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VIET NAM SPECIAL REPORT ON MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION

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Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation

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PREFACE

(translated)

Viet Nam is one of the countries most affected by natural disasters and climate change. Storms and floods are the most frequent and severe natural disasters affecting Viet Nam. Viet Nam is suffering 6 to 7 typhoons every year, on average. Between 1990 and 2010, 74 floods have occurred in the river systems of Viet Nam. Severe drought, saline water intrusion, landslides and other natural disasters are hindering the development of Viet Nam. Extreme disasters are more frequent in recent years, causing more damage to people and impacting significantly on the economy.

The "Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (SREX Viet Nam) was produced by the Institute of Meteorology, Hydrology and Climate Change (Ministry of Natural Resources and Environment) and the United Nations Development Programme of the (UNDP), with the participation of the National University of Hanoi; Water Resources University Hanoi; Can Tho University; Hue University; Department of Meteorology, Hydrology and Climate Change; National Centre for Hydro-meteorological Forecasting; Non-Governmental Organizations; and local and international experts on disaster risk management and climate change adaptation.

The report assesses extreme events and their impact on the natural environment, social economic development and sustainable development of Viet Nam; the future changes in extreme climate events due to climate change; interactions between climatic, environmental and human factors; and promote adaptation to climate change and management of risks of disaster and extreme events in Viet Nam.

The Ministry of Natural Resources and Environment is very pleased to introduce SREX Viet Nam, especially the summary for policy makers, as a basis for guidance to ministries, sectors and localities who are building and implementing effective response plans for good management of disaster risks and climate change adaptation.

Minister
Ministry of Natural Resources and Environment

[signed]

Nguyễn Minh Quang

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GreenID

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Centre for Social Research and Development (CSRD)

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SECTION 1.

SUMMARY FOR POLICYMAKERS

SPM

Summary for Policy Makers

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CONTENTS

A. Background

This Summary for Policy Makers (SPM) gives the main findings of the *Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* ("SREX Viet Nam"). SREX Viet Nam builds on the Intergovernmental Panel on Climate Change's *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* ("SREX") (IPCC, 2012a). Likewise, this SPM builds on the SPM in SREX (IPCC, 2012b).

SREX Viet Nam analyses the Vietnamese situation in light of the global SREX findings. SREX Viet Nam assesses the Vietnamese literature on climate change and extreme weather and climate events ('climate extremes') and the implications of these events for society and sustainable development. It assesses the interaction of climatic, environmental, and human factors that can lead to impacts and disasters, and options for managing the risks patterns, in order to advance adaptation to climate change and the management of extreme events and disasters in Viet Nam.

The main concepts and definitions used in SREX Viet Nam are given in Box SPM-1.

The character and severity of impacts from climate extremes depends on the extremes and also on exposure and vulnerability. In this report, adverse impacts are considered disasters when they produce widespread damage and cause severe alterations in the normal functioning of communities or societies. Climate extremes, exposure, and vulnerability are influenced by a wide range of factors, including anthropogenic climate change, natural climate variability, and socioeconomic development (Figure SPM-1). Disaster risk management and adaptation to climate change focus on reducing exposure and vulnerability and increasing resilience to the potential adverse impacts of climate extremes, even though risks cannot fully be eliminated (Figure SPM-2). Through good management of ecological systems, human systems and other development processes the risks and the impact of weather and climate extremes that actually happen can be mitigated. (Chapter 4, 5, 6, 8)

This report integrