuation in demand experienced by other crops. Almost 50% (VND10.5 million) of the total cost per ha of rice production is labour cost, which, since they do the work themselves, is considered direct income. Further, the smaller but higher returns from 'other vegetables' explains why some farmers are willing to take the risk of crop loss by using their land to grow vegetables during the main flood season.

The estimated cost of flood damage to agriculture used in this study is a function of the inundation depth, land use type and timing of floods. However, no consideration was given to potential loss incurred indirectly, for example, through traffic interruption (getting produce to market), delayed crop planting and intangible costs.

With all three flood classes having occurred in central Vietnam in the last decade, close attention is being given to flood prevention measures. Current proposals, including upgrading dykes and improving drainage by removing excess sedimentation in the river basins, aim to reduce the susceptibility of agricultural production to loss resulting from extreme flood events. The results of this study can give weight to the decisions made.

4.6 Conclusion

This study estimated the direct damage caused by 1:10, 1:20 and 1:100-year floods to agricultural production in Quang Nam province, Vietnam. The estimates of the total direct losses (in 2010 prices) to the four main crops in the agricultural sector for a 1:10, 1:20 and 1:100-year floods are approximately VND22 billion, VND115 billion and VND147 billion, respectively. These results can be used for *ex-ante* predictions as they have been verified by losses recorded by the local government in the corresponding years for both 1:10 and 1:100-year floods. Further, these direct losses represent a percentage loss in value (for the four main crop types) in the inundated area of 12%, 56% and 62% for 1:10, 1:20 and 1:100-year floods, respectively. For many individual farmers, total crop loss will be experienced. In addition, if a 1:100-year flood occurs at the end of September when the summer-autumn rice crops are ready to harvest, the impacts will be devastating.

This study utilises a method of analysis that can be replicated elsewhere. By using flood inundation maps and the likely timing of the flood event relative to crop rotation, the extent of devastation to specific crop types can be quantified and an economic assessment conducted. This study extends our knowledge of agricultural flood damage in Vietnam. However, gathering of additional flood duration data and greater detail on crop development stages would improve future studies. Furthermore, the release of additional water into the river systems from hydro dams during extreme floods exacerbates the flooding to agricultural land. With increasing demand for renewable power, more hydro-power stations are being planned and developed. This development needs to be monitored and included as part of future analyses to provide better information for mitigation decision making. Future research is needed to estimate the indirect damage incurred by extreme floods, not only on the agricultural sector, but other sectors and the economy as a whole.

It is clear that the agricultural flood damage in Vietnam is significant and of concern. While the flood protection systems (such as dyke and reservoir systems) have played an important role in protecting agricultural production from flooding, the effective legal system is also a crucial tool for the government to minimize the damage caused by flooding upon agriculture. The extent of this content is presented in the next chapter.

Chapter 5

Institutional structures underpinning flood management in Vietnam[15]

[15] Chau, V. N., Holland, J., & Cassells, S. (2014). Institutional structures underpinning flood management in Vietnam. *International Journal of Disaster Risk Reduction*, 10, 341–348

Abstract - The Germanwatch global climate risk index (GCRI) (Harmeling & Eckstein, 2012) ranked Vietnam the 6th country most affected by extreme weather events between 1992 and 2011. Similarly, the World Bank (2010b) estimated that 59 percent of Vietnam's total land area and 71 percent of its population were living with the risk of being exposed to extreme storm events and flooding. Like other countries that are prone to natural disasters, the government of Vietnam has developed extensive legislation to improving resilience to and minimise the risks posed by natural disasters.

In this study, the existing legal systems regarding flood management are reviewed and opportunities to strengthen them are identified. The legislation was reviewed in consultation with flood management specialists and government officials at the central, provincial and district levels. Local community members were also interviewed to gain insights as to how they are affected by floods and impacted by flood mitigation measures.

Whilst there are a large number of legal documents pertaining to natural disaster management, they are fragmented, overlapping and repetitive. In addition, lack of training and insufficient technical and financial support at local levels exacerbates the problems. Recommendations are made to strengthen institutional support to economic sectors and individuals who are victims of extreme flood events. These include: a shift from the current 'top-down' approach to include a 'bottom-up' approach; encouragement of transparency and accountability; decentralisation of the allocation of both technical and financial resources to improve training, particularly at the local levels and; to investigate the merits of introducing insurance schemes.

5.1 Introduction

Ranked 6th amongst the world's most vulnerable countries with respect to natural disasters (on the global climate risk index of 2013 between 1992 and 2011) (Harmeling & Eckstein, 2012), the losses in both economic and human terms are a significant concern for Vietnam. Further, the World Bank (2010b) estimated that 59 percent of Vietnam's total land area and 71 percent of its population were living with the risk of being exposed to extreme storm events and flooding. Vietnam is located within a tropical monsoon zone, has a coastline of more than 3,400km and a topography that makes it particularly susceptible to significant damage from extreme floods, storms and droughts (Kellogg Brown & Root Pty. Ltd., 2009; Luong, Nguyen, Wilderspin, & Coulier, 2011; World Bank, 2010). Whilst much endeavour has been made to put the best structural protection measures in place, weaknesses in both the legal system and in institutional structures hinder the ability of the government to effectively respond to emergencies.

Effective emergency response includes mitigation, preparedness, response and recovery measures (Ahmed, 2013; Simonovic, 2012; Tol, van der Grijp, Olsthoorn & van der Werff, 2003). However, Baker and Refsgaard (2007) contend that an effective legal system is an important adaptation measure, and one that enhances the likelihood of success of emergency reaction strategies. This is particularly so within the context of climate change which is characterised by both 'known' and 'unknown' uncertainties (Bouwer, 2013; Heazle et al., 2013,; IPCC, 2012). Weak policy or poor performance may result in additional damage and increased vulnerability to natural disasters (IFA, 2005).

Natural disasters themselves also provide opportunities to learn from and improve natural disaster management systems. The learning opportunities that are exposed during and after disasters come in the form of experience, evaluation and institutional strengthening (Baker & Refsgaard, 2007; Lin, Chang, Tan, Lee, & Chiu, 2011; Omidvar, Zafari, & Derakhshan, 2010). Institutional assessment assists in defining the existing internal capacity of agencies involved in disaster management (IFA, 2005), while policy strengthening and development or identification of gaps in particular elements of the management cycle add to both collective and individual capability building in response to natural disasters. With the increase in the incidence of natural disasters around the globe, there has been a corresponding increase in the need to revisit and reform natural disaster management policies (Lin et al., 2011).

There is strong evidential support for integrating a ‘bottom-up’ approach on natural disaster management into the existing institutional ‘top down’ planning paradigm (Næss, Bang, Eriksen, & Vevatne, 2005; Smit & Wandel, 2006; van Aalst, Cannon, & Burton, 2008). The studies of Næss, Bang, Eriksen and Vevatne (2005) in Norway, and Kusumasari and Alam (2012) in Indonesia both highlighted the importance of the role and capability of local authorities in natural disaster management, not just in developed but also in developing countries. The delegation of many flood impact mitigation responsibilities to local decision makers is becoming increasingly common in the United States (Brody, Kang, & Bernhardt, 2010).

The increasing incidence of climate–induced natural disasters, combined with increasing urbanisation, rapid population and economic growth, have exacerbated environmental degradation in Vietnam (Dasgupta, Laplante, Meisner, Wheeler, & Yan, 2009; IPCC, 2007; World Bank, 2010). Like other countries that are prone to natural disasters, Vietnam has developed extensive legislation in this area that focuses on prevention and mitigation measures (CCFSC, 2011; IFRC & ADB, 2009). Despite the willingness of and efforts made by the government, including structural measures and policy development, the damage caused by natural disasters remains significant, particularly in the agricultural sector (Chau et al., 2013; Chau, Cassells, & Holland, 2014). Therefore, it would appear that existing disaster and post-disaster relief policies in Vietnam have a number of limitations. This study explores the flood disaster risk management legislation in Vietnam, identifies gaps in natural disaster management policy and provides suggestions to improve the flood risk management agenda in Vietnam.

5.2 Research approach

The focus of this study is the flood management policies at the national level and the institutional arrangements for the implementation of these at provincial, district and commune levels. Quang Nam province (and in particular the flood-prone districts of Dien Ban, Dai Loc, Duy Xuyen and Nong Son) in the centre of the country and in the tropical monsoon zone, was chosen for this study as a type for Vietnam agriculture. In order to review existing flood management policies, these were collected from the Vietnam Government's legal document database (OOG, 2013), the Central Committee for Flood and Storm Control (CCFSC, 2011), the Department of Agriculture and Rural Development of the Quang Nam province and the Agriculture Divisions of the four districts. The institutional structures and the operationalisation of flood management systems at central, provincial, district and commune levels of government were reviewed and individuals were consulted in each of the hierarchical levels. Further, extensive site visits were undertaken in order to become familiar with the study area. Consultation and discussions took place between October 2011 and February 2012. Finally, recommendations are made to improve the effectiveness of the flood management legislation and practices in Vietnam.

5.3 Current legal documents pertaining to natural disaster management in Vietnam

After independence in 1945, the Vietnam government released its first Order (Order No.70/SL) pertaining to flood management. The implementation of this order led to the establishment of the Central Committee for Dyke Maintenance, which was later replaced by the Central Committee for Flood and Storm Control (CCFSC). Almost 70 years have passed since the first legislation was issued, and since then hundreds of legal documents have been passed. These included laws, ordinances, decrees, decisions and regulations creating a legal framework for the purpose of flood and storm control (initially) and natural disaster management (currently) across multiple sectors in Vietnam (CCFSC, 2011; Goosby, Mielbrecht, Sage, Chiesa, & Askov, 2010; IFRC & ADB, 2009; OOG, 2013). Despite a large number of legal documents, there is no single comprehensive law on multi-hazard disaster risk management. Water related disasters are considered the most threatening in Vietnam and the Law on Water Resources (2012) provides the principal legislative framework for any water resource management activities. The main purpose of this law is to promote sustainable water resource management and indirectly encompasses matters relating to disasters such as flooding. However, its role is not specifically directed to flood management, rather referring this function to both the Law on Dykes (2006) and the Ordinance on Flood and Storm Prevention and Control (2000). These two are key legal documents pertaining to flood management in Vietnam.

The Law on Dykes was adopted by the National Assembly in 2006 and provides a hierarchical system to manage dyke systems, which are the traditional structures for flood control in Vietnam. This law assigns authority to the Ministry of Agriculture and Rural Development (MARD), which has the primary responsibility for dyke management, planning, investment, maintenance, upgrading, protection, utilisation and emergency response. The law also decentralises authority to both provincial and district governments which manage the dykes within their territory, and are required to comply with central government planning to ensure nationwide consistency. Communities are also legally bound to be responsible for dyke management, protection and emergency responses, however, they tend to be slow to act and their contributions are insignificant. The reason for this is that while responsibilities for dyke management are devolved to provincial and district authorities, in practice resourcing is withheld, leaving the authorities closest to the vulnerability without sufficient resources to take the necessary action.

Dykes in Vietnam have a dual purpose role, both as a bank for irrigation and acting as a drainage canal (pers.comm. Central Project Office. 2011a; 2011b). This role as a drainage canal means that not only do dykes come under the Law on Dykes (2006) but are also governed by the Ordinance on the Management of Irrigation and Drainage Structures (2001), the purpose of which is to enhance the management and protection of dykes. This ordinance also devolves authority for the operation and protection of hydraulic structures to local government bodies and authorised organisations.

Another important body of flood management legislation was the Ordinance on Flood and Storm Prevention and Control (2000), however, with the need for more comprehensive legislation on natural disaster management, it has been superseded by the Law on Natural Disaster Prevention and Mitigation (LNDPM) that came into effect in 2014. The LNDPM governs not only traditional flood and storm disasters, but deals with disaster risk management in general, addressing three key elements, namely natural disaster prevention, response and rehabilitation. The LNDPM also addresses the rights and duties of both individuals and organisations with regard to natural disaster prevention and mitigation.

The hierarchical framework of the LNDPM is a top-down approach that highlights the responsibilities of the various levels of government. At the national level, the Prime Minister presides over a Central Steering Committee for Natural Disaster Prevention and Mitigation (CSCNDPM) and, in support, each government department has established a committee to govern activities within their portfolio. At lower levels of government they have established Natural Disaster Prevention, Mitigation and Search and Rescue Committees that drive and co-ordinate immediate responses to natural disasters.

In 2009, the government began implementing a National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (2007). This strategy focuses on integrating natural disaster management with socio-economic needs to ensure effective responses to both natural disaster events and their recovery phase. The strategy included public awareness campaigns to educate communities about flood preparedness and responses, however, the programmes continue to struggle because of insufficient budgetary allocations (pers.comm. Water Resources and Flood and Storm Control Division. 2011a).

A key body of legislation that provides support to Vietnam's flood management and response framework is the Ordinance on the State of Emergency (2002). However, an outline of its importance it is not publically available (pers.comm. Disaster Management Centre 2011a; Dyke Management and Flood and Storm Control Department. 2013). The ordinance is credited with being the most comprehensive legal text to date on emergency response to flooding and storms. The protocols are that, (Decree No.71/2002/ND-CP, 2002) following the announcement of an emergency by the Vietnamese State President, the Prime Minister will establish a Steering Committee to command all emergency response activities. The Chairman of the Provincial People's Committee of each affected province automatically becomes a member of the Steering Committee, providing guidance to provincial, district and local authorities who coordinate the emergency response activities during and post disaster.

Despite providing a useful continuum for responses to all types of disasters, from central government through to commune levels, the Ordinance on the State of Emergency (2002) does not provide any guidelines or support mechanisms for practice exercises, deemed crucial for parties to gain the skills required to respond when an actual disaster strikes. Practice exercises, which are seldom conducted at any of the levels, so that supposed leaders are ill-prepared for such an emergency (pers. comm. The Standing Office for Flood and Storm Control of Quang Nam, 2011).

5.4 Institutional structure for flood management

An evaluation of the current centralised institutional framework in Vietnam reveals that there are few incentives for local governments to be proactive with regard to flood management planning. These findings corroborate those of a Norwegian study by Næss et al. (2005). A framework of the Vietnamese flood management structure showing the levels of responsibility, is presented in Figure 5.1.

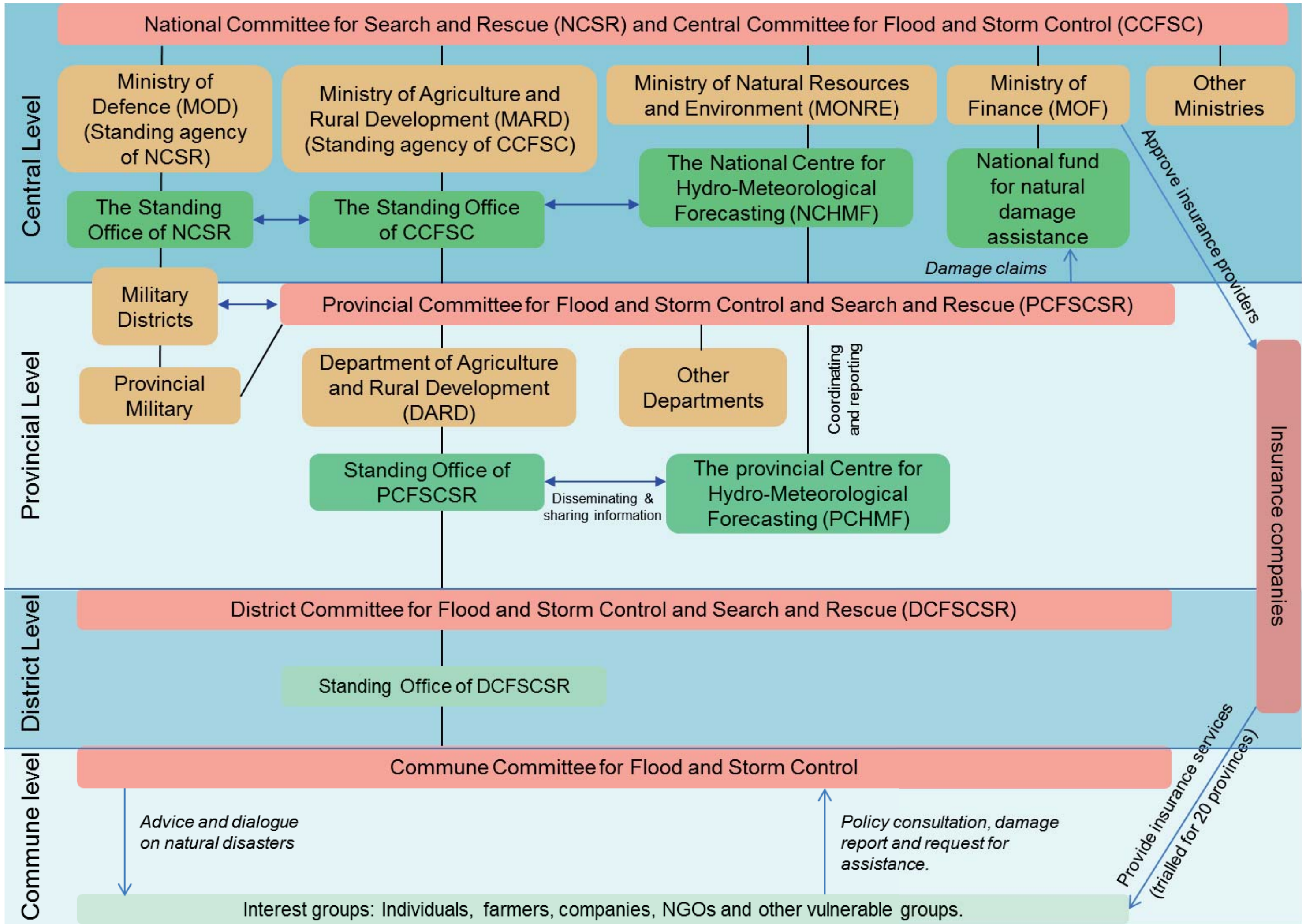


Figure 5.1. Institutional framework for flood management in Vietnam.

From the figure it can be seen that the central government agencies with responsibilities for flood management are the National Committee for Search and Rescue (NCSR) and the Central Committee for Flood and Storm Control (CCFSC), for which the Ministry of Defence (MOD) and the Ministry of Agriculture and Rural Development (MARD) are the respective standing agencies. The roles of the CCFSC and NCSR are principally policy implementation and guidance, including decision making in affected areas before, during, and after a flood event. The military can also be called upon for assistance in the case of natural disasters.

At the provincial level, the Provincial Committee for Flood and Storm Control and Search and Rescue (PCFSCSR), chaired by the Chairman of the Provincial People's Committee (PPC), is directly responsible for flood management and reports to the PPC. As with the structure at the central level, the departments of the Provincial People's Committee (for example, DARD) are members of the PCFSCSR. A similar structure exists at both district and commune levels with a District Committee for Flood and Storm Control and Search and Rescue (DCFSCSR) and a Commune Committee for Flood and Storm Control and Search and Rescue (CCFSCSR). Although the CCFSC, PCFSCSR, DCFSCSR and CCFSCSR's roles appear to be focused on flood and storm management, they are also responsible for other natural disasters such as earthquakes, tsunamis, tornadoes and landslides (Vietnam Government, 2010), as Vietnam has yet to establish a national body for overall disaster management.

In summary, the committees for Flood and Storm Control and Search and Rescue were established within all government levels and facilitated by MARD and MOD (at the central level), DARD (at the provincial level), an agriculture or economic unit (at the district level) and any available resources (at commune level). These are the agencies directly responsible for facilitating coordination among various government agencies during all phases of disaster management. The committees are activated during the flood and storm season in order to coordinate and communicate the level and timing of early warnings and to adapt and respond to unforeseen situations during flooding events. The PCFSCSR and DCFSCSR are normally disestablished after each flood season. The participants of the CCFSC, NCSR, PCFSCSR, DCFSCSR and CCFSCSR include the involvement of almost all government agencies (they are members of committees as presented in Figure 5.1) at the four levels of flood management. It is important to note that these structures are similar to those defined for the LNDPM. MARD covers all flood management activities through its permanent bodies of the Dyke Management and Flood and Storm Control Department (DMFSC) and the Disaster Management Centre (DMC) under the Water Resources Directorate of MARD. The DMFSC and the DMC's primary functions include: policy and decision-making processes relating to dyke management, and flood and storm prevention and response; control, inspection and management of the implementation of the national strategy on natural disaster prevention, mitigation and control, and; disaster response activities. MARD, together with the Ministry of Planning and Investment (MPI), allocate government funding for all flood and storm management activities to the relevant implementing agencies at the central and local levels. At the provincial level, the DARDs are responsible for the implementation of disaster management policies in their province. The Provincial People's Committee assigns DARD responsibility for flood preparedness and response activities. Similar responsibilities are assigned to the agriculture units at the district level, however, their budgets are limited. The Commune People's Committees have a very limited role in flood management, with the exception of information gathering and flood warning functions within their communes.

Emergency assistance to affected people (including the distribution of food, drink, shelter and healthcare) is implemented by government authorities and civil society organisations, mainly through the Vietnam Fatherland Front and the Vietnam Red Cross. Where damage is significant, the government may reimburse specific groups, such as farmers, from the national budget.

In order for strategies or policies to be successful they must be supported by the financial, technical and institutional resources required to implement them. Flood management in Vietnam is based on a top-down approach with the government's roles concentrated at central and provincial levels. However, site visit observations and discussions with officials in charge of the nine main flood-affected districts and communes in Quang Nam province, have shown that it is the district and commune officials who are the first responders during natural disasters, since they are the people with advanced knowledge of their area. They are the ones who bear responsibility and are the authorities most frequently contacted by the public, particularly farmers, requesting relief support.

Vietnam's 'top-down' approach weakens the ability of the local authorities to respond to natural disasters. For example, the Committees for Flood and Storm Control and Search and Rescue are ineffective, due to poor training and lack of essential resources, particularly at the commune level (CCFSCSR) and to a lesser extent, at the district level (DCFSCSR). It is important to note the shortage of professionally trained disaster management personal at all levels. Natural disaster management in most of the government agencies (with the exception of the DMC of MARD) is governed by the officers of the irrigation and dyke management sub-divisions who operate out of the Agriculture and Rural Development division. At each flood district in Quang Nam province, for example, only one or two officers work in this role, and even then only on a temporary basis, as they are responsible for other unrelated duties (pers.comm. Water Resources and Flood and Storm Control Division. 2011b). Most have no formal background or training in natural disaster management (pers.comm. Water Resources and Flood and Storm Control Division. 2011c). These limitations clearly contribute to underperformance with regard to response to natural disasters.

In addition, offices and facilities utilised by natural disaster response personnel are poorly resourced. There are insufficient basic tools and equipment, such as protective headgear and clothing, provided to emergency responders. Boats and land-based facilities are not well equipped for search and rescue operations (pers.comm. Water Resources and Flood and Storm Control Division. 2011a). The combination of all these issues contribute to an inadequate response to natural disasters at the local level.

5.5 Discussion

Whilst considered to be the most comprehensive legal document on natural disaster management in Vietnam, the LNDPM emphasises natural disaster management rather than today's more common focus on 'risk management', which represents a shift away from traditional natural disaster protection (Büchele et al., 2006; Merz, Hall, Disse, & Schumann, 2010; Schanze, 2006). According to Merz et al., (2010) traditional flood control focused on structural measures to prevent particular flood events (e.g. a 100-year flood), whilst the flood risk management approach places emphasis on reducing damage rather than responding to particular flood events that are becoming increasingly difficult to predict. Flood risk management is becoming more advanced as it integrates fragmented approaches towards risk reduction, such as a single structural approach, into a comprehensive approach (Merz et al., 2010).

The duplication and overlap of flood management roles and responsibilities in Vietnam hinder rather than aid flood risk management. As with the example of dyke management, coming under both the Law on Dykes (2006) specifically dealing with dykes from the viewpoint of a flood-protection structural measure, and at the same time protected by the Ordinance on the Management of Irrigation and Drainage Structures (2001) as an irrigation and drainage structure. This creates confusion, as dykes are governed by Flood and Storm control divisions but are also managed by irrigation companies responsible for irrigation and drainage structures.

In addition, there can be repetition around who is tasked with the implementation of legislation. For example, the LNDPM, defines provincial and district authorities as having the exact same responsibilities for natural disaster management. These responsibilities include: the preparation and approval of natural disaster prevention and mitigation plans; workforce mobilisiation along with materials, vehicles, and other essential items and; coordinating practice exercises for disaster response. The fact that the commune authority is also charged with similar responsibilities creates confusion and duplication and the overlapping results in less accountability and hinders effective preparation for, response to, and rehabilitation following natural disasters events.

Despite the large number of legal documents, they do not completely cover policies essential for flood damage mitigation. One such policy concerns a lack of insurance, which if in place could be used to provide timely relief and facilitate disaster recovery (Linnerooth-Bayer, Mechler, & Hochrainer, 2011). Those obtaining insurance protection could mitigate risk from natural disasters as well as bankruptcy. This would be particularly helpful to farmers, who are among some of the poorest people in Vietnam. To this end, the government trialled a pilot agricultural insurance scheme from 2011 to 2013 in 20 of the country's 63 provinces (Prime Minister of Vietnam, 2011). Whilst the trial period has ended, no data and evaluation reports have been published.

Whilst laudable policies are approved, the funds to implement them are inadequate. For example, whilst the National Strategy for Natural Disasters Prevention, Response and Mitigation to 2020 (2007) aims at upgrading dyke systems in the central region and providing disaster management for local government officials (pers.comm. Water Resources and Flood and Storm Control Division. 2011a), the budgetary allocations for natural disaster management remain unclear in the annual state budgets. There are special budgetary allocations at the central and provincial levels for natural disaster management that focus primarily on dyke maintenance and on landslide and erosion prevention, and when a disaster is declared, additional central and provincial contingency funds are used. Consequently, the rapid deployment of resources at the district and commune levels are constrained because funding is concentrated with central or provincial decision makers.

In addition to the uncertainty resulting from an inequitable or inefficient distribution of funds, inappropriate financial relief is provided by government to support flood recovery initiatives. The Vietnam government often uses its contingency and other financial resources as a relief source for people adversely affected by the floods. This support is often provided in the form of agricultural supplies like seeds, instead of meeting the immediate needs of the flood-affected people (pers.comm. Agricultural Division of Dai Loc District. 2011; Agricultural Division of Dien Ban District. 2011; Agricultural Division of Duy Xuyen District. 2011). Furthermore, government relief resources were significantly over-claimed by local governments (for example the 2009 claim) as a result of poor natural disaster damage assessment criteria (Prime Minister of Vietnam, 2012).

Extensive research programmes and projects relating to natural disasters have been conducted at both national and provincial levels. In the case of Quang Nam province, for example, there were more than 30 assessment projects related to floods, other natural disasters and climate change during the period of 2006-2013. However, through the field observation, most of these were lack of proper designed studies using single mode methodology to identify and quantify technique issues of natural hazard risks. Therefore, decision makers lack suitable information to evaluate the damage accurately, and, as a result, often take inadequate action to mitigate and recover from the economic, social and environmental impacts of natural disasters.

Despite ever-increasing damage from extreme floods, possibly exacerbated by technically poor information and ineffective decision making, it is the collectives, rather than individual decision makers who are often held to account regarding flood damage. This is made easier with the overlap of responsibilities, leaving authorised agencies able to blame each other and so avoid responsibility. In clear cases where mistakes are revealed, natural disaster damage is often attributed to general reasons such as ‘an out of control event’ or, ‘inadequate structural measures’ rather than identifying the responsible decision makers. Though lessons are learnt after every flood season, many mistakes are often repeated (such as inappropriate reservoir operation resulting in increasing flood discharge during floods).

In this study we acknowledge the dependency of subsistence farmers on natural flood events. However, given the ever increasing frequency and intensity of large floods, it is becoming increasingly evident that institutional reforms that address both the vulnerability of infrastructure as well as the vulnerability of communities is required (Tran, Marincioni, Shaw, Sarti & An, 2008). There is no easy fix to the problems associated with natural disaster management. Planning and management strategies that integrate the physical, social, institutional, environmental and economic elements of disaster planning are essential if Vietnam is to improve its track record of dealing with large flood events.

Both the causes and impacts associated with large flood events are complex and cover a suite of geophysical, institutional and social factors. It stands to reason, therefore, that any strategies designed to ameliorate or mitigate the impacts of large flood events draws upon a good understanding of social, cultural and physical processes (Tran, Marincioni, Shaw & Sarti, 2010).

5.6 Recommendations

Measures to reduce the impact of extreme weather events, particularly flooding, remain a high priority in Vietnam. The Vietnamese government has made a great deal of progress to prevent or mitigate damage by employing traditional structural measures like dykes and reservoirs and enacting legislative development, policy formulation and public awareness programmes to ameliorate the impacts of natural disasters. These on-going effects have already improved natural disaster management, however, if the institutional, technical and financial challenges highlighted in this paper were resolved, it would strengthen the government’s ability to respond to natural disasters. Recommendations to strengthen flood management practices in Vietnam therefore include:

– Reforming existing policy into a single comprehensive natural disaster management policy with clear guidelines for the effective coordination of all involved parties in order to address the fragmentation and duplication of functions.

- Replacing the current ‘top-down’ approach by combining it with a ‘bottom-up’ approach to provide more effective connection between the various institutions charged with providing assistance to flood-affected victims.

- Regularly monitoring and evaluation of flood prevention, mitigation and recovery plans using independent bodies to ensure accountability and transparency. Results of the monitoring and evaluation process should be published.

- For each risk-prone area, preparedness, mitigation, response and recovery plans should be established and approved by appropriate authorities. The plans should define clearly what should or can be done, as well as how, and for whom, for each level of natural disaster, before, during and post-disaster.

- There should be a decentralisation of responsibilities (and the financial resources to meet these responsibilities) to appropriate government levels and agencies, based on the classified level and type of natural disaster. Technical and financial support should be addressed and allocated appropriately to local governments. This will enable the district and commune Committees of Flood and Storm Control and Search and Rescue to be visible and proactive. This would ensure responsibility is appropriately assigned and that implementation takes place.

– Subsidies and relief allocation should be based on the approved risk/damage classification (e.g. crop type and crop development stage, inundation level and duration) to ensure effective disaster recovery.

– The capacity of agencies authorised to manage natural disasters should be strengthened and emphasis placed at the local level.

– Improved training for officials with disaster management and response roles.

– Agencies responsible for risk-prone areas should be appropriately equipped and practice exercises in emergency response should be a regular occurrence.

– Natural disaster insurance schemes that provide timely relief to disaster victims should be investigated.

5.7 Conclusion

As with governments of other countries prone to natural disasters, the government of Vietnam has been paying increasing attention to improving resilience and minimising the risks posed by natural disasters. Due to a lack of consistency and cohesion, current legislation and the concomitant allocation of roles and responsibilities for disaster management are duplicated, overlapping and fragmented. Lack of training and insufficient technical and financial support at local levels exacerbates the problems. These limitations weaken natural disaster preparedness, response and recovery capacity in Vietnam, and as a consequence, the damage resulting from natural disasters are a greater hindrance for socio-economic development than it might otherwise be.

Recommendations made in this chapter focus on several key areas. These are: to move from a fragmented ‘top-down’ approach to a more inclusive integrated approach to natural disaster management; to instigate independent monitoring and evaluation to encourage increased transparency and accountability; to decentralise the allocation of both technical and financial resources to improve training particularly at the local level thus strengthening the capacity of those closest to the most flood-affected sections of the community.

The following chapter combines the institutional review that was the subject of this chapter with the technical and economic considerations addressed in previous chapters in order to develop a synthesised overview of the management and mitigation of considerations associated responding to extreme flood events in Vietnam.

Chapter 6

Strengthening flood management in the agriculture sector in Vietnam

Abstract – Weaknesses are revealed in both the provincial and local authorities' policies for flood management in Vietnam, which is currently based on a top-down approach. Technical and economic analyses such as Geographic Information Systems (GIS) and Cost-Benefit Analysis (CBA) make it possible to quantify and value economic impacts associated with flood damage to agriculture. Such analyses could be used to provide valuable information to inform agricultural flood managers. In addition, the institutional and legal framework underpinning operational flood management systems must operate efficiently to enable authorities to combat the consequences of severe flood events in the future.

Currently, there is little systematic documentation of detailed data and institutional arrangements for flood management in Vietnam. In order to examine existing flood management and the systematic connection from central to local authorities in Vietnam, a matrix was set up regarding data and capabilities specifically for GIS and CBA application as well as their integration in flood management decision making. Taking Quang Nam province as a case study, the matrix's information/data are collected and evaluated using field observation and consultation with experts.

It was found that technical and economic analyses are often lacking or poorly implemented at local government level and consequently ill-informed decisions are often made. Recommendations are made which include establishing a data collection system for flood management, focusing on quality, quantity and accessibility, which is updated regularly. Also needed an increased availability of software, of appropriate training in the execution of technical and economic analyses as well as is the application of these to inform decision making for policy and mitigation measures. Finally, sound implementation strategies and

institutional arrangements focusing on community engagement are required to ensure legislative and policy decisions are carried out.

6.1 Introduction

Well-known strategies to avoid flood damage include flood control using engineered works such as dams, stop-banks or flood-ways; the exclusion of vulnerable people and property development from flood risk areas; and living with flood risk but with a high degree of preparedness (UN-HABITAT & UNEP, 2002). Having experienced frequent devastating floods, storms and other extreme weather events for thousands of years, Vietnamese people and their authorities have developed a number of measures to mitigate the impacts of natural hazard risks.

The famous Vietnamese myth of the God of the Mountains (Son Tinh) and the God of the Water (Thuy Tinh) relates that the two Gods went to war and, over a very long period of time, the God of the Water harnessed water to fight the God of the Mountains, who, in turn, created towering ranges to avoid inundation caused by his enemy. With the high ground created to counteract the rising water, the God of the Mountains finally won the battle and the water had to recede. However, Thuy Tinh returns annually for revenge. The Vietnamese people use this myth to explain the frequency of the flooding in Vietnam. This myth also signaled resettlement in higher land to stay away from flood as an initial measurement to dealing with floods.

Since the 12th century, thousands of kilometres of flood protection dykes have been built in Vietnam. From the late twentieth century, flood prevention reservoir systems have also played an important role in flood damage mitigation in Vietnam. In the last decade, with the increased incidence of extreme flood events, Vietnam has paid attention to integrated flood prevention and mitigation that focuses not only on structural measures (dykes, reservoirs and drainage systems) but also on the development of non-structural measures, such as early warning systems, education and awareness.

Currently, flood prevention and mitigation processes in Vietnam are based primarily on a top-down approach. The central government, through its Central Committee for Flood and Storm Control (CCFSC) and the Ministry of Agriculture and Rural Development (MARD), coordinates all flood management activities along with the National Committee for Search and Rescue (NCSR). The national and provincial Centres for Hydro-Meteorological Forecasting (CHMFs) also play a crucial role by providing flood forecast information to the government for its decision-making. Regionally, the Provincial Committee for Flood and Storm Control (PCFSC) and the Department of Agricultural and Rural Development (DARD) are directly involved in responses to floods under the leadership of the Provincial People’s Committee. At the district and commune level, Committees for Flood and Storm Control (CFSC) have been established to provide local awareness, preparedness and responses to flood events.

While institutional structures, roles, responsibilities, information flow and decision-making processes for flood prevention and mitigation are formalised from central to local levels, they do not operate as efficiently as they could, without and do not employ effectively delegating authority. There is a common understanding that institutional support is essential for effective flood management (UNDP, 2005). However, efficacy depends on the capacity to implement relevant policy and legal mechanisms including law enforcement, implementation guidelines, human resources, technical tools and political support.

In Chapter Five, weaknesses were revealed in both the provincial and local authorities' policies for flood prevention and mitigation in Vietnam. It is suggested that this stems from the lack of a single comprehensive manual or detailed guidelines for successive stages of the flood management cycle or from the lack of well-informed decision making at either district or commune levels. Instead, responses occur on a case-by-case or ad-hoc basis.

Recent studies indicate that the escalation of flood threats is influenced by climate change, therefore floods may increase in magnitude, frequency and intensity (IPCC, 2012; Karl, Melillo, & Peterson, 2009; Kwak, Takeuchi, Fukami, & Magome, 2012; Wang, Kuo, & Shiau, 2013; World Bank, 2010b). In addition, developing countries face greater flood damage risk due to insufficient resources, such as funding, infrastructure, technology, human capital, enforcement programmes and organisational capacity for flood management (Katsuhama, 2010).

Making use of historical flood depth data, digital elevation model (DEM) and land use information, the Geographic Information System (GIS) simulates and provides excellent forecast information to help inform future flood risk management strategies. As Wijesekara et al. (2013) suggest, such information contributes toward the development of river plain land use planning, management and policy. A good understanding of flood dynamics and associated impacts were attained by developing a geospatial model that maps flood scenarios (presented in Chapter Three) and economic analyses of post-flood agricultural impacts (presented in Chapter Four). A review was undertaken of both the legal structure and institutional arrangements of flood management in Vietnam (presented in Chapter Five) and this illustrated that whilst the existing policies and strategies are crucial, they amount to little without both the support information and the ability to implement them.

To understand the reasons behind those issues, this chapter focuses on the evaluation of technical and economic applications to inform and implement flood risk management policy. This evaluation also aimed to address the strengthening of flood planning in the agriculture sector at the provincial and local levels in Vietnam. The chapter first reviews the current practices regarding GIS, economic analyses and policies as they pertain to flood planning and impact management. Secondly, the need to strengthen existing flood planning approaches at provincial and local levels in Quang Nam province is examined. Finally, recommendations are made to improve the effectiveness of flood management in Quang Nam.

6.2 Flood management in Quang Nam province

Quang Nam province, with a population of 1.4 million, suffers frequent flooding and large parts of the province's agricultural land are inundated during the rainy season. Information was gathered during a field visit to the nine flood-prone districts of Quang Nam and from consultation with experts working in the study area in Quang Nam and also in Vietnam (with some 36 semi-structured interviews and discussions taking place).

Flood damage has been increasing in Quang Nam due to the increasing intensity of rainfall coupled with poor infrastructure development and maintenance, as evidenced in Figure 6.1.

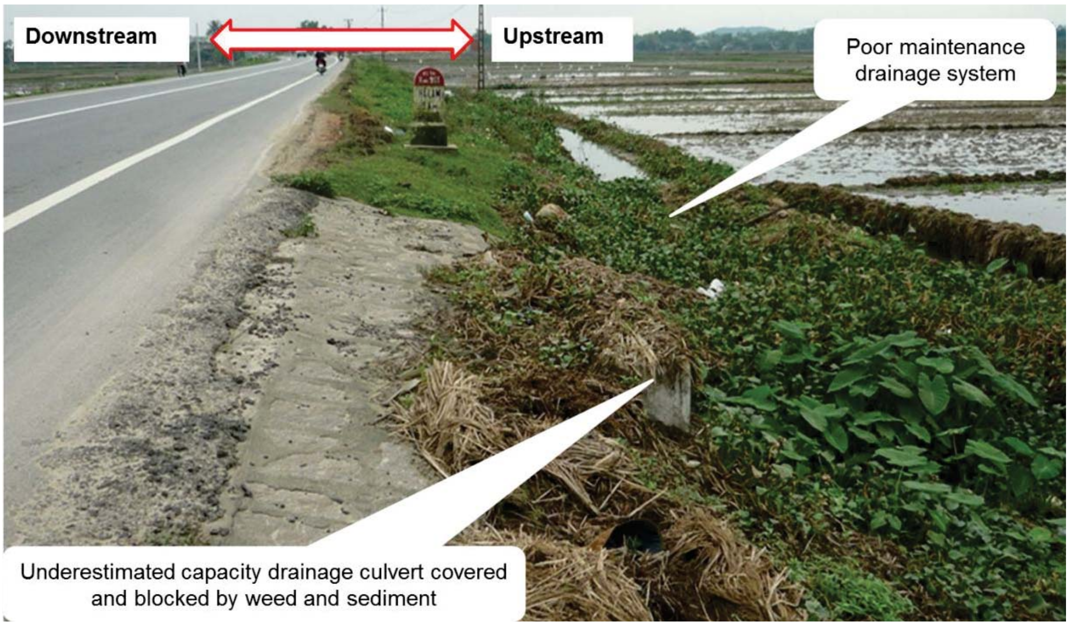


Figure 6.1. Inadequate capacity and maintenance of infrastructure amplifying flood damage in Quang Nam province.

Figure 6.1 shows a section of National Road No.1 demonstrating both poor design and poor maintenance. National Road No.1 runs the length of the province and where drainage is poor, it acts like a dam wall leading to further inundation problems. Railway embankments do the same. Insufficient maintenance and management of river and drainage canal beds result in significant sediment build-up impeding the flow of floodwaters down the river systems. Flooding in Quang Nam often suspends the traffic flow on National Road No.1 connecting North and South Vietnam, resulting in disruption to the distribution of goods, thus affecting the economy as a whole. The 1999, 2007, 2009 and 2013 floods revealed these vulnerabilities and the limitations of existing structural infrastructures and risk management strategies.

Hydro dams (operated by Vietnam Electricity (EVN), under the umbrella of the Ministry of Trade and Industry) are an integral part of flood control in Vietnam, although their first priority is electricity generation. The operating of the dams often respond poorly to flood control by discharging large amounts of water during the floods (Bruun, 2012). This worsens the flooding and increases downstream vulnerabilities. Cooperation between local authorities and the dams' operators is relatively poor, although central government requires the protection of downstream interests.

In addition, changing land use has impacted the scale of flood damage. Pressure for economic development were, firstly, through the conversion of upstream forestland into hydro dams for electricity generation and secondly, by the conversion of downstream low-lying farmland and rural areas into residential and industrial areas has led to diminished water retention capacity and consequent increases in peak discharges.

Flood control infrastructure in Quang Nam has been developed in accordance with provincial master plans and in consultation with representatives of the Provincial authorities (including DARD, DONRE, DOIP and DOF). However, several infrastructure projects are either yet to be implemented or have not been completed due to lack of funding (Institute of Water Resources Planning, 2011).

Although flooding is a frequent event and many constraints are present in flood management as well as in floodplain development, there is little systematic documentation of flood hazards data and information in Quang Nam province. Land use, infrastructure and flood mapping, along with some data exist in hard copy, although this information is often out of date due to poor management or infrequency and high costs of updating. In addition it is thought that little sharing of data occurs and local authorities are unaware of the types of data required and how to access and use this data.

In order to examine existing flood management and the systematic connection from central to local authorities in Quang Nam province, a matrix was set up (presented in Figure 6.2) regarding the application of GIS and CBA, as well as their integration in flood management decision making. The data and information (listed as items in the matrix) required for GIS and CBA application and legal implementation on flood management in Vietnam were identified in Chapters Three, Four and Five from information collected during a field visit to Quang Nam province and to central government from November 2011 to February 2012.

In Figure 6.2 the levels of government are displayed on the horizontal axis of the matrix and since Vietnam's flood management is based on a top-down approach it involves central government (MARD and MONRE), the provincial government (DARD, DPI, DOF and DONRE) and the local authorities (at the district and commune levels). The vertical axis of the matrix is populated with the items required for flood management using GIS, CBA and legislative implementation. The vertical columns alternate between quantitative and qualitative data, respectively.

An interval scale was determined through consultation with experts (pers.comm. Agricultural Division of Dien Ban District, 2011; Agricultural Division of Dai Loc District, 2011; Agricultural Division of Duy Xuyen District, 2011; Disaster Management Centre, 2011a; Quang Nam Centre for Hydro – Meteorological Forecasting, 2011; Water Resources and Flood and Storm Control Division, 2011a.) to evaluate both quality and quantity of the listed items. This rating scale is as follows: 1-2 represents a shortage in quantity of data or a lack of quality data; 3 represents sufficient quantity of data and data of average quality; and 4-5 represents plentiful data or data of high quality. Colour coding was used to enhance the visual representation of the matrix with red (1-2) being 'poor', yellow (3) being 'marginal', and green (4-5) being 'good', as shown in Figure 6.2.

Items	Local authorities				Provincial government						Central government			
	Commune		District		DARD		DONRE		DPI&DOF		MARD		MONRE	
	Qty	*Qal*	*Qty*	*Qal*	*Qty*	*Qal*	*Qty*	*Qal*	*Qty*	*Qal*	*Qty*	*Qal*	*Qty*	*Qal*
a. GIS														
Hydrological data	1	2	3	2	3	4	3	4	N/A	N/A	4	4	4	4
Historical flood data	2	2	3	2	3	4	3	4	N/A	N/A	4	4	4	4
Meteorological data	1	2	3	2	3	4	3	4	N/A	N/A	4	4	4	4
DEMs	1	1	1	2	3	3	4	3	N/A	N/A	2	3	3	3
Landsat images	1	1	1	1	2	3	3	4	N/A	N/A	2	3	4	4
Land use maps	2	2	2	3	2	3	2	3	N/A	N/A	2	3	3	3
Soil maps	2	3	2	3	2	4	2	4	N/A	N/A	3	4	3	4
Rural settlement map	2	2	2	3	3	3	3	3	N/A	N/A	3	3	3	3
Urban settlement map	2	2	2	3	2	3	3	3	N/A	N/A	2	3	3	3
Thermatic (e.g. river and road) maps	2	3	2	3	3	3	4	3	N/A	N/A	3	3	4	4
GIS software	1	1	1	1	2	2	N/A	N/A	N/A	N/A	3	4	N/A	N/A
Computer and printer	3	2	2	3	3	3	N/A	N/A	N/A	N/A	4	4	4	4
Other equipment (e.g. GPS)	1	1	1	1	3	2	N/A	N/A	N/A	N/A	3	3	N/A	N/A
GIS skills	1	1	1	1	2	2	N/A	N/A	N/A	N/A	2	3	N/A	N/A
b. CBA														
Agricultural flood risk identification	2	2	2	3	3	3	N/A	N/A	N/A	N/A	3	3	N/A	N/A
Agricultural susceptibility to depths of flood water	2	2	2	3	2	3	N/A	N/A	N/A	N/A	2	3	N/A	N/A
Damage data from past flood events	1	3	1	3	3	2	N/A	N/A	N/A	N/A	3	2	N/A	N/A
Flood damage scenarios	2	2	2	2	2	3	N/A	N/A	N/A	N/A	2	3	N/A	N/A
Flood risk management budgets	2	2	2	3	3	3	N/A	N/A	3	3	3	4	N/A	N/A
Crop seasons, yield and price	4	4	4	4	4	4	N/A	N/A	4	4	4	4	N/A	N/A
Seeds price	4	3	4	3	4	3	N/A	N/A	4	3	3	3	N/A	N/A
Labour wage	4	4	4	3	4	3	N/A	N/A	4	3	N/A	N/A	N/A	N/A
Fertilisers and pesticides prices	4	3	4	3	4	3	N/A	N/A	4	3	4	3	N/A	N/A
Tractor costs	4	3	4	3	4	3	N/A	N/A	4	3	N/A	N/A	N/A	N/A
Water charge	4	3	4	3	4	3	N/A	N/A	4	3	4	3	N/A	N/A
Land use tax	4	3	4	3	4	3	N/A	N/A	4	3	N/A	N/A	N/A	N/A
Financial support and insurance	2	2	3	2	4	3	N/A	N/A	4	3	4	4	N/A	N/A
CBA skills and practice	1	1	1	1	3	2	N/A	N/A	N/A	N/A	4	2	N/A	N/A
Computers and printers	3	2	2	3	3	3	N/A	N/A	N/A	N/A	4	4	N/A	N/A
c. Legislation														
Legal documents	2	4	3	4	4	4	N/A	N/A	N/A	N/A	4	4	N/A	N/A
Guidelines for law implementation	2	3	3	3	3	4	N/A	N/A	N/A	N/A	3	4	N/A	N/A
Dissemination of legislation	2	2	3	3	3	4	N/A	N/A	N/A	N/A	4	4	N/A	N/A
Leadership	2	2	2	3	3	3	N/A	N/A	N/A	N/A	3	4	N/A	N/A
Community engagement	2	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Collaboration between parties	2	3	2	3	2	3	N/A	N/A	N/A	N/A	3	3	N/A	N/A
Law enforcement	2	2	2	2	3	3	N/A	N/A	N/A	N/A	4	3	N/A	N/A
Support facilities (e.g. office, computer, printer)	3	2	3	2	4	4	N/A	N/A	N/A	N/A	4	4	N/A	N/A
Monitoring and evaluation	1	2	2	3	3	3	N/A	N/A	N/A	N/A	3	4	N/A	N/A

Legend

Qty : Quantity — Few 1 2 3 4 5 Many

Qal : Quality — Low 1 2 3 4 5 High

Rating of quantity and quality of listed items: Poor | Marginal | Good | N/A: Not applicable

DARD: Department of Agricultural and Rural Development; DONRE: Department of Natural Resources and Environment; DPI: Department of Planning and Investment; DOF: Department of Finance; MARD: Ministry of Agricultural and Rural Development; MONRE: Ministry of Natural Resources and Environment; MPI: Ministry of Planning and Investment; MOF: Ministry of Finance

Figure 6.2. Rating of both quantity and quality of items required for GIS, CBA applications and legal implementation on flood management.

It can be seen from Figure 6.2 that the technical and economic assessment processes that inform flood risk management practices are relatively poorly applied and utilised in Quang Nam province, as for elsewhere in Vietnam. While central government has some access to quality information, this is not the case for local authorities. This is of particular concern as the recording, understanding and utilisation of data and methods of analysis for flood management is known to affect the quality of decision making processes. The differing levels of information, both in quality and quantity between government departments illustrate the lack of connectedness between the agencies responsible. It is evident that data and expertise are missing for many of the categories and the reasons for these are outlined below in the following subsections.

6.2.1 GIS application in flood mapping

Section (a) of Figure 6.2 shows that the data, equipment and skills for GIS application is more readily available and of higher quality at the central level, and remains poor at the local authority level. Most of the data listed are developed by various government agencies at central and provincial level with very limited accessibility, even among the government agencies at each level. In addition, data reliability are also a concern as the metadata (metadata in this case is data regarding the source, author, date, version and resolution of a data set) are frequently missing and updating of data are poor and occur infrequently. This may be partly due to GIS (which requires a high level of knowledge, skills, time and cost) being still a little-used technology in Vietnam. GIS applications are poorest at the district and commune levels, because of poor skills capacity or low demand for GIS applications due to the limited powers assigned to local authorities. This may be compounded by a lack of access to tools used for accessing such information, for example, GIS software appears to be lacking at this level, as are the skills required to effectively run such software. In contrast central government appears to have reasonably good quality and quantity of information – although there remains room for improvement. At this level, there is also better access to appropriate tools with up-to-date computers, access to GIS software and at least some of the required skills to use such programmes. Much of the data from the provincial government are not applicable for DPI & DOF as they are not responsible for technical issues such as flood mapping. However, it is still evident that DARD and DONRE (provincial government authorities), have better access to higher quality information than local authorities, especially the data contained in the first four rows of the matrix.

6.2.2 Applied CBA in agricultural flood management

It can be seen in section (b) of Figure 6.2, relating to CBA, that significant data are not applicable from parts of the matrix concerning the CBA, parts of the matrix is populated with N/A (not applicable) since it is not relevant for some agencies (e.g. DONRE and MONRE) as they are less involved with projects concerning the agricultural sector. Despite this, it appears that the quality and quantity of information regarding risk identification, past damage and available finance are greater at the central and provincial levels. The same pattern is evident at the bottom of this section where central government is better informed regarding financial support & insurance, CBA skills and practice. In addition, central government has greater access to higher quality computing systems.

One area that scores highly across all three levels of government is yield estimate, crop sale price and production costs. Although some data are not applicable for some central and provincial agencies, this is the one area in the matrix where local government is on “even footing” with provincial and central government. This is due to the fact that this data forms part of the statistical data generated at the local level and is required to be systematically and regularly collected by the General Statistical Office (GSO). It is noted that the GSO’s network reaches commune levels effectively. This may be due in part to sufficient funding for their assigned duties.

Figure 6.2 also shows that the data on the cost of agricultural inputs such as seed, fertiliser and product price are widely available, however, these vary from place to place within the province as result of lack of interference from the government to monitor and control prices. The data are accessible from the provincial Statistics Office or its branch in each district. The problems existing here are poor agricultural risk identification and corresponding susceptibility of agriculture to flooding both of which are crucial for appropriate flood damage estimation. Information on the agricultural activities exposed to flooding, water depths and inundation areas is commonly collected and modeled, with the work being undertaken through contracts between provincial or central government agencies and consulting firms. To date, results are often not published or accessible to either the public or local authorities. The centralisation of information results in a deprivation of information on costs and available funding resources for flood management measures at the local level. Despite requesting support from central and provincial governments to fulfill the need for flood management activities, the local authorities tend to simply accept whatever support is given by central government through the coordination of the provincial government.

6.2.3 Implementation of flood management legislation

Central government creates the majority of the legislation, however it is not being effectively communicated to provincial government and subsequently to local government. It is noted here in section (c) (as with section (b)) of Figure 6.2 that many entries are 'not applicable' since this information is not relevant for a number of agencies (DONRE, DPI, DOF and MONRE). These agencies have limited involvement in flood management policies, and this involvement is confined to forecasting (DONRE and MONRE), socio-economic development planning (DPI) and financial management (DOF).

As can be seen from section (c) of Figure 6.2, legal documents and guidelines are available at central and provincial government levels. Despite most laws and policies being freely available from central government websites, without adequate information technology (IT) skills these are frequently not accessed by local authorities who rely heavily on paper copies of documents. Limited numbers of documents are disseminated via paper copy, hence the low scores in section (c) among the district and commune level institutions. The lack of awareness of government policies by commune level authorities contributes to poor dissemination of the relevant information to the community, the majority of whom are subsistence farmers.

It is interesting to note that if an item received high scores at the local level, it also earned a similar score at the provincial and central government levels. However, the reverse is not true. It is hypothesised that this is because higher authorities have jurisdiction to request information from lower government agencies, enabling them access to information they believe they require. However it does not seem to be a requirement for higher level government to disseminate information to lower level authorities, which is unfortunate as data can be of greater importance to application at the local authority level. This demonstrates the disadvantage of a top-down approach, where information collected by central government does not get passed on to local authorities.

6.3 Discussion

Insufficient data to effectively use tools (such as GIS and CBA) for flood risk analyses has led to poor information being provided for public awareness and for decision making by local authorities in Quang Nam province. As a consequence of being unable to access information and essential resources, communities are unlikely to be proactive in reducing their flood risks (IFRC, 2011). Thus there is a lack of effectiveness by government investment in flood risk management projects. If spatial and economic analyses are practiced, they are often stand stand-alone projects and are frequently ignored by officers when making their decisions. The situation is worst at local government levels as here there are neither sufficient human resources nor capacity to generate the information required for adequate decision making. In addition, poor technical and economic practices weaken data quality and availability and vice versa (the lack of high quality data discourages the application of GIS and CBA). Access to some data is becoming more freely available (e.g. general statistical data), however, several types of data remain “sensitive” or difficult to access (e.g. topography and maps). Data security remains an issue with many government officials, due to fears stemming from the Vietnam war era, although access to such information is now easily accessible due to advances in technology (e.g. DEM provided by NASA[16] and detailed maps available from Google). Thus, access to data, even data not related to national security, has been limited in Vietnam.

There are many benefits from spatial flood risk assessment which include underlying risks and identifying vulnerabilities that help to establish appropriate mitigation and adaptation measures (Lindley, Handley, McEvoy, Peet, & Theuray, 2007). Despite receiving increased attention and being identified as a useful spatial analysis tool that provides important information for decision makers and planners, GIS is not well applied to agricultural flood management in Vietnam. This is because GIS applications in Vietnam are relatively new. In addition, government agencies rely upon consultant firms for spatial analysis and mapping, which contribute to poor GIS performance by government officers. Consequently uninformed decisions are made. This issue is particularly evident at the local level, where small mapping jobs do not attract the interest of consultancy firms, yet still require complex administrative procedures to be

[16] The National Aeronautics and Space Administration (NASA) of the United States of America

approved. The risks of uninformed decisions being made are wasting of resources and increased damage.

The understanding of flood damage costs and the consequences of extreme floods on agricultural production is essential to appreciate what happens to production under flood conditions (McDonald, 1970). In addition, the economic evaluation of flood damage to agriculture can affect whether there is additional or avoided damage (Brémond et al., 2013). Currently there are a number of flood damage evaluation methods used (Brémond et al., 2013; Merz, Kreibich, et al., 2010; Messner et al., 2007), however, these unlikely to be familiar to local and provincial flood management officers. This situation occurs in Quang Nam and extends to most provinces of Vietnam. There are several reasons for this and to illustrate this CBA will be used as an example. Firstly, the limitation of CBA application is that project approval is based more on political and social will than on economic feasibility. Economic analysis is a required element in the initial stages of development projects (National Assembly, 2003). However, approximately 71% of the Vietnamese population, the majority of whom are subsistence farmers, are susceptible to natural extreme events. Natural disaster risk management projects, such as flood prevention projects, have favoured vulnerable subsistence farmers as the Vietnamese government gives greater emphasis to social welfare issues than to the economic indicators of the projects. Whilst this can be a good thing, economic considerations should be included in the decision to improve the efficiency of the development projects.

The second reason for the limited CBA application in the agricultural flood damage evaluation is lack of knowledge, experience and poor requirements for economic impact assessment of flood damage on agricultural production. The information required to conduct agricultural flood damage evaluation at different levels of government is presented in section (b) of Figure 6.2, which indicates the lack of data/information on agricultural flood susceptibility as result of poor research, and data collection and management. The consequence of incomplete economic evaluation regarding flood damage is that policy makers are more likely to make ill-informed decisions at the flood recovery phase. The 2009 flood and storm damage, for example, was overestimated by the Quang Nam provincial government in order to claim higher relief payments from the central government. This situation occurred not only in Quang Nam but in seven other provinces nationwide (Prime Minister of Vietnam, 2012). While the problem raised an urgent requirement for appropriate tools such as CBA for effective flood relief compensation, it also highlighted the poor capacity for using economic evaluation tools for flood management at the local government levels in Quang Nam, as well as in Vietnam as a whole.

The impact of poor flood damage analyses directly affects subsistence farmers, who rely not only on their own experience but also on information provided from government for their agricultural activities. It is important to note that the poor households in Vietnam are also predicted to be hit partly by decline in agricultural incomes resulting from climate change and partly by an increase of living costs (World Bank, 2010a). Information regarding flood impacts on agricultural costs and benefits does not filter down to subsistence farmers. Therefore, even the most experienced farmers are still gambling against the weather for crop success. The result of this is that relatively small flood events may have severe impacts on the livelihoods of subsistence farmers. In addition, informative GIS and CBA results enable other flood affected parties, such as the food processing industry, to consider alternative or complementary investments to minimise the impact of floods.

It is not necessary for every government's flood management staff to be skilled regarding GIS and CBA applications, but the basic skills and knowledge to bring available information/resources such as spatial and economic susceptibility analyses into decision making are necessary to ensure an effective decision. Knowledge of agricultural flood risk and susceptibility can be provided to decision makers in different ways. For example, based on the benefit-cost ratio outcomes, the agricultural flood area could be categorised into zones using GIS. Each zone would have its own development criteria or restrictions based on flood depth and CBA analysis. As an illustration, the Quang Nam agricultural land was divided into four zones based on water depth levels (<1m, 1-2m, 2-3m and >3m). The results from the CBA model in Chapter Four confirmed that rice plantation in inundation zones >3m are not recommended as the costs outweigh the benefits in most of flood scenarios. Rice planting in these zones could come with such restrictions. Until constraints on the application of GIS and CBA are lifted, this information will remain unavailable and damage expenses will continue at significant cost to central government.

Along with limitations surrounding the use of technical and economic analyses, policy and legal implementation shortcomings also contribute to poor flood management within local authorities in Quang Nam province. The leading cause of shortcomings is that local government does not have a clear vision and strategy to implement laws pertaining to natural disasters effectively, so instead reacts on a case by case basis. This contributes to reducing community engagement with the implementation of laws, which are already restricted as a result of poor communication and disconnection between authorities and the public. While community engagement (which ensures the flood management policy will be put into practice) remains constrained, law enforcement is ineffective. To date, no one has been brought to the court for violation of flood laws in Quang Nam province. The highest punishments given have been administrative warnings, which provide little deterrent for offenders.

Human resources are another barrier for the successful implementation of flood management laws. Most local government officials do not have sufficient knowledge and skill relating to flood management nor the ability to use available information to make decisions. Government officials rely on their superiors for decision-making and act as they are instructed. Local government officials often hesitate to discuss flood management issues with the community. Very often, the community cannot rely on local officials for flood mitigation, response and recovery activities. Therefore, flood management leadership is weak at the local level in the Quang Nam province.

The poor integration of technology and economics in policy contributes to weakened flood management efforts in the Quang Nam province. It is noted that the lack of measurement tools and evaluations to determine the effectiveness of flood management policies for agriculture result in policy failure and continued ill-informed decision making. This will continue until better quality data is collected and modeling is conducted, resulting in freely available information (Okuyama & Chang, 2004) to be integrated into flood management policies. For any policy implementation, 'clear guidance of roles and responsibilities together with powers and resources at each scale of action are essential before it can be effective and workable in practice' (Lindley et al., 2007, p. 66). This chapter shows that opportunities exist for the government to improve flood management, particularly agricultural flood damage mitigation, and several recommendations are made in the following section to strengthen the use of technical and economic applications in Vietnam.

6.4 Recommendations

The use of technical and economic applications for flood risk management can be strengthened through four steps. The first step is to clarify the necessity for these applications at each level of government (provincial, district and commune). The answers for questions like 'How can technical and economic information be used at each level of government to enhance flood prevention and mitigation processes?' and 'What level of technical and economic applications is needed at each level of governance?' will direct the focus as well as taking full advantage of existing capacities, both human resources and facilities.

The second step is to establish a data collection system for flood management which focuses on quality, quantity, and accessibility. A database that allows access and updates by all levels of government would improve the quality and quantity of available information. The database would need to be well configured, regularly maintained and updated, as well as freely available to those needing to access it. If successful this would eliminate the constraints of data availability, reliability and accessibility still prevalent in Vietnam. It is suggested that the GSO's data system could be a model for a natural disaster data system.

The third step is the consideration of the cost and simplicity of operation of technical application (such as GIS) and the necessary. While equipment for GIS operation (e.g. computers and internet connection) are considered essential and hence are available at facilities at all levels of authority, suitable software with regard to cost and ease of operation is required. Simple and user-friendly applications will encourage use by government officials, who often lack confidence with new technology.

The fourth step is in providing technical (e.g. GIS) and economic (e.g. damage estimation and CBA) analysis training that supports decision making for government officials. It is noted that there is frequent turnover of personnel in charge of flood management as they often hold multiple positions and flood management is usually a temporary duty. In addition, incomes for such positions are relatively low, making it difficult to retain staff. Thus, it would be beneficial for this to be a long term position and as such should be effectively selected for GIS and CBA training, with appropriate remuneration offered.

It is also recommended that data on agricultural susceptibility to flood levels should be improved through scientific research (e.g. research like that of Kotera and Nawata (2007) for rice plantations). Estimation of flood damage will be more accurate if susceptibility data for each crop variety affected by various inundation levels over a range of floodwater durations are available. Then, agricultural inundation zones and relevant information could be established and made available for each flood-prone area.

A further recommendation is the adoption of sound legislative implementation strategies for more effective flood management policy. These strategies should include dissemination of the implementation guidelines for legal documents to improve public awareness and allow for community participation in flood management. In addition, skillful community engagement and implementation of leadership should be enhanced for effective implementation of flood management policies in Vietnam.

Finally, technical and economic perspectives should be taken into account for flood management decisions, and integrated into policies. According to Chalmers (2003), “it is the business of policy makers and practitioners to intervene in other people's lives. Although they usually act with the best of intentions, however, their policies and practices sometimes have unintended, unwanted effects, and they occasionally do more harm than good” (p. 22) therefore, ”their policies and practices should be informed by rigorous, transparent, up-to-date evaluations” (p.24). The flood managers are required to bring all available information and resources such as technical and economic information and funding into their decision making. Technically and economically informed policy, in conjunction with good implementation strategies, will strengthen the effectiveness of decisions made by government officials. Consequently, these measures will improve flood management capacity in Vietnam.

6.5 Conclusion

This study highlights the current situation regarding technical and economic applications to inform flood management authorities in Quang Nam province. Results show that the use of technical applications (such as GIS) and economic analyses (such as CBA) are limited so that there is little information like this for the development of flood management policies at the local level in Quang Nam. This is due primarily to a lack of knowledge, skill and reliable information for analyses such as GIS, flood damage estimation and CBA. This study extends the current understanding of the local government's flood management capacity in Quang Nam by promoting the use of such analyses to inform and thus improve flood management policy making. Flood risk management practices informed by spatial and economic analyses lead to non-structural adaptation measures, becoming more important in the context of increased frequency of extreme flood events. This is clearly another opportunity to improve the flood risk management in Vietnam.

Although this study was conducted in Quang Nam province, the Quang Nam experience is considered to be representative of other provinces. Therefore lessons learned in this province and for this sector can be extended to other flood-prone areas and for other sectors in Vietnam.

In previous chapters, a spatial analysis of flood impact on agricultural land was constructed using ArcGIS software. The result of the analysis was then used to estimate and evaluate the potential damage and impact of extreme flood events on agricultural production. In addition, an analysis of the legal documents and institutional arrangements underpinning Vietnam’s flood management was undertaken to identify opportunities where these legal systems and institutional arrangements can be strengthened. Identified in this chapter are specific areas to target when strengthening agricultural flood risk management in Vietnam. An overall discussion is presented in Chapter Seven, followed by conclusions and recommendations arising from the research in Chapter Eight.

Chapter 7

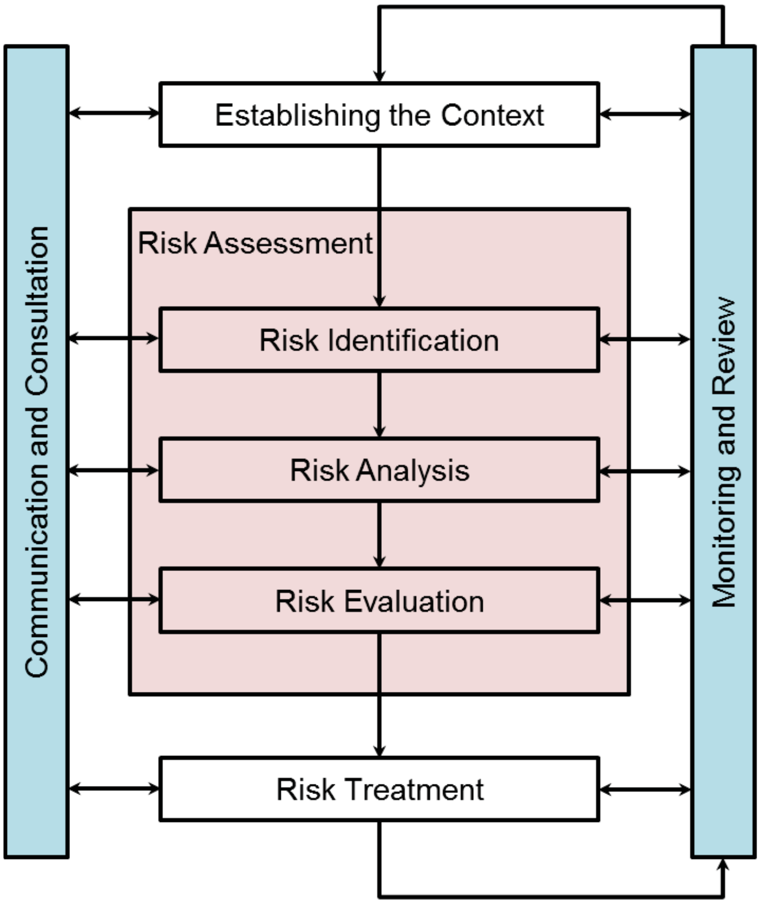
Discussion

7.1 Introduction

Extreme weather events are increasingly reported worldwide (CRED, 2013a; Guha-Sapir, 2012; Harmeling & Eckstein, 2012). Floods, the most common natural disasters, are predicted to increase in frequency and cost, and arguably pose the most significant risk to the agricultural sector (IPCC, 2012; Simonovic, 2012). While normal seasonal flooding is essential to provide the nutrients required to increase soil fertility, extreme flood events expose subsistence farmers and the economy to extensive food shortages and the government to significant compensation claims (World Bank, 2009). Simply stated, extreme flood events pose a significant threat to human security and socio-economic development (Scheuer, Haase, & Meyer, 2012). As a result flood damage mitigation efforts are receiving increased attention from government decision makers, scientists and other stakeholders.

Flood defence engineering that employs probabilistic risk analysis is used around the world to design hard infrastructure solutions to flood-prone environments. A cost-benefit analysis (CBA) often accompanies project design to undertake project feasibility and sensitivity analyses. Recently, this traditional form of flood prevention has shifted to flood management that adopts a more strategic approach towards solutions that do not rely solely upon engineered flood defense structures such as dykes and reservoirs, but also considers other alternatives, such as land use changes (Hall & Penning-Rowsell, 2011). Integrated flood management has only recently been applied in the Vietnamese context and many aspects are still in the process of being implemented.

The objectives of both traditional and modern flood management approaches are to minimise negative impacts of flooding. Successful flood management practices integrate several steps, including mitigation, preparedness, response and recovery (Simonovic, 2012). The United Nations (2002, p. 24) has provided guidelines for effective flood risk management comprised of “an identification of the risk, the development of strategies to reduce that risk, and the creation of policies and programmes to put these strategies into effect”. Katsuhama (2010), described four steps in the process of flood management. The first step is data collection and analysis to identify flood risk; the second is performing and prioritising flood management alternatives for identified risk; the third step involves detailed designs of risk reduction alternatives in both infrastructure and policy; and the final step is the implementation and operation of infrastructure policy instruments. The effectiveness of flood management processes is highly dependent upon the knowledge of the likelihood of flooding, risk reduction options, reduction strategy policies and the connection between these components. Hence, the assessment of current and future risk became important research questions (Falter et al., 2013). The importance of risk assessment is highlighted in the risk management process as outlined in Figure 7.1.



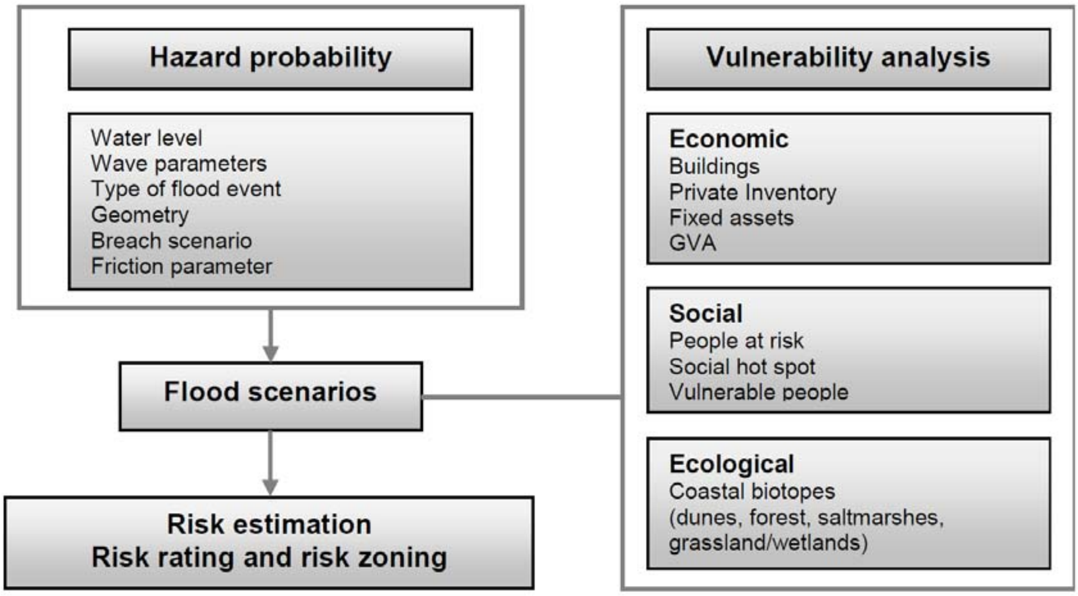
Source: Adapted from ISO in Purdy (2010, p. 883)

Figure 7.1. The process of risk management.

The next two sections focus on aspects of risk assessment as identified in Figure 7.1, namely risk identification, analysis and evaluation in the context of extreme flood risk to agriculture. The focus of section 7.4 will be on risk treatment that is informed by risk assessment.

7.2 Agricultural flood risk assessment

Flood risk identification is the first of three steps in the risk assessment process (Figure 7.1). The purpose of this step is to identify and define aspects of the flood risk problem by using a risk scenario, which is 'a sequence of events with an associated frequency and consequence' (Simonovic, 2012, p. 35). Flood risk scenarios can be developed in several ways, depending on the amount of data, resources and time available. Such scenarios include analyses of historical flood data, statistical and modeling tools and dam failure mode and effect analyses (de Moel et al., 2009; Simonovic, 2012). These methods can be used to demonstrate the extent of the flood and water depth (de Moel et al., 2009). The simulation of the inundation process modeled in this study, using historical flood data, has been applied successfully to identify the likely extent of flooding for three classes of extreme flood events. The flood inundation results were then combined with land-use information to map the impact of these flood events on agricultural land in the province. This approach, as presented in Figure 7.2, was also applied by Kaiser, Kortenhaus, Hofmann and Sterr (2008) in a pilot study of German Bight Coast.



Source: Adapted from Kaiser et al. (2008, p.15)

Figure 7.2. Flood risk analysis tool.

In their case study, as illustrated in Figure 7.2, Kaiser el al. (2008) overlaid flood scenarios on vulnerable items using a GIS-based tool to map different zones of flood risk flood scenarios. This technique allows elements and assets at risk (such as buildings and people) from a particular flooding scenario to be visualised and quantified. Although agricultural flood risk was not targeted in the study of Kaiser el al. (2008), their tool is comparable to that described in this research.

The analysis phase of the risk assessment process involves an identification and inventory of the elements at risk through appropriate evaluation criteria and maps (Scheuer et al., 2012). Among flood parameters (e.g. flood extent, duration and flow velocity), water depth is factor most frequently used for damage evaluation of flood events (de Moel et al., 2009; Messner et al., 2007). By using the inundation level parameter, quantification of direct damage to crops was estimated.

After the assets and elements at risk are identified and inventoried, an evaluation of flood risk is required. This last step in the risk assessment process requires an estimation of the damage of assets and elements at risk to flooding (Messner et al., 2007; VanDine, 2012). Whilst criteria for risk evaluation are diverse, from socio-economic values to environmental issues, damage costs are most commonly used for flood risk evaluation (VanDine, 2012).

The basic function used to estimate flood damage in a number of studies is the depth-damage function, where damage is a function of the both the value and susceptibility of elements at risk (Duttaa et al., 2003; Hansen, 1987; Kaiser et al., 2008; Penning-Rowsell et al., 2013). Susceptibility is itself a function of characteristics ofboth flood inundation and of the elements at risk. For example crop susceptibility is not solely calculated using inundation depth and type of crop, it also is a function of flood duration, crop development stage and flood damage mechanisms, hence it is a complex estimation resulting in uncertainties of outcome (Messner et al., 2007). In this study two different measures were used to reflect crop susceptibility based on the availability of data. These were yield loss (for rice and corn) and area requiring replanting (for beans and ‘other vegetables’). These susceptibilities were functions of the inundation depth and timing of the flood event with respect to crop development stage.

The identification of flood risks, their impacts and subsequent evaluation are critical to informing flood management actions. Failure to carry out this step presents a risk to the choice of flood management plans, strategies and measures aimed at reducing flood damage. While, in this thesis, spatial analysis illustrates the impact of flooding upon agricultural land, economic evaluation valued the direct damage caused by the three flood events on agricultural production. The economic evaluation also assessed the flood risk tolerance of agricultural production for the mainly subsistence farmers through a CBA for each flood event. The spatial assessment provided flood risk scenarios for the economic analyses that could be effectively used for the consideration of appropriate flood risk reduction measures (Olfert & Schanze, 2007).

7.3 The value of assessment tools in flood management

The focus of this section will be on the value of two assessment tools in particular spatial analyses of extreme flood events and economic analyses of flood damage. GIS is considered an advanced technology for spatial analysis and has been applied widely to natural hazard risk assessment (Finn & Thunen, 2013, 2014; Finn, Yamamoto, & Thunen, 2012; Finn, 2011), CBAs are usually used to evaluate the economic feasibility of flood risk management projects (Brémond et al., 2013). An increasing number of studies (Brémond et al., 2013; Merz, Kreibich, et al., 2010; Messner et al., 2007; Meyer & Messner 2005; Penning-Rowsell et al., 2013) have verified economic assessment of flood damage as essential for flood risk management. However, these tools and their integration of them in the flood risk assessment decision making process have received little attention in Vietnam.

7.3.1 The value of GIS in flood management in Vietnam

GIS is used to help predict the impact of flooding on agriculture. The mapping technique used in this study is easily and quickly replicated, potentially allowing updated agricultural impact assessment as a function of land use, DEM resolution, flood marks and flood frequencies. The simplicity of the GIS technique offers a significant advantage for new adopters of the technology. Furthermore, the inundation maps resulting from the GIS application show locations to implement appropriate mitigation measures once decided upon.

Despite its advantages, lack of current data for technical analyses remains an important issue in Vietnam. In the case study of Quang Nam province, for instance, the most recently available land use map was updated in 2005. In addition, the missing source of data causes difficulties for users. Very often, data was collected and executed by different agencies for different flood events (e.g. flood marks). These authorised agencies use government resources or international resources (commonly provided in the form of development assistance) to undertake data collection, but are often unwilling for these data to be shared. Lack of readily available quality data will reduce GIS's effectiveness for understanding and taking action on agricultural flood mitigation.

In addition, the current use of GIS in the decision making process is limited, discouraging further application for disaster management purposes at the provincial and local government levels in Vietnam. A key reason for this is that junior officials with relatively advanced IT (information technology) skills tend to act passively and take instruction from superiors, who themselves lack the skills and understanding of the technology so are more likely to make decisions and take action based on qualitative information and previous personal experience, rather than using information from technical and economic analyses. Furthermore, while GIS skills levels at research and consultancy agencies are relatively advanced, they do not have access to, or sufficient funding to collect, the required data. This is partly a result of incomplete records spread among various government agencies, but is compounded by the lack of sharing between agencies. Although contractors have been assigned to study flood management issues, results of these studies are often not adequately considered during the provincial and local government decision making process.

7.3.2 Valuing agricultural flood damage

CBA is a decision-support tool that is commonly used to determine the efficiency and benefits of preventative disaster measures such as dam and dyke systems and reducing or avoiding flood impacts by, for example, the restoration of flood plains (Mechler, 2005). The recent trend shows that flood risk management is becoming the dominant approach for flood control, therefore, the estimation of the economic effects of flood damage is gaining greater significance.

This study shows the usefulness and applicability of CBA for evaluating the economic impact of flood events on agricultural production in Vietnam, where data scarcity has previously provided a barrier to this type of study. However, the application and effectiveness of this type of analysis remains limited in Vietnam, where decisions are based not only on economic indicators but are also heavily influenced by social and political agendas. Government decisions are made with the best of intentions, but are not necessarily the best decisions, and this leads to problems for subsistence farmers who are greatly affected as few livelihood options exist outside agriculture in these areas.

7.4 Potential measures and instrument options for flood risk treatment

Following the risk assessment measures depicted in Figure 7.1 is the risk treatment phase. This step involves a range of risk treatment options to reduce flood risk (VanDine, 2012). These can be physical interventions or policy instruments or a combination of both. Physical interventions to reduce flood damage include structural measures to contain floodwaters (e.g. dams and dykes) and also land management decisions (e.g. restoring floodplains). Policy instruments and other non-structural tools such as land use regulation, financial incentives and communication (e.g. early flood warning and flood mapping) are also used to reduce flood damage (Meyer, Priest, & Kuhlicke, 2012; Olfert & Schanze, 2007; Samuels, Klijn, Kortenhaus, & Sayers, 2009). In addition, the risks of extreme floods also can be reduced using institutional arrangements whereby the authorities work together with the public to identify risks and design institutional preparedness and response strategies for relief and recovery (Lebel, Nikitina, Kotov, & Manuta, 2006). As presented in Table 7.1, a number of existing measures and instruments can be deployed in different phases of the flood risk management process to reduce flood impacts (Olfert & Schanze, 2007).

Table 7.1. Types of measures and instruments.

Category	Examples
Physical measures	
Adaptation measures	• Land management • River channel and coastal management
Control measures	• Flood storage • Flood water transfer • Channel conveyance and capacity • Coastal alignment • Coastal energy accommodation • Drainage and pumping systems • Flood proofing of building and technical infrastructure
Retreat measures	• Evacuation of human life • Evacuation of assets and life stock
Policy instruments	
Regulation instruments	• Water management • Spatial planning • Environmental protection
Stimulation instruments	• Financial incentives • Financial disincentives
Communication instruments	• Communication/Dissemination • Warning/Instruction
Compensation instruments	• Risk and loss distribution

Source: Adapted from Olfert and Schanze (2007, p.14)

As can be seen from Table 7.1, a large variety of different options are available to combat flood risk. While the physical interventions are divided into adaptation, control and retreat groups, the instruments are categorised as regulation, stimulation, communication and compensation policies. The measures and instruments that are identified in the table are accompanied by a list of suggestions on mechanisms to ameliorate flood damage. An example of physical adaptation measure is land management that can be agricultural crop change or/and reforestation, while flood zoning standards is an option for spatial planning, a policy regulation instrument (Olfert & Schanze, 2007). The question now turns to what is being done to effectively reduce flood damage.

While structural measures to contain flooding remain the primary management mechanism (Meyer et al., 2012), non-structural instruments are becoming an increasingly important approach for flood risk management (Brémond et al., 2013; Merz, Kreibich, et al., 2010). However, an integrated approach that combines both types is becoming the preferred approach for flood risk management (Jha, Bloch, & Lamond, 2012). The decision on what measure or instrument to select and how it is operated is influenced by a number of factors (Olfert & Schanze, 2007). These factors include characteristics of flood events and land use, policy, economic conditions and administrative capacity. Hence, the approach for flood risk treatment varies. The method used in this study to assess the impact of extreme floods upon agricultural production in Quang Nam province has enabled the delineation of areas subject to flooding under three flood scenarios. This allows the identification and consideration of further actions to reduce the associated agricultural flood risk in Vietnam.

Despite the increased attention (such as the elimination of the summer rice crop since 2004), there is still a lot of room for the improvement in land use management approaches to combating flood damage. Recent studies (Dawson et al., 2011; Posthumus, Hewett, Morris, & Quinn, 2008; Pottier, Penning-Rowsell, Tunstall, & Hubert, 2005; Samuels, 2005; Wheater & Evans, 2009), indicate that land use management is the most useful tool in controlling future flood risk. Agricultural land is a limited resource in Vietnam and, to ensure the country's food security, using land susceptible to flooding is unavoidable. Because of this, land use management is of particular importance to the low-lying areas that are prone to flood in Vietnam.

This study provides a detailed picture of crop rotations, seasons and susceptibilities to submergence during flooding. Mapping techniques shown in this study would allow identification of areas where crops able to withstand submergence could be successfully cultivated, leaving areas less prone to flooding available for crops sensitive to submergence. On the other hand, crop types adapted to growing under inundation could be considered as an alternative in the flooding areas. Inundation maps from this study can be used to avoid conflict that may arise when agricultural development is approved prior to the detection of flood risk.

Nevertheless, the effectiveness of flood management measures and instruments are strongly influenced by institutional arrangements[17]. Increasingly the literature highlights the important role of institutional factors in natural disaster management (Adger, 2000; Ahmed, 2013; Khan & Rahman, 2007;

[17] Institutional arrangements are the policies, systems, and processes that organizations use to legislate, plan and manage their activities efficiently and to effectively coordinate with others in order to fulfill their mandate (UNDP, 2013)

Kusumasari & Alam, 2012; Næss et al., 2005). Adger (2000, p.738) indicated that "underlying vulnerability to hazards can be exacerbated, even in the absence of changes in the profile of the hazard, simply by changes in institutional form". It is particularly appropriate in Vietnam because the economy is still in a process of transition from a highly centralised planned to market economy that "has undermined collective action to ameliorate flooding hazards" (Adger, 2000, p. 738). This study has looked closely at both policy and government structure underpinning Vietnam's flood management. The findings of this study suggest that the current fragmented, 'top-down' approach policies should be rallied into a comprehensive policy, including 'bottom-up' approach and appropriate respect for accountability and equity. Further recommendations to improve the current flood management institutional arrangements will also be addressed in chapter 8 of conclusions and recommendations.

7.5 The relevance of this study to the LNDPM

This research resonates with or informs the planning and management requirement set out in the articles of the new law on Natural Disaster Prevention and Mitigation, 2013 (LNDPM). Article 17 of LNDPM requires that flood risk analysis and evaluation (including flood mapping and classification of flood risk zones) be undertaken. This research did both a flood risk analysis and evaluation, and in addition the study also provides a flood risk assessment required by article 16 of LNDPM to be integrated into socio-economic development.

Furthermore, the spatial analyses from this study responds to the Ministry of Natural Resources and Environment's requirement to identify, evaluate and zone natural hazard risk as set out in article 42 of LNDPM. The limitations to conducting technical flood risk analysis and economic flood damage evaluations identified in this study provide useful information to the Ministry of Agriculture and Rural Development. Article 42 of LNDPM also recognises the need to conduct research and apply advanced technologies on natural disaster management and provide capacity building for individuals working on natural disaster management.

7.6. Conclusion

This study is an example of the use of an advanced technology to identify and display spatial impacts of natural hazards. The results of the spatial analysis are then employed in an economic analysis to more effectively inform the decision making process. The results of spatial, economic and institutional analyses provide policy makers with tools to assist with selecting appropriate flood management options. While flood maps assist local authorities in locating vulnerable properties and crops in the flood zone, the planned land use incorporated with floodplain mapping could avoid conflict arising from approved development projects. This study fits well in the literature of risk management in general and flood risk management in particular and contributes to the efforts of the Vietnamese government to combat the negative impacts of flooding.

Chapter 8

Conclusion and recommendations

8.1 Introduction

Vietnamese agriculture is vulnerable to extreme weather events and, although the cost of damage to the agricultural sector is small relative to losses in urban and industrial sectors, its impact is felt in rural Vietnam where more than two-thirds of the population live and work in the sector. Research on flood damage to agriculture has received little attention and without this knowledge post-disaster compensation claims have been too high and relief provisions inadequate. The aim of this research was to show how geospatial technologies, economic analysis and institutional reforming can together improve decision making to reduce the vulnerability of Vietnam's agricultural sector to extreme flood events. The focus of the study was Quang Nam province, central Vietnam.

8.2 Research outcomes

By using a spatial analysis technique and economic analyses, it was possible to create accurate multi-scenario maps of areas prone to flooding, as well as calculate the associated value of lost agricultural output in Quang Nam province from flooding. The 1:10, 1:20 and 1:100-year floods resulted in 27%, 31% and 33% respectively, of arable land being inundated. The estimated value of direct losses to the four main crops for a 1:10, 1:20 and 1:100-year flood are approximately VND22 billion, VND115 billion and VND147 billion, respectively. These represent a percentage loss in value in the inundated areas for 1:10, 1:20 and 1:100-year floods, of 12%, 56% and 62%, respectively. Benefit-cost ratios, already very low for subsistence farmers, are further eroded in years of extreme floods, with many farmers experiencing a net loss.

Further, there is a move away from technical flood control measures that are solely reliant upon structural measures toward flood risk management strategies that include mitigation, preparedness, response and recovery strategies. However, changing from a paradigm of flood control to flood risk management raises challenging issues for the design, implementation and operation of flood management policies. Whilst technical and economic analyses are important to help inform the design of flood risk management strategies, effective leadership and institutional arrangements are critical for the efficacy and sustainability of the implementation and operation of flood management strategies. This research examined in detail the current institutional arrangements and found that flood management legislation lacked cohesion. In addition, while flood prevention and mitigation activities were officially decentralised to local authorities, power remains at central and provincial government levels as local authorities have insufficient financial and human capacity to implement their assigned duties. Whilst the case study is undertaken at a provincial level, the principles can be extrapolated to apply to the national level.

8.3 Recommendations

In Appendix D a detailed summary is provided of the current situation and the research findings pertaining to flood management in rural Vietnam. Alongside the research findings recommendations are made that target four areas: leadership, technical, economic and institutional arrangements. Mismatch between government priorities and local needs arising from top-down management can be overcome through consultation with stakeholders. Technical and economic analyses can be better used to inform decision making and institutional arrangements require effectiveness and accountability from a wide range of players at the central, provincial and local levels, as well as social and community organisations and individuals.

8.3.1 Recommendations regarding leadership

It is recommended that the government, researchers and experts work together with the local community on a flood management agenda that reflects the needs of all society. The main barriers to proper and effective government leadership are the top-down approaches where priorities are determined and funding set by central government. Often the context and needs of stakeholders and local government is not well understood by central and provincial policy makers. Some improvements to government leadership might be achieved by community consultation on issues relating to flood management including funding allocation and access to government funded flood management projects.

8.3.2 Recommendations pertaining to technical data and research

From Appendix D it can be seen that there are three key recommendations relating to technical analyses for flood management. The first is to establish a standardised, comprehensive data system for natural disaster risk management and ensure that these data are accessible by researchers and experts. This system should include a data/information sharing mechanism among data holders, decision makers and researchers. The data users would be required to make results available to data providers through a central depository and include any essential references and actions. The data collections and storage must be consistent and transparent and updated regularly and systematically for all flood events. Once the data system was established, technical analyses would be more easily carried out, as would training in such analyses. This would also provide an opportunity for decision making training. Consequently, this is likely to increase awareness among decision makers regarding the usefulness of advanced technology.

The second recommendation is to increase the use of technical analyses to inform decision making regarding flood risk management. For this purpose, the third recommendation is to implement a programme to develop technology capacity among staff.

8.3.3 Recommendations regarding economic analyses

There are two recommendations pertaining to the economic analyses on agricultural flood damage. The first recommendation is that as with technical data, economic agricultural flood damage data be collected, standardised and stored in a data system for natural disaster risk management. Then estimated predictions of agricultural flood damage under different scenarios could be adopted as a standard for accountable and transparent flood damage compensation as well as allocation of other relief resources. The second recommendation is that decision making be informed by economic analyses rather than being too heavily influenced by social and political factors. For example, relief payments from the central government could be based on flood damage estimations from economic analyses. For this purpose, it also recommended that the economic flood damage analyses should be improved through providing training courses to technicians and to those who will then use the analyses as a reliable source of information to make effective decisions.

8.3.4 Recommendations regarding institutional arrangements

The existing legislation has laid the foundations for the current multi-layered flood management institutional arrangement in Vietnam. Although there is a structure in place from central to local levels with the involvement of authorities, scientific institutions, social organisations and individuals on flood management, it is recommended that policies, operational capacities and coordination mechanisms need to be further enhanced. Such strengthening of the natural disaster management system can be done though a disaster management policy, with various support practices such as training and capacity building, awareness activities, coordination and information exchange. The following recommendations focus on policy, organisational functioning, training, mobilising resources and networking.

With regard to policy, it is first recommended that the government adopts a comprehensive policy framework for natural disaster management. Policies should be reviewed and updated regularly. While laws are drafted by legislative bodies, the development of policies should include intensive public consultation. The second recommendation for policy is that the current top-down flood management approach needs to shift to a bottom-up approach that reflects stakeholders' needs. The third recommendation is that flood mitigation policies be broadened to include non-structural measures. In this regard, land use planning and implementation is recommended for consideration and application on floodplains. Resources and supplies should be identified in advance for effective response and support at the farm level.

With regard to organisations, the first recommendation is that the roles and responsibilities of government agencies and individuals should be clarified, from central through to local levels. In addition, inter-ministerial coordination should be improved for smooth operation of flood management. The second recommendation is to devolve greater powers to the provincial government to allow them to take action quickly and responsibly before and during time of flooding. This decentralisation should improve flood management practices. A third recommendation is that while social organisations are playing increasingly important roles in natural disaster management, a strategy is required that enables them to respond more effectively to both the emergency and recovery phases of flood management. This is likely to improve the mobilisation of accessible resources essential for effective flood recovery.

It is further recommended that leadership capacity be strengthened and clear decision making mechanisms be developed. Awareness of the impact and consequences of insufficient leadership capacity is needed and are required to address this shortcoming.

In order to better mobilise resources, both *ex-ante* and *ex-post* evaluation methods should be employed to ensure efficient and equitable resource allocation and distribution. These evaluation methods will require increased funding and much-improved data collection and data availability.

To ensure that flood damage assessment is kept up to date, a pipeline for information flow is needed between researchers, educators, consultants, social organisations and flood managers. It is recommended that a network be established to provide feedback to policy makers as well as encourage dialogue between researchers, agricultural planners and policy makers. Facilitated conferences, workshops and forums are recommended to facilitate the flow of information and encourage networking and collaboration.

8.4 Recommendations for further research

In this study, severe flood impacts on agricultural land were predicted using GIS and the value of the damage was estimated for the four main crops in Quang Nam province. However, future research needs to extend this to include all aspects of the agricultural sector. As data collected improves, future studies need to broaden the focus of flood damage to include indirect flood damage such as disruption to transportation and agricultural trade, loss of value added food production, damage to infrastructure and also intangible losses such as health and psychological damage to farmers.

To ensure that the estimation of flood damage on crops is more reliable, it is also recommended that future studies are undertaken to improve data on crop susceptibility. The research on crop susceptibility should identify correlation between the crop damage with duration and level of inundation in different crop development stages.

The literature shows that many agricultural flood damage studies have focused on severe flood events, such as 1:100-year floods. However, the cumulative damage of small floods may be larger than infrequent but more dramatic flood events (SciDev.Net, 2013). Therefore, extension of this study into annual or smaller scale floods may contribute substantially to flood management in Vietnam where the flood damage values may be smaller in scale but have a significant social and economic impact in the largely subsistent agricultural sector.

Another factor that contributes to flood damage in Quang Nam province is the operation of hydro-power generators during flood season. For dam safety purposes hydro-power dams often discharge large amounts of water downstream during floods (pers.comm. Water Resources and Flood and Storm Control Division, 2011a). It is suggested that future research needs to extend to include the impact of hydro-power operations on flood damage in the province.

The approaches of this study are applied successfully to assess the impact of flooding on agriculture. A similar approach could be made to include other natural hazards such as salinity intrusion and droughts, which are also increasing in frequency and severity in central Vietnam (Quy, 2011). Further research can also use this study’s principles to extend the understanding of the impacts of other natural hazards on other vulnerable areas, such as urban and industrial zones.

This research contributes to the body of knowledge in Vietnam concerning estimations of flood damage to agriculture. In addition a comprehensive analysis was made of current institutional arrangements within the country pertaining to flood management. Uptake of the recommendations made here will go some way toward the improvement of flood management in Vietnam.

References

Abdalla, R. (2009). Distributed GIS approach for flood risk assessment. *International Journal on Advances in Security*, *2*(2&3), 182–189.

Abdalla, R., & Niall, K. (2009). WebGIS-based flood emergency management scenario (pp. 7–12). Presented at the 2009 International Conference on Advanced Geographic Information Systems & Web Services, Cancun, Mexico: IEEE Xplore.

Adger, W. N. (2000). Institutional adaptation to environmental risk under the transition in Vietnam. *Annals of the Association of American Geographers*, *90*(4), 738–758.

Ahmed, Z. (2013). Disaster risks and disaster management policies and practices in Pakistan: a critical analysis of disaster management Act 2010 of Pakistan. *International Journal of Disaster Risk Reduction*, *4*, 15–20.

Anselmo, V., Galeati, G., Palmieri, S., Rossi, U., & Todini, E. (1996). Flood risk assessment using an integrated hydrological and hydraulic modeling approach: a case study. *Journal of Hydrology*, *175*(1–4), 533–554.

Baker, D., & Refsgaard, K. (2007). Institutional development and scale matching in disaster response management. *Ecological Economics*, *63*(2&3), 331–343.

Banerjee, L. (2010). Effects of flood on agricultural productivity in Bangladesh. *Oxford Development Studies*, *38*(3), 339–356.

Biltonen, E. F. (2001). *Cost-benefit analysis of a flood protection project incorporating poverty alleviation concerns: case study Vietnam*. Colorado State University, Colorado.

Bouwer, L. M. (2013). Projections of future extreme weather losses under changes in climate and exposure. *Risk Analysis*, *33*(5), 915–930.

Brémond, P., Grelot, F., & Agenais, A.-L. (2013). Review Article: economic evaluation of flood damage to agriculture – review and analysis of existing methods. *Nat. Hazards Earth Syst. Sci.*, *13*(10), 2493–2512.

Brody, S. D., Kang, J. E., & Bernhardt, S. (2010). Identifying factors influencing flood mitigation at the local level in Texas and Florida: the role of organizational capacity. *Natural Hazards*, *52*(1), 167–184.

Bruun, O. (2012). Sending the right bill to the right people: climate change, environmental degradation, and social vulnerabilities in central Vietnam. *Weather, Climate, and Society*, *4*(4), 250–262.

Büchele, B., Kreibich, H., Kron, A., Thieken, A., Ihringer, J., Oberle, P., … Nestmann, F. (2006). Flood-risk mapping: contributions towards an enhanced assessment of extreme events and associated risks. *Nat. Hazards Earth System Science*, *6*(4), 485-503.

CCFSC (Central Committee for Flood and Storm Control). (2011). Legal documents on flood, storm prevention and natural disaster mitigation. Agricultural publisher. Retrieved from http://www.ccfsc.gov.vn/showlaws.aspx?ladid=77

CCFSC (Central Committee for Flood and Storm Control). (2012). Disaster database. Retrieved April 14, 2012, from http://www.ccfsc.gov.vn/KW6F2B34/Disaster-Database.aspx

Chalmers, I. (2003). Trying to do more good than harm in policy and practice: the role of rigorous, transparent, up-to-date evaluations. *Annals of the American Academy of Political and Social Science*, 589, 22–40.

Changnon, S. D. (2003). Measures of economic impacts of weather extremes. *Bulletin of the American Meteorological Society*, *84*(9), 1231–1235.

Chau, V. N., Holland, J., Cassells, S., & Tuohy, M. (2013). Using GIS to map impacts upon agriculture from extreme floods in Vietnam. *Applied Geography*, *41*, 65–74.

Chau, V. N, Cassells, S., & Holland, J. (2014). Economic impact upon agricultural production from extreme flood events in Quang Nam, central Vietnam. *Natural Hazards*, Article first published online: 10 SEPT 2014 | DOI:10.1007/s11069-014-1395-x .

Chau, V. N., Holland, J., & Cassells, S. (2014). Institutional structures underpinning flood management in Vietnam. *International Journal of Disaster Risk Reduction*, *10*, 341–348.

Charrier, R., & Li, Y. (2012). Assessing resolution and source effects of digital elevation models on automated floodplain delineation: a case study from the Camp Creek Watershed, Missouri. *Applied Geography*, *34*, 38–46.Cologne University of Applied Sciences. (2013). Land use and climate change interactions in central Vietnam. Retrieved January 5, 2013, from http:// www.lucci-vietnam.info/

CRED (Centre for Research on the Epidemiology of Disasters). (2013a). EM-DAT database. Retrieved November 13, 2012, from http://www.emdat.be

CRED (Centre for Research on the Epidemiology of Disasters). (2013b). The OFDA/CRED international disaster database. Retrieved January 23, 2013, from http://www.emdat.be

Dasgupta, S., Laplante, B., Meisner, C., Wheeler, D., & Yan, J. (2009). The impact of sea level rise on developing countries: a comparative analysis. *Climatic Change*, *93*(3), 379–388.

Dawson, R. J., Ball, T., Werritty, J., Werritty, A., Hall, J. W., & Roche, N. (2011). Assessing the effectiveness of non-structural flood management measures in the Thames estuary under conditions of socio-economic and environmental change. *Global Environmental Change*, *21*(2), 628–646.

De Moel, H., Van Alphen, J., & Aerts, J. C. J. H. (2009). Flood maps in Europe - methods, availability and use. *Natural Hazards and Earth System Science*, *9*(2), 289–301.

Downton, M. W., & Pielke, R. A. (2005). How accurate are disaster loss data? the case of U.S. flood damage. *Natural Hazards*, *35*(2), 211–228.Duttaa, D., Herathb, S., & Musiake, K. (2003). A mathematical model for flood loss estimation. *Journal of Hydrology*, *277*, 24–49.

ECLAC (Economic Commission for Latin America and the Caribbean). (2003). Handbook for establishing the socio-economic and environmental effects of natural disasters. United Nations, ECLAC and International Bank for Reconstruction and Development (The World Bank).

Falter, D., Vorogushyn, S., Lhomme, J., Apel, H., Gouldby, B., & Merz, B. (2013). Hydraulic model evaluation for large-scale flood risk assessments. *Hydrological Processes*, *27*(9), 1331–1340. FAO. (2012). FAOSTAT 2012. Retrieved November 25, 2012, from http://faostat3.fao.org/faostat-gateway/go/to/home/E

Finn, M. P. (2011). Recent literature in cartography and geographic information science. *Cartography and Geographic Information Science*, *38*(4), 398–409.

Finn, M. P., & Thunen, D. (2013). Recent literature in cartography and geographic information science. *Cartography and Geographic Information Science*, *40*(4), 363–381.

Finn, M. P., & Thunen, D. (2014). Recent literature in cartography and geographic information science. *Cartography and Geographic Information Science*, *41*(2), 179–192.

Finn, M. P., Yamamoto, K. H., & Thunen, D. (2012). Recent literature in cartography and geographic information science. *Cartography and Geographic Information Science*, *39*(4), 232–260.

Förster, S., Kuhlmann, B., Lindenschmidt, K.-E., & Bronstert, A. (2008). Assessing flood risk for a rural detention area. *Nat. Hazards Earth Syst. Sci.*, *8*(2), 311–322.

Gianinetto, M., Villa, P., & Lechi, G. (2006). Post flood damage evaluation using Landsat TM and ETM+ data integrated with DEM. *Geoscience and Remote Sensing, IEEE Transactions on*, *44*(1), 236–243.

Goosby, S., Mielbrecht, S., Sage, N., Chiesa, C., & Askov, D. (2010). *Flood modeling and early warning capacity development: concept of operations* (Unpublished). Hanoi, Vietnam.

GSO (General Statistics Office of Vietnam). (2010). *The 2009 Vietnam population and housing census: major findings*. Hanoi, Vietnam. Retrieved November 23, 2011, from http://www.gso.gov.vn/default_en.aspx?tabid=476&idmid=4&ItemID=9815

GSO (General Statistics Office of Vietnam). (2011). *Statistical yearbook of Vietnam 2010*. Hanoi, Vietnam: Statistical Publishing House.

GSO (General Statistics Office of Vietnam). (2012). Yield of main annual crops. General Statistics Office of Vietnam. Retrieved April 17, 2013, from http://www.gso.gov.vn/default_en.aspx?tabid=469&idmid=3&ItemID=13072

Guha-Sapir, D. (2012). *Disasters in numbers - 2011*. Presented at the CRED – UNISDR Press Conference, Geneva. Retrieved March 2, 2013, from http://www.emdat .be/press-conference

Hall, J., & Penning-Rowsell, E. (2011). Setting the scene for flood risk management. In *Flood risk science and management*. Wiley-Blackwell.

Hansen, W. J. (1987). *National economic development procedures manual - agricultural flood damage* (No. IWR Report 87-R-10) (p. 182). Washington DC: Water Resources Support Center, Institute for Water resources.

Harmeling, S., & Eckstein, D. (2012). *Global climate risk index 2013: Who suffers most from extreme weather events? weather-related loss events in 2011 and 1992 to 2011*. Born: Germanwatch e.V. Retrieved May 18, 2013, from www.germanwatch.org/en/cri

Heazle, M., Tangney, P., Burton, P., Howes, M., Grant-Smith, D., Reis, K., & Bosomworth, K. (2013). Mainstreaming climate change adaptation: an incremental approach to disaster risk management in Australia. *Environmental Science & Policy*, *33*, 162–170.

Hien, H. M., Trung, T. N., Looijen, W., & Hulsbergen, K. (2005). Flood vulnerability analysis and mapping in Vietnam. In P. van Oosterom, S. Zlatanova, & E. M. Fendel (Eds.), *Geo-information for disaster management* (pp. 67–83). Berlin: Springer.

Ho, L. T. K., & Umitsu, M. (2011). Micro-landform classification and flood hazard assessment of the Thu Bon alluvial plain, central Vietnam via an integrated method utilizing remotely sensed data. *Applied Geography*, *31*(3), 1082–1093.

Hosking, J. R. M., & Wallis, J. R. (1997). *Regional frequency analysis: an approach based on L-moments*. Cambridge, New York, Melbourne, Cape Town, Singapore, Sao Paulo: Cambridge University Press.

IFA (Institutions for Floods in Asia). (2005). *Institutional capacity in natural disaster risk reduction: A comparative analysis of institutions, national policies, and cooperative responses to floods in Asia* (p. 39). Kobe, Japan: Asia-Pacific Network for Global Change Research.

IFRC (International Federation of Red Cross and Red Crescent Societies). (2010). *Disasters in Asia: the case for legal preparedness*. Geneva, Kuala Lumpur.

IFRC (International Federation of Red Cross and Red Crescent Societies). (2011). *Desk review on trends in the promotion of community-based disaster risk reduction through legislation*. Geneva: IFRC (International Federation of Red Cross and Red Crescent Societies).

IFRC (International Federation of Red Cross and Red Crescent Societies), & ADB (Asian Development Bank). (2009). *Legal preparedness for responding to disasters and communicable disease emergencies: study report (Viet Nam)* (p. 206). Kuala Lumpur.

Institute of Geography. (2010). *Contract for consultants' services to carry out surveys and hydrodynamic flood modeling in the Vu Gia Thu Bon river basin in Quang Nam province* (Unpublished) (p. 130). Hanoi, Vietnam.

Institute of Geography. (2011). Assessing effects of and responses to climate change on environment and socio-economic development in mid-central Vietnam. Retrieved March 15, 2012, from http://ecoenvi.org/

Institute of Water Resources Planning. (2011). *Review and update the flood prevention plan for central provinces: Vu Gia-Thu Bon river (In Vietnamese: Rà soát, bổ sung quy hoạch phòng chống lũ các tỉnh miền Trung: lưu vực sông Vu Gia-Thu Bồn)*. Hanoi, Vietnam.

IPCC. (2007). *Climate Change 2007: The physical science basic. Contribution of working group I to the fourth assessment report of Intergovernmental Panel on climate change*. Cambridge, UK: Cambridge University Press.

IPCC. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation*. Cambridge.

Jha, A. K., Bloch, R., & Lamond, J. (2012). *Cities and flooding - a guide to integrated urban flood risk management for the 21st century*. Washington D.C: World Bank.

Joe, L. (2001). How does flooding affect corn yield? *Corn Agronomy*. Retrieved December 3, 2012, from http://corn.agronomy.wisc.edu/WCM/W091.aspx

Kaiser, G., Kortenhaus, A., Hofmann, S., & Sterr, H. (2008). *Integrated flood risk analysis and management methodologies. Pilot study "German Bight coast": Executive summary* (No. T27-07-01).

Karl, T. R., Melillo, J. M., & Peterson, T. C. (2009). *Global climate change impacts in the United States*. New York.

Katsuhama, Y. (2010). *Capacity building for flood management in developing countries under climate change*. Colorado State University, Colorado.

Kellogg Brown & Root Pty. Ltd. (2009). *Vietnam water sector review* (Report). Hanoi: Ministry of Natural Resources and Environment.

Khan, M. R., & Rahman, M. A. (2007). Partnership approach to disaster management in Bangladesh: a critical policy assessment. *Natural Hazards*, *41*(2), 359–378.

Kotera, A., & Nawata, E. (2007). Role of plant height in the submergence tolerance of rice: a simulation analysis using an empirical model. *Agricultural Water Management*, *89*(1–2), 49–58.

Kusumasari, B., & Alam, Q. (2012). Bridging the gaps: the role of local government capability and the management of a natural disaster in Bantul, Indonesia. *Natural Hazards*, *60*(2), 761–779.

Kwak, Y. J., Takeuchi, K., Fukami, K., & Magome, J. (2012). Assessment of Flood Risk and Future Change due to Climate Change in Asia-Pacific Region Based on MRI-GCM Model (Vol. 14, p. 7157). Presented at the EGU General Assembly 2012, Vienna, Austria.

Lastra, J., Fernández, E., Díez-Herrero, A., & Marquínez, J. (2008). Flood hazard delineation combining geomorphological and hydrological methods: an example in the Northern Iberian Peninsula. *Natural Hazards*, *45*(2), 277–293.

Lebel, L., Nikitina, E., Kotov, V., & Manuta, J. (2006). Assessing institutionalized capacities and practices to reduce the risks of flood disasters. In J. Birkmann (Ed.), *Measuring vulnerability to natural hazards: Towards disaster resilient societies*. Tokyo: United nations University Press.

Lee, K. S., & Lee, S. I. (2003). Assessment of post-flooding conditions of rice fields with multi-temporal satellite SAR data. *International Journal of Remote Sensing*, *24*(17), 3457–3465.

Li, K., Wu, S., Dai, E., & Xu, Z. (2012). Flood loss analysis and quantitative risk assessment in China. *Natural Hazards*, *63*(2), 737–760.

Lin, Y. J., Chang, Y. H., Tan, Y. C., Lee, H. Y., & Chiu, Y. J. (2011). National policy of watershed management and flood mitigation after the 921 Chi-Chi earthquake in Taiwan. *Natural Hazards*, *56*(3), 709–731.

Lindley, S. J., Handley, J. F., McEvoy, D., Peet, E., & Theuray, N. (2007). The role of spatial risk assessment in the context of planning for adaptation in UK urban areas. *Built Environment*, *33*(1), 46–69.

Linnerooth-Bayer, J., Mechler, R., & Hochrainer, S. (2011). Insurance against losses from natural disasters in developing countries: evidence, gaps and the way forward. *IDRiM Journal*, *1*(1), 1–23.

Luong, O., Nguyen, T., Wilderspin, I., & Coulier, M. (2011). *A preliminary analysis of flood and storm disaster data in Viet Nam*. Hanoi, Vietnam.

McDonald, G. T. (1970). Agricultural flood damage assessment: a review and investigation of a simulation method. *Review of Marketing and Agricultural Economics*, *38*(3), 105–120.

Mechler, R. (2003). Natural disaster risk and cost-benefit analysis. In A. Kreimer, M. Arnold, & A. Carlin (Eds.), *Building safer cities: the future of disaster risk* (p. 324). Washington, DC: World Bank.

Mechler, R. (2005). *Cost-benefit analysis of natural disaster risk management in developing countries*.

Merz, B., Hall, J., Disse, M., & Schumann, A. (2010). Fluvial flood risk management in a changing world. *Natural Hazards and Earth System Sciences*, *10*, 509–527.

Merz, B., Kreibich, H., Schwarze, R., & Thieken, A. (2010). Review article "assessment of economic flood damage." *Nat. Hazards Earth Syst. Sci.*, *10*(8), 1697–1724.

Messner, F., Penning-Rowsell, E., Green, C., Meyer, V., Tunstall, S., & Veen, A. van der. (2007). *Evaluating flood damages: guidance and recommendations on principles and methods* (Report No. T09-06-01). Centre of Environmental Research, Dresden Flood Research Center. Retrieved July 8, 2012 from http://www.floodsite.net/html/publications2.asp?documentType=1&Submit=View

METI (The Ministry of Economy Trade and Industry of Japan, & NASA (The United States National Aeronautics and Space Administration). (2011). Release of ASTER GDEM version 2. Retrieved January 1, 2010, from http://www.jspacesystems.or.jp/ersdac/GDEM/E/4.html

Meyer, V., Becker, N., Markantonis, V., Schwarze, R., van den Bergh, J. C. J. M., Bouwer, L. M., … Viavattene, C. (2013). Review article: assessing the costs of natural hazards – state of the art and knowledge gaps. *Nat. Hazards Earth Syst. Sci.*, *13*(5), 1351–1373.

Meyer, V., & Messner, F. (2005). *National flood damage evaluation methods: a review of applied methods in England, the Netherlands, the Czech Republik and Germany* (UFZ Discussion Paper No. 21/2005). Helmholtz Centre for Environmental Research (UFZ), Division of Social Sciences (ÖKUS). Retrieved October 5, 2012, from http://ideas.repec.org/p/zbw/ufzdps/212005.html

Meyer, V., Priest, S., & Kuhlicke, C. (2012). Economic evaluation of structural and non-structural flood risk management measures: examples from the Mulde River. *Natural Hazards*, *62*(2), 301–324.

Ministry of Natural Resources and Environment. (2009). *Climate change, sea level rise scenarios for Vietnam*. Hanoi: Ministry of Natural Resources and Environment.

Morris, J., & Brewin, P. (2013). The impact of seasonal flooding on agriculture: the spring 2012 floods in Somerset, England. *Journal of Flood Risk Management*, 1–13.

Næss, L. O., Bang, G., Eriksen, S., & Vevatne, J. (2005). Institutional adaptation to climate change: flood responses at the municipal level in Norway. *Global Environmental Change*, *15*(2), 125–138.

National Assembly. (2003). Law on construction No.16/2003/QH11.

Okuyama, Y. (2007). Economic modeling for disaster impact analysis: past, present, and future. *Economic Systems Research*, *19*(2), 115–124.

Okuyama, Y., & Chang, S. E. (2004). *Modeling spatial and economic impacts of disasters*. New York: Springer.

Olfert, A., & Schanze, J. (2007). *Methodology for ex-post evaluation of measures and instruments in flood risk management (postEval)* (No. T12-07-01).

Omidvar, B., Zafari, H., & Derakhshan, S. (2010). Reconstruction management policies in residential and commercial sectors after the 2003 bam earthquake in Iran. *Natural Hazards*, *54*(2), 289–306.

OOG (Office of Government). (2013). Government's legal document database. Retrieved July 5, 2013, from http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban

Pantaleoni, E., Engel, B. A., & Johannsen, C. J. (2007). Identifying agricultural flood damage using Landsat imagery. *Precision Agriculture*, *8*(1-2), 27–36.

Parker, D., Green, C., & Thompson, P. (1987). *Urban flood protection benefits: a project appraisal guide (The red manual)*. Aldershot, UK: Gower Technical Press.

Peltonen-Sainio, P., Jauhiainen, L., Trnka, M., Olesen, J. E., Calanca, P., Eckersten, H., … Orlandini, S. (2010). Coincidence of variation in yield and climate in Europe. *Agriculture, Ecosystems & Environment*, *139*(4), 483–489.

Penning-Rowsell, E., & Parker, D. J. (1987). The indirect effects of floods and benefits of flood alleviation: evaluating the Chesil Sea Defence Scheme. *Applied Geography*, *7*(4), 263–288.

Penning-Rowsell, E., Yanyan, W., Watkinson, A. r., Jiang, J., & Thorne, C. (2013). Socioeconomic scenarios and flood damage assessment methodologies for the Taihu Basin, China. *Journal of Flood Risk Management*, *6*(1), 23–32.

Pham, V. T. (2011, June). *Country report on rice cultivation practice: Vietnam*. Presentation, Bangkok. Retrieved June 26, 2012, from http://www.jgsee.kmutt.ac.th/apnproject/Web_Postconference/pdf/8_Vietnam.pdf

Posthumus, H., Hewett, C. J. M., Morris, J., & Quinn, P. F. (2008). Agricultural land use and flood risk management: engaging with stakeholders in North Yorkshire. *Agricultural Water Management*, *95*(7), 787–798.

Pottier, N., Penning-Rowsell, E., Tunstall, S., & Hubert, G. (2005). Land use and flood protection: contrasting approaches and outcomes in France and in England and Wales. *Applied Geography*, *25*(1), 1–27.

Prime Minister of Vietnam. (2007). *Decision to approve the national strategy for natural disaster prevention, response and mitigation to 2020* (No. 172/2007/QD-TTg) (p. 37). Hanoi: Government office.

Prime Minister of Vietnam. (2009). *Decision No. 1590/QD-TTg: approving the strategic orientation on development of water resources of Vietnam*. Hanoi: Government Office.

Prime Minister of Vietnam. (2011). Decision on experiment of agricultural insurance in the period of 2011-2013. Retrieved January 21, 2012, from http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=2&mode=detail&document_id=99293

Prime Minister of Vietnam. (2012). The inspection results on utilisation and allocation of government relief fund for calamity and diseases rehabilitation 2009. Retrieved January 23, 2013 from http://www.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=2&mode=detail&document_id=155656

Purdy, G. (2010). ISO 31000:2009 - setting a new standard for risk management. *Risk Analysis*, *30*(6), 881–886.

Quang Nam People's Committee. (2005). *Flood prevention, response and rehabilitation report 2004* (Unpublished). Tam Ky city.

Quang Nam People's Committee. (2008). *Flood prevention, response and rehabilitation report 2007* (Unpublished). Tam Ky city.

Quang Nam People's Committee. (2010). *Flood prevention, response and rehabilitation report 2009* (Unpublished). Tam Ky city.

Quang Nam Statistics Office. (2007). *Quang Nam statistical yearbook 2006*. Tam Ky: Statistical Publishing House.

Quang Nam Statistics Office. (2011). *Quang Nam statistical yearbook 2010*. Tam Ky: Statistical Publishing House.

Quy, N. B. (2011). *Assessing impacts of climate change on disasters related to stream flow (flood and drought) in Quang Nam, Vietnam* (Research report). Hanoi: Water Resources University.

Read Sturgess and Associates. (2000). *Rapid appraisal method (RAM) for floodplain management*. The state of Victoria, Australia: Department of Natural Resources and Environment.

Samarasinghe, S. M. J. ., Nandalal, H. ., Weliwitiya, D. ., Fowze, J. S. ., Hazarika, M. ., & Samarakoon, L. (2010). Application of remote sensing and GIS for flood risk analysis: a case study at Kalu-Ganga river, Sri Lanka. Presented at the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Tokyo, Japan: International Society for Photogrammetry and Remote Sensing.

Samuels, P. (2005). The European perspective and research on flooding. In D. W. Knight & A. Shamseldin (Eds.), *River basin modeling for flood risk mitigation*. London: Taylor & Francis.

Samuels, P., & Gouldby, B. (2009). *Language of risk - project definitions (second edition)* (No. T32-04-01). Retrieved January 8, 2013, from http://www.floodsite.net/html/partner_area/project_docs/T32_04_01_FLOODsite_Language_of_Risk_D32_2_v5_2_P1.pdf

Samuels, P., Klijn, F., Kortenhaus, A., & Sayers, P. (2009). *FLOODsite final report - volume 1: advancement in knowledge and understanding* (No. T35-09-01).

Schanze, J. (2006). Flood risk management - a basic framework. In J. Schanze, E. Zeman, & J. Marsalek (Eds.), *Flood risk management: hazards, vulnerability and mitigation measures* (pp. 1–20). Springer Netherlands.

Scheuer, S., Haase, D., & Meyer, V. (2012). Spatial explicit multicriteria flood risk - fundamentals and semantics of multicriteria flood risk management. In *Flood risk and flood management*. New York: Nova Science Publishers, Inc.

SciDev.Net. (2013, September 9). Data gaps hamper disaster risk reduction. *SciDev.Net*. Retrieved September 9, 2013, from http://www.scidev.net/global/earth-science/news/data-gaps-hamper-disaster-risk-reduction.html

Simonovic, S. P. (2012). *Floods in a climate change: risk management*. Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, Sao Paulo: Cambridge University Press.

Simonović, S. P. (1999). Social criteria for evaluation of flood control measures: Winnipeg case study. *Urban Water*, *1*(2), 167–175.

Simonovic, S. P., & Carson, R. W. (2003). Flooding in the red river basin – lessons from post flood activities. *Natural Hazards*, *28*(2), 345–365.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292.

Smith, K., & Ward, R. C. (1998). *Floods: Physical processes and human impacts*. New York: John Wiley & Sons Inc.

Tachikawa, T., Hato, M., Kaku, M., & Iwasaki, A. (2011). The characteristics of ASTER GDEM version 2 (p. 4). Presented at the IGARSS 2011.

Thieken, A., Merz, B., Kreibich, H., & Apel, H. (2006). Methods for flood risk assessment: concept and challenges (p. 12). Presented at the International workshop of flash floods in urban areas, Muscat-Sultanate, Oman.

Tol, R. S. J., van der Grijp, N., Olsthoorn, A. A., & van der Werff, P. E. (2003). Adapting to climate: a case study on Riverine flood risks in the Netherlands. *Risk Analysis*, *23*(3), 575–583.

Uddin, K., Gurung, D., Giriraj, A., & Shrestha, B. (2012). Application of remote sensing and GIS for flood hazard management: a case study from Sindh province, Pakistan, 5.

UNDP. (2005). *A global review: UNDP support to institutional and legislative systems for disaster risk management* (p. 70). Geneva.

UNDP. (2013). Institutional arrangement. *Capacity development*. Retrieved October 13, 2013, from http://www.undp.org/content/undp/en/home/ourwork/capacitybuilding/drivers_of_change/institut_arrangemt/

UN-HABITAT, & UNEP. (2002). *Mitigation, management and control of floods in South Asia* (Vol. 3). UN-HABITAT and UNEP.

United Nation. (2002). *Guidelines for reducing flood losses* (p. 87). New York.

Van Aalst, M. K., Cannon, T., & Burton, I. (2008). Community level adaptation to climate change: the potential role of participatory community risk assessment. *Global Environmental Change*, *18*(1), 165–179.

VanDine, D. (2012). *Risk management - Canadian technical guidelines and best practices related to landslides: a national initiative for loss reduction* (Open File 6996). Victoria, BC: Geological Survey of Canada.

Vietnam Government. (2010). Decree on organisation, function, duties, authorities and coordination mechanism of the committees for flood and storm control (CFSCs) and committees for search and rescue (CSRs) at ministerial, sectorial and provincial levels (No.14/2010/ND-CP).

Wang, H.-W., Kuo, P.-H., & Shiau, J.-T. (2013). Assessment of climate change impacts on flooding vulnerability for lowland management in south-western Taiwan. *Natural Hazards*, *68*(2), 1001–1019.

Wang, Y., Colby, J. D., & Mulcahy, K. A. (2002). An efficient method for mapping flood extent in a coastal floodplain using Landsat TM and DEM data. *International Journal of Remote Sensing*, *23*(18), 3681–3696.

Wang, Y., Yong-song, Z., Wei-hong, C., & Peng, L. (2010). Flood inundation and disaster prediction based on DEM. In *2010 second IITA international conference on geoscience and remote sensing (IITA-GRS)* (Vol. 1, pp. 54–56).

Ward, P. J., Pauw, W. P., van Buuren, M. W., & Marfai, M. A. (2013). Governance of flood risk management in a time of climate change: the cases of Jakarta and Rotterdam. *Environmental Politics*, *22*(3), 518–536.

Westen, C. V. (2010). GIS for assessment of risk from geomorphological hazards. In I. Alcántara & A. Goudie (Eds.), *Geomorphological hazards and disaster prevention* (pp. 205 – 220). Cambridge; New York: Cambridge University Press.

Wheater, H., & Evans, E. (2009). Land use, water management and future flood risk. *Land Use Policy*, *26, Supplement 1*, S251–S264.

Wijesekara, G. N., Farjad, B., Gupta, A., Qiao, Y., Delaney, P., & Marceau, D. J. (2013). A comprehensive land-use/hydrological modeling system for scenario simulations in the elbow river watershed, Alberta, Canada. *Environmental Management*, 1–25.

Wilby, R. L., & Keenan, R. (2012). Adapting to flood risk under climate change. *Progress in Physical Geography*, *36*(3), 348–378.

World Bank. (2009). *Assessment of innovative approaches to flood risk management and financing in agriculture : the Thailand case study*. Washington D.C. Retrieved September 8, 2012, from https://openknowledge.worldbank.org/handle/10986/12704

World Bank. (2010a). *Economics of adaptation to climate change - Vietnam* (No. 70272). Washington.

World Bank. (2010b). *Weather the storm: option for disaster risk financing in Vietnam* (p. 143). Washington, D.C.

World Bank. (2013). Poverty reduction in Vietnam: remarkable progress, emerging challenges. Retrieved February 15, 2013, from http://www.worldbank.org/en/news/feature/2013/01/24/poverty-reduction-in-vietnam-remarkable-progress-emerging-challenges

Zheng, T., & Wang, Y. (2006). Mapping flood extent using a simple DEM-Inundation model. *The North Carolina Geographer*, *15*, 1–19.

Personal communication (pers.comm.)

Agricultural Division of Dai Loc District. (2011). Interview with the agricultural manager, Agricultural Division of Dai Loc District, Quang Nam province (13 December).

Agricultural Division of Dien Ban District. (2011). Interview with the agricultural manager, Agricultural Division of Dien Ban District, Quang Nam province (14 December).

Agricultural Division of Duy Xuyen District. (2011). Interview with the economic agriculture manager, Agricultural Division of Duy Xuyen District, Quang Nam province (14 December).

Agricultural Division of Nong Son District. (2011). Interview with the economic agriculture manager, Agricultural Division of Nong Son District, Quang Nam province (15 December).

Agricultural Extension Centre. (2011). Interview with Deputy Director, Agricultural Extension Centre of Quang Nam’s Department of Agricultural and Rural Development (15 December).

Central Project Office. (2011a). Interview with Deputy Director General, Central Project Office, Ministry of Agricultural and Rural Development (10 October).

Central Project Office. (2011b). Interview with Deputy Director General, Central Project Office, Ministry of Agricultural and Rural Development (14 October).

Disaster Management Centre. (2011a). Interview with the manager of Information and Statistical Division, the Directorate of Water Resources, Ministry of Agriculture and Rural Development (November 9).

Disaster Management Centre. (2011b). Interview with the manager of Community Based Disaster Management Division, the Directorate of Water Resources, Ministry of Agriculture and Rural Development (November 15).

Disaster Management Centre. (2011c). Interview with Dr. M. H. Hoang, Official of Training and Technology Transfer Division, the Directorate of Water Resources, Ministry of Agriculture and Rural Development (November 24).

Dyke Management and Flood and Storm Control Department. (2013). Message correspondence with Mr. H. Nguyen, Chief division, Dyke Management and Flood and Storm Control Department, Directorate of Water Resources (20 March).

Quang Nam Centre for Hydro – Meteorological Forecasting. (2011). Interview with Mr. T. Truong, Director, Quang Nam Centre for Hydro – Meteorological Forecasting (16 December)

Water Resources and Flood and Storm Control Division. (2011a). Meeting with Director, Deputy Director, the natural disaster manager and the construction manager, Water Resources and Flood and Storm Control Division of Quang Nam's Department of Agricultural and Rural Development (12 December).

Water Resources and Flood and Storm Control Division. (2011b). Interview with the Deputy Director of Water Resources and Flood and Storm Control Division of Quang Nam's Department of Agricultural and Rural Development (13 – 18 December).

Water Resources and Flood and Storm Control Division. (2011c). Interview with the natural disaster manager, Water Resources and Flood and Storm Control Division of Quang Nam's Department of Agricultural and Rural Development (17 December).

Appendix A: Inundation maps and agricultural land affected

This study assessed the impact of 1:10, 1:20 and 1:100-year floods on agricultural land use in the Quang Nam province. The results of inundation and agricultural impacts for 1:100-year flood are presented in Chapter Three. The following figures present the 1:10 and 1:20-year floods' inundation maps and their impact on agricultural land in Quang Nam province.

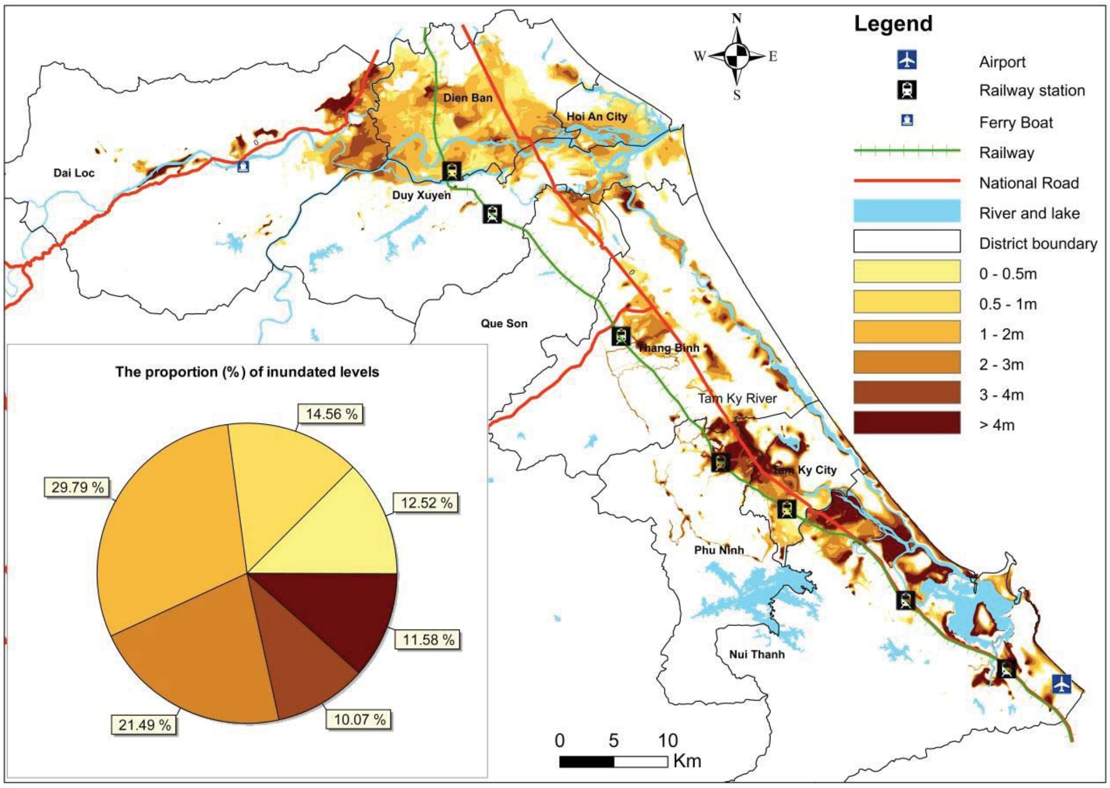


Figure A.1. Predicted inundation of Quang Nam province resulting from a 1:10-year flood event.

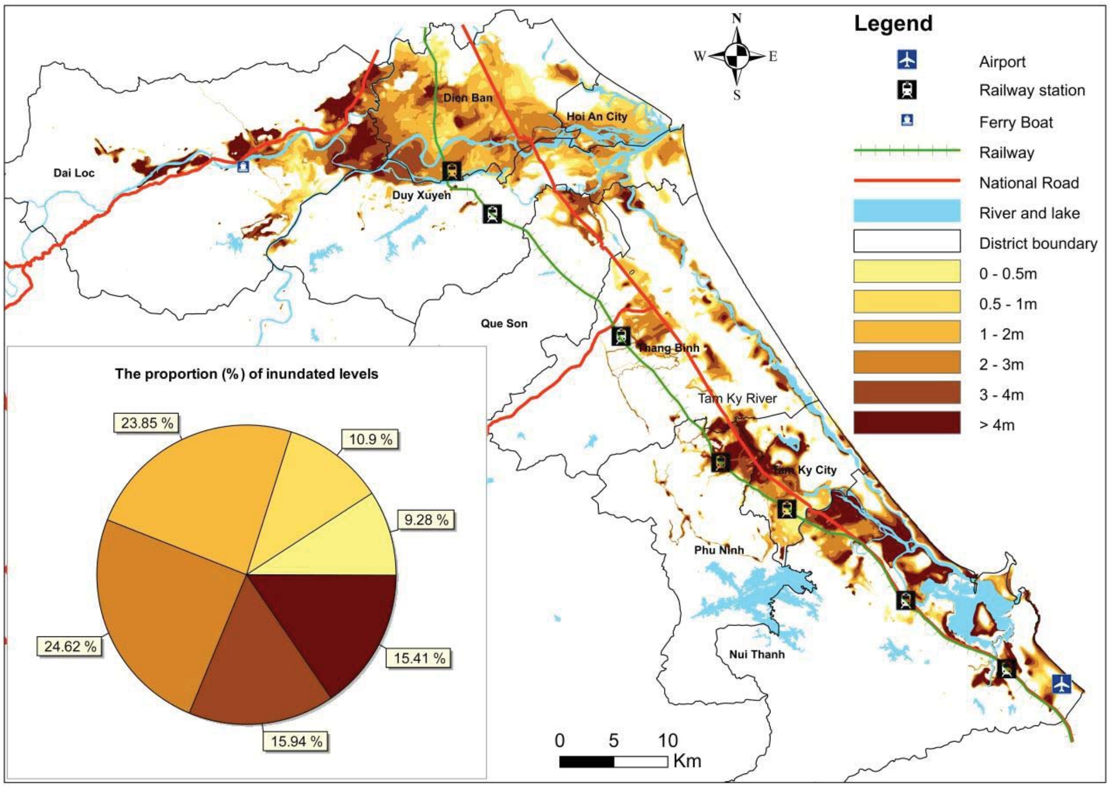


Figure A.2. Predicted inundation of Quang Nam province resulting from a 1:20-year flood event.

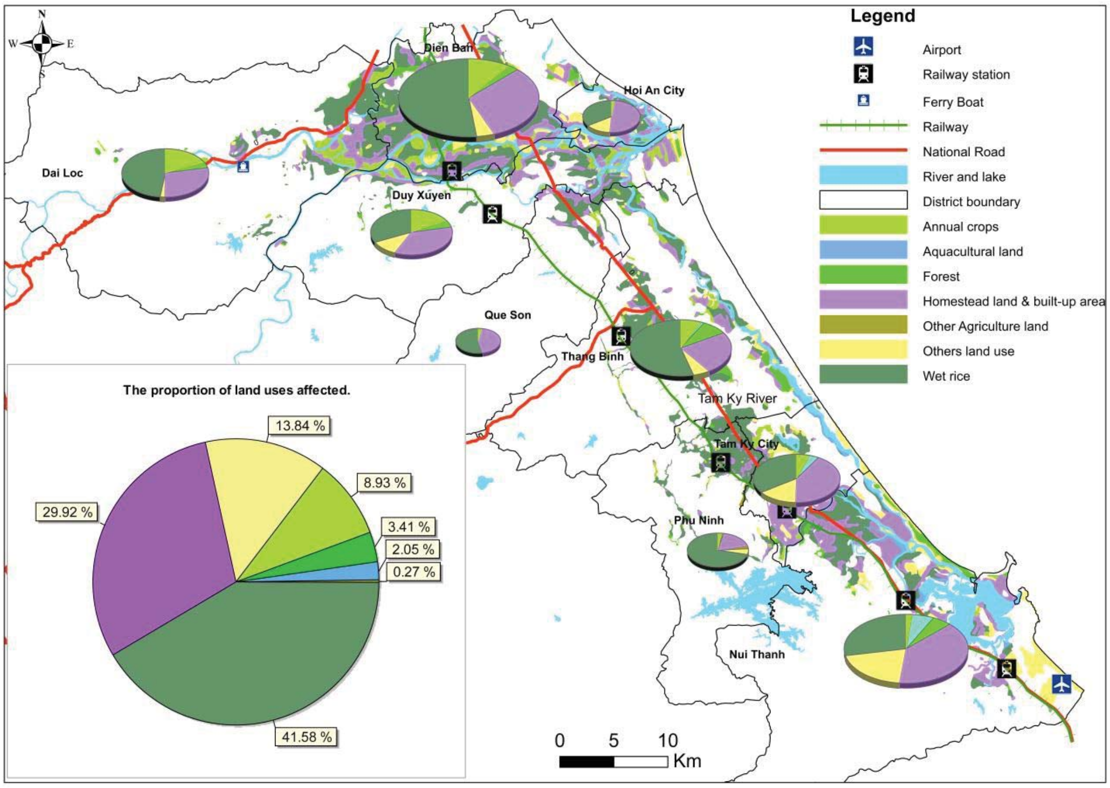


Figure A.3. Different land uses in Quang Nam province's districts affected by the 1:10-year flood.

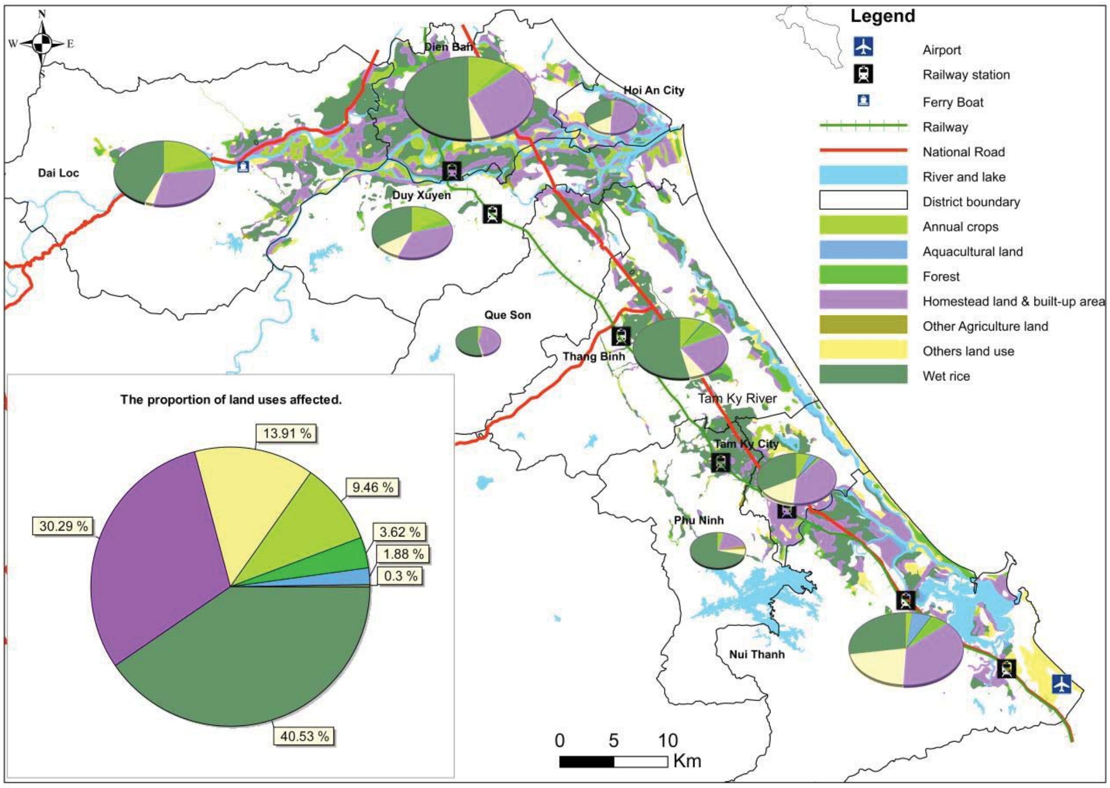


Figure A.3. Different land uses in Quang Nam province's districts affected by the 1:10-year flood.

Appendix B: Agricultural data

B.1. Agricultural and economic data

The data for 2010 crop production costs and the outputs were collected during the field trip in Quang Nam province. The data are presented in Table B.1 and the financial rice budget is presented in Table B.2.

Table B.1. Farm gate prices of agricultural inputs and outputs.

Item	Units	Costs
1. Inputs		
1.1. Seeds		
Rice	10^3 VND/kg	9
Corn	10^3 VND/kg	27
Beans	10^3 VND/kg	28
Vegetables	10^3 VND/ha	800
1.2. Fertiliser		
Urea	10^3 VND/tonne	7,000
Superphosphate	10^3 VND/tonne	3,800
KCL	10^3 VND/tonne	12,500
Lime	10^3 VND/tonne	1,200
Farm yard manure	10^3 VND/tonne	380
1.3. Agrochemicals (eg. pesticides)		
Rice	10^3 VND/ha	600
Corn	10^3 VND/ha	600
Beans	10^3 VND/ha	600
Vegetables	10^3 VND/ha	600
1.4. Others		
Tractor Hire	10^3 VND/hour	150
Labour	10^3 VND/day	60
Water charge	10^3 VND/ha	0
Land	10^3 VND/ha	0
2. Outputs		
Rice	10^3 VND/tonne	4,811
Corn	10^3 VND/tonne	4,743
Beans	10^3 VND/tonne	21,000
Vegetables	10^3 VND/tonne	3,360

Table B.2. Financial budget of rice production per hectare (2010 yield and prices).

Item	Unit	Quantity	Price (10^3VND)	Cost (10^3VND/ha)
Outputs				
Product	Tonne	5.33	4,811	25,628
Inputs				
1. Seed	Kg	100	9.0	900
2. Fertilisers:				
Urea	Kg	180	7.0	1,260
Superphosphate	Kg	260	3.8	988
KCL	Kg	110	12.5	1,375
Lime	Kg	90	1.2	108
Farm yard manure	Tonne	7	380.0	2,660
3. Agrochemicals	Lump sum	1	600.0	600
4. Land preparation	tractor hour	9	150.0	1,350
5. Bags and packaging	Lump sum	1	500.0	500
6. Irrigation maintenance costs	kg of rice	90	4.8	433
7. Labour:				
Seedling preparation	Day	5	60	300
Transplanting/planting	Day	20	60	1,200
Fertiliser application	Day	20	60	1,200
Agrochemical application	Day	5	60	300
Weeding	Day	60	60	3,600
Harvesting	Day	40	60	2,400
Threshing	Day	15	60	900
Drying	Day	10	60	600
8. Transportation	Lump sum	1	550	550
9. Cooperative charge	kg of rice	15	4.8	72
10. Water charge	VND	1	-	-
11. Land	VND	1	-	-
Total costs				***21,296***

Table B.3. Financial budget of corn production per hectare (2010 yield and prices).

Item	Unit	Quantity	Price *(10³VND)*	Cost *(10³VND/ha)*
Outputs				
Product	Tonne	4.94	4,743	23,430
Inputs				
1. Seed	Kg	25	27	675
2. Fertilisers				
Urea	Kg	230	7	1,610
Superphosphate	Kg	360	3.8	1,368
KCL	Kg	125	12.5	1,563
Farm Yard Manure	Tonne	8	380	3,040
3. Agrochemicals	Lump sum	1	600	600
4. Land preparation	Tractor hour	5	150	750
5. Bags and packaging	Lump sum	1	500	500
6. Irrigation maintenance costs	kg of rice	50	4.811	241
7. Labour:				5,880
Transplanting/planting	Day	30	60	1,800
Fertiliser application	Day	12	60	720
Agrochemical application	Day	3	60	180
Weeding	Day	25	60	1,500
Harvesting	Day	14	60	840
Threshing	Day	9	60	540
Drying	Day	5	60	300
8. Transportation	Lump sum	1	500	500
9. Cooperative charge	kg of rice	15	4.743	71
10. Water charge	VND	1	-	-
11. Land	VND	1	-	-
Sub-total				***16,797.2***

Table B.4. Financial budget of beans production per hectare (2010 yield and prices).

Item	Unit	Quantity	Price (10^3VND)	Cost (10^3VND/ha)
Outputs				
Product	Tonne	1.16	21,000	24,360
Inputs				
1. Seed	kg	65	25.00	1,625
2. Fertilisers				
Urea	kg	30	7.0	210
Superphosphate	Kg	60	3.8	228
KCL	Kg	60	12.5	750
Lime	Kg	300	1.2	360
Farm Yard Manure	Tonne	6	380	2,280
3. Land preparation	tractor hour	7	150	1,050
4. Agrochemicals	Lump sum	1	640	640
5. Bags and packaging	Lump sum	1	2000	2,000
6. Labour				4,680
Transplanting/planting	Day	12	60	720
Fertiliser application	Day	8	60	480
Agrochemical application	Day	5	60	300
Weeding	Day	30	60	1,800
Harvesting	Day	20	60	1,200
Drying	Day	3	60	180
7. Transportation	Lump sum	1	500	500
8. Water charge	VND	1	0	-
9. Land	VND	1	0	-
Total costs				***14,323***

Table B.5. Financial budget of 'other vegetables' production per hectare (2010 yield and prices).

Item	Unit	Quantity	Price *(10^3VND)*	Cost *(10^3VND/ha)*
Outputs				
Product	Tonne	13	3,360	43,680
Inputs				
1. Seed/planting materials	Lump sum	1	800	800
2. Fertilisers				
Urea	Kg	150	7	1,050
Superphosphate	Kg	50	3.8	190
KCL	Kg	100	12.5	1,250
Farm Yard Manure	Tonne	3	380	1,140
3. Agrochemicals	Lump sum	1	640	640
4. Bags and packaging	Lump sum	3	1000	3,000
5. Labour				10,800
Land preparation	Day	20	60	1,200
Transplanting/planting	Day	40	60	2,400
Fertiliser application	Day	20	60	1,200
Agrochemical application	Day	10	60	600
Weeding	Day	30	60	1,800
Harvesting	Day	60	60	3,600
6. Transportation	Lump sum	3	300	900
7. Water charge	VND	1	0	-
8. Land	VND	1	0	-
Total costs				***19,770***

Appendix C: Legal documents

Table C. List of key legal documents related flood management.

Year	Type	Title	
		in English	**In Vietnamese**
1992-2000	Constitution	Constitution of the Socialist Republic of Viet Nam 1992-2000	Hiến pháp nước Cộng hòa Xã hội chủ nghĩa Việt Nam 1992-2000
2005	Law	Law on Environmental Protection, No. 52/2005/QH11 promulgated by the National Assembly on 29th November 2005	Luật bảo vệ môi trường, số 52/2005/QH11 do Quốc hội ban hành ngày 29/11/2005
2006	Law	Law on dykes, No. 79/2006/QH11 promulgated by the National Assembly on 29th November 2006	Luật Đê điều số 79/2006/QH11 do Quốc hội ban hành ngày 29/11/2006.
2008	Law	Law on promulgation of legal acts, No.17/2008/QH12 promulgated by the National Assembly on 3 June 2008	Luật ban hành văn bản quy phạm pháp luật số 17/2008/QH12 do Quốc hội ban hành ngày 3/6/2008
2012	Law	Law on the Water Resources, No. 17/2012/QH13 promulgated by the National Assembly on 21/6/2012	Luật Tài nguyên nước số 17/2012/QH13 do Quốc hội ban hành ngày 21/6/2012
2013	Law	The Law on Natural Disaster Prevention and Mitigation No.33/2013/QH13 promulgated by the National Assembly on 19 June 2013	Luật phòng, chống thiên tai số: 33/2013/QH13 do Quốc hội ban hành ngày 19/6/2013
1993	Ordinance	Ordinance on flood and storm prevention and control 1993	Pháp lệnh phòng, chống lụt, bão 1993
2000	Ordinance	Ordinance on State of Emergency, No.20/2000/PL-UBTVQH Promulgated by the Standing Committee of National Assembly on 4 April 2000	Pháp lệnh tình trạng khẩn cấp, số 20/2000/PLUBTVQH10, do Ủy ban Thường vụ Quốc hội ban hành ngày 4/4/2000
2000	Ordinance	Ordinance amending and supplementing a number of articles of the Ordinance on flood and storm prevention and control (20/3/1993), No.	Pháp lệnh của Ủy ban Thường vụ Quốc hội số 27/2000/PL-UBTVQH10 ngày 24 tháng 8 năm 2000 sửa đổi, bổ sung một số điều của Pháp lệnh

		27/2000/PLUBTVQH promulgated by the Standing Committee of National Assembly on 24 August 2000	phòng, chống lụt, bão
2001	Ordinance	The Ordinance on the Management of Irrigation and Drainage Structures, No.32/2001/PL-UBTVQH10 promulgated by the Standing Committee of the National Assembly on 4 April 2001	Pháp lệnh Khai thác và bảo vệ công trình thủy lợi số 32/2001/PL- UBTVQH10 ngày 04/4/2001
1997	Decree	Decree No. 50-CP of May 10, 1997 of the Government promulgating the Regulation on establishment and operation of the Local Flood and Storm Fund	Nghị định của chính phủ số 50/CP ngày 10 tháng 5 năm 1997 của Chính phủ ban hành quy chế thành lập và hoạt động của quỹ phòng, chống lụt, bão của địa phương
2002	Decree	Decree No. 71/2002/ ND-CP, detailing the implementation of a number of articles of the Ordinance on the State of emergency in case of great disaster or dangerous epidemics, issued by the Government on 23th July 2002	Nghị định số 71/2002/NĐ-CP quy định chi tiết thi hành một số điều của Pháp lệnh Tình trạng khẩn cấp trong trường hợp có thảm hoạ lớn, dịch bệnh nguy hiểm, do Chính phủ ban hành ngày 23/7/2002
2003	Decree	Decree 143/2003/NĐ-CP dated 28/11/2003 detailing the implementation of a number of articles of the Ordinance on the Management of Irrigation and Drainage Structures	Nghị định số 143/2003/NĐ-CP ngày 28 tháng 11 năm 2003 của Chính phủ Quy định chi tiết thi hành một số điều của Pháp lệnh Khai thác và bảo vệ công trình thuỷ lợi
2006	Decree	Decree No. 08/2006/ND-CP promulgated by the Prime Minister dated 16th January 2006 detailing a number of articles of the Ordinance on Flood and Storm Prevention and Control, which was amended and supplemented on 24 August 2000	Nghị định số 08/2006/ND-CP quy định chi tiết việc thi hành Pháp lệnh phòng chống lụt bão, do Chính phủ ban hành ngày 20/3/1993, đã được sửa đổi, bổ sung ngày 24/8/2000, bởi Nghị định 08/2006/ NĐ-CP ban hành ngày 16/1/2006
2007	Decree	Decree No. 129/2007/NĐ-CP dated 2/8/2007 promulgated by the Cabinet on provisions of administrative sanctions in the dyke offends.	Nghị định số 129/2007/NĐ-CP ngày 02 tháng 8 năm 2007 của Chính phủ Quy định xử phạt vi phạm hành chính về đê điều
2010	Decree	Decree No. 14/2010/NĐ-CP dated 27/2/2010 defines the	Nghị định số 14/2010/NĐ-CP ngày 27 tháng 02 năm 2010

		organisation, duties, powers and coordination mechanisms of the Steering Committee for Flood and Storm Central, Steering Committee for Flood and Storm and search and rescue Ministries, branches and localities	của Chính phủ Quy định về tổ chức, nhiệm vụ, quyền hạn và cơ chế phối hợp của Ban Chỉ đạo phòng, chống lụt, bão Trung ương, Ban Chỉ huy phòng, chống lụt, bão và tìm kiếm cứu nạn các Bộ, ngành và địa phương
2010	Decree	Decree No. 04/2010/NĐ-CP dated 15/1/2010 on provisions of administrative sanctions in the flood and storm prevention and control.	Nghị định số 04/2010/NĐ-CP ngày 15 tháng 01 năm 2010 của Chính phủ Quy định xử phạt vi phạm hành chính trong lĩnh vực phòng, chống lụt, bão
2006	Decision	Decision No. 46/2006/ QD-TTg approving the scheme on the general planning for the search and rescue domain up to 2015, with a vision to 2020, promulgated by the Prime minister on 28th Feb 2006	Quyết định số 46/2006/QĐ-TTg về việc phê duyệt Đề án Quy hoạch tổng thể lĩnh vực tìm kiếm cứu nạn đến năm 2015, tầm nhìn 2020, do Thủ tướng Chính phủ ban hành ngày 28/2/2006
2007	Decision	Decision 172/2007/ QĐ-TTg approving the National strategy for natural disaster prevention, response and mitigation to 2020, promulgated by the Prime Minister on 11th November 2007	Quyết định , số 172/2007/QĐ-TTg về việc phê duyệt Chiến lược quốc gia phòng chống và giảm nhẹ thiên tai đến 2020, do Thủ tướng chính phủ ban hành ngày 16 tháng 11 năm 2007
2008	Decision	Decision No. 118/2008/QD-TTg promulgating the Regulation on financial management of search, rescue, salvage and response to natural disasters and catastrophes, by the Prime Minister on 27th August 2008,	Quyết định số 118/2008/QĐ-TTg ngày 27/8/2008 của Thủ tướng chính phủ ban hành Quy chế quản lý tài chính đối với hoạt động tìm kiếm cứu nạn, cứu hộ, ứng phó thiên tai,thảm hoạ.
2008	Decision	Decision No. 158/2008/QĐ-TTg approving the National Core Programme on Climate Change, promulgated by the Prime Minister on 2nd February 2008	Quyết định số 158/2008/QĐ-TTg về việc phê duyệt Chương trình mục tiêu quốc gia về biến đổi khí hậu, do Thủ tướng Chính phủ ban hành ngày 02/02/2008
2009	Decision	Decision No. 76/2009/ QD-TTg on strengthening the National Committee for search and rescue and organisational system of search and rescue of Ministries and Provinces,	Quyết định 76/2009/QD-TTg về việc kiện toàn uỷ ban quốc gia tìm kiếm cứu nạn và hệ thống tổ chức tìm kiếm cứu nạn các bộ ngành TW và địa phương, do Thủ tướng Chính

		promulgated by the Prime Minister on 11th May 2009	phủ ban hành ngày 11/05/2009
2009	Decision	Decision No. 76/2009/ QD-TTg promulgated by the Prime Minister on mechanisms and policies for supporting crop seeds, livestock, fisheries to areas damaged by natural disasters and diseases.	Quyết định 142/2009/QĐ-TTg của Thủ tướng Chính phủ về cơ chế, chính sách hỗ trợ giống cây trồng, vật nuôi, thủy sản để khôi phục sản xuất vùng bị thiệt hại do thiên tai, dịch bệnh.
2009	Decision	Decision 1002/QD-TTg dated 18/2/2009 promulgated by the Prime Ministe on approving the community awareness raising and community-based disaster risk management (CBDRM) programme.	Quyết định số 1002/QĐ-TTg ngày 13 tháng 7 năm 2009 của Thủ tướng Chính phủ về việc phê duyệt Đề án "Nâng cao nhận thức cộng đồng và quản lý rủi ro thiên tai dựa vào cộng đồng"
2011	Decision	Decision No. 17/2011/QD-TTg promulgated by prime Minister on the warning for tropical depression, storms and flooding	Quyết định 17/2011/QĐ-TTg về Quy chế báo áp thấp nhiệt đới, bão, lũ do Thủ tướng Chính phủ ban hành
2006	Regulation	Regulation on Earthquake Announcements and Tsunami Warning, promulgated together with Decision No.264/2006/QD-TTg by the Prime Minister on 16th November 2006	Quy chế báo tin động đất, cảnh báo sóng thần, ban hành kèm theo Quyết định số 264/2006/QĐ-TTg của Thủ tướng Chính phủ ngày 16/11/2006
2006	Regulation	Regulation on announcement of tropical depressions, typhoons, hurricanes and floods, promulgated together with Decision No.245/2006/QD-TTg of the Prime Minister on 27th October 2006	Quy chế báo áp thấp nhiệt đới, bão, lũ, ban hành kèm theo Quyết định số 245/2006/QĐ-TTg của Thủ tướng Chính phủ ngày 27/10/2006

Appendix D: Research findings and recommendations for flood management

Category	Current situation	Research findings	Recommendations
Leadership			
Research agenda	Agenda determined by central government	Mismatch between priorities at different levels of government (e.g. central, provincial and local)	Research agenda reflecting the needs of all of society
Research implementation	Often sub-contracted to research institutes, universities and consulting firms	Organisations have a proprietary attitude to research results and raw data	Improved transparency and access to government funded research
Technical			
Data			
Compatibility	Data are collected and used differently by institutions in various ministries and government levels	Data are difficult to aggregate to study interdisciplinary problems	Improve data design and transferability
Storage	Data are stored with many government departments/agencies (e.g. flood marks stored by the Central Committee for Flood and Storm Control (CCFSC), the Provincial Committee for Flood and Storm Control (PCFSC) and Ministry of Science and Technology (MOST) and research institutes)	Storage not centralised so hindered the research and left gaps	Establish a comprehensive and standardised data system for natural disaster risk management
Updating	Not regularly updated (e.g. land use data)	Insufficient up-to-date information for decision making	Regular data updates
Quality	Incomplete, inconsistent and unreliable	Better data at central than provincial and local levels	Improve, standardise and decentralise data collection and distribution

Category	Current situation	Research findings	Recommendations
Availability	Limited availability for research and decision making (e.g. satellite image and historical hydraulic data)	Limited technical flood risk analyses	Make data easily accessible
Use of current technology	Limited adoption of current technology at provincial government and non-existent at local government levels.	Investment in current technology is constrained by insufficient financial resources, consequently; – Mismatched technologies amongst departments – Dated systems – Contracts to third parties	Develop strategies to standardise technologies through government departments To increase the use of technical analyses to inform decision making
Training and capacity building	Identified gaps in knowledge and skills, particularly at the local government levels. Local officials are dependent upon their superiors' instructions and experiences for decision making	Inadequate training and expertise at provincial and local levels regarding advanced technologies (e.g. GIS analysis). Ill-informed decisions made without reference to technical analyses. Officials' responsibilities often unclear resulting in wasted time and resources.	Implement a programme to develop technology capacity among staff Develop leadership and accountability metrics
Economic			
Data			
Collection	Whilst most economic data are robust, the exception seems to be flood damage data at all levels of government	Missing and inadequate data	Improve data design and transferability
Storage	Flood damage data are stored by CCFSC and DCFSC	Storage not centralised preventing sound research	Establish a standardised comprehensive data system for natural disaster risk management

Category	Current situation	Research findings	Recommendations
Quality	Flood damage data are inconsistent and unreliable at all government levels	Can lead to incorrect or exaggerated economic losses at the provincial and local levels	Improve the quality and reliability of the data
Availability	Limited availability for research and decision making (e.g. satellite image and historical hydraulic data)	Limited economic flood damage analyses	Make data easily accessible
Research capacity	Provincial and local government officials lack knowledge, practice and skills in estimation of flood risk damage and economic analyses.	Insufficient economic analyses on agricultural flood damage available to inform decision making.	Provide training on agricultural economics theory, policy and evaluation
Applied economic research	Decision making heavily influenced by social and political factors rather than by economic analyses.	Inaccurate and inappropriate resources are allocated by the government towards agricultural flood relief and recovery	Improve accountability and transparency for allocation of resources. Adopt pre-established agricultural flood damage based on potential susceptibility
Institutional arrangement			
Policies	Top-down approach with extensive, fragmented and overlapping policies Lack of criteria for determining and responding to different levels of extreme flooding	Difficult for policies to be implemented effectively Increase flood damage resulting insufficient information for public awareness and respond to extreme flooding	Shift to include bottom-up approaches and needs in flood management policies To develop national and provincial policies reflecting all stakeholders' needs
Mitigation	Too much emphasis on central and provincial governments' reliance on infrastructure for flood control and management	Expensive and missed opportunities to take advantages of non-structural measures (e.g. land use planning)	Balance structural and non-structural measure. Improve local land use planning and implementation
Preparedness	Emphasis on public	Policies do not	Developing an

Category	Current situation	Research findings	Recommendations
and response	awareness through media before flood season. Encourage early harvest to avoid flood damage	integrate different phases of the flood cycle (before, during and after flood event) Insufficient resources and supplies for post flood recovery	emergency operations plan that addresses identified hazards, risks, and response measures Identifying resources and supplies that may be required in an emergency and recovery
Farm level support	Insufficient and inappropriate seeds, breeding and funding support for recovery	Recovery was delayed and insufficient due to ineffective response by local governments	Design a policy that responds appropriately to stakeholders' needs
Organisations			
National	CCFSC (chaired by Minister of Ministry of Agriculture and Rural Development (MARD)) directs the preparation, implementation annual plans and provide solutions for flood management. MARD also coordinates flood management activities through providing guidance and support for policies implementation to lower government levels Each of other ministries also established its own committees for flood and storm control Overlapping and conflict of authorities among ministries (MARD responsible for flood management, the Ministry of Industry and Trade (MOIT) in charge with hydro-power and the Ministry of Natural Resources and Environment (MONRE) accountable for water resources management)	Top-down approach hinders clear separation of responsibilities, coordination and allocation between government agencies Lack of uniform response to flood management that results poor linkages between the ministries as well as between both central and local government authorities (e.g. MARD, MOIT, MONRE and the Provincial Department of Agriculture and Rural Development (DARD))	Clarify roles and responsibilities of both departments and individuals Improve inter-ministerial coordination at all levels
Provincial	PCFSC commands and DARD coordinates flood	Provincial government tend to	Improve flood management capacity

Category	Current situation	Research findings	Recommendations
	management activities DARD implements most of mitigation measures (focus on flood control structures) assignments assigned by central government	rely heavily upon central guidance and financial resources for flood management. Little knowledge of non-structural approaches	and practice for provincial authorities through providing more flexibility and administrative autonomy to get things done quickly and effectively without involving too much bureaucracy
Local	District authorities and provincial authorities are assigned the same functions Commune level responses are limited, by law, to non-structural local support Local authorities are impotent to flood management resulting insufficiency human resources, skills and budgets	This creates duplication and confusion, local needs are often not met	Clarify roles and responsibilities of both departments and individuals
Social	The Red Cross, Fatherland Front, Young Union and other organisations and volunteers respond independently to flood events	This creates duplication and confusion, local needs are often not met	Establish a strategy that enables social organisations to respond more effectively to flood emergency and recovery phases
Capacity building and training	Poor decision making mechanisms and insufficient information for decision making Lack of leadership and accountability at local levels	This hinders timely and effective implementation of flood risk management policies Loss of public confidence in government leadership Poor leadership at a high level has a cascading effect	Develop clear decision making mechanisms and improve leadership. Raise awareness of both the impact and the consequences of insufficient leadership capacity and institute educational programmes to address this shortcoming
Mobilising resources	District-level disaster response budgets are	Insufficient resources are	Employ *ex-ante* and *ex-post* evaluation

Category	Current situation	Research findings	Recommendations
	sourced, and if insufficient, supplemented by central government Because of their community-based networks, Red Cross and Fatherland Front mobilise public sector resources and allocate them to flood victims	allocated for post-flood recovery	methods to ensure resource allocation and distribution are efficient and equitable
Networking	Government agencies cooperate with scientific institutions mainly via contracts No official sharing (network/database) of information	Available information is often incomplete and of variable quality	Set up a network and pipeline for information flow between researchers, educators, agricultural planners and flood managers Provide facilitated conferences, workshops and forums

Appendix E: Human ethics approval

MASSEY UNIVERSITY

24 June 2011

Vu Ngoc Chau
PhD Student, Ecology Group
Institute of Natural Resources
PN624

Dear Vu

Re: The Implication of Climate Change Impacts on Vietnam Agriculture Production in Vietnam – Quang Nam Province Case Study

Thank you for your Low Risk Notification which was received on 16 June 2011.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

> *"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*
>
> *If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone 06 350 5249, e-mail humanethics@massey.ac.nz".*

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

John G O'Neill (Professor)
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Massey University Human Ethics Committee
Accredited by the Health Research Council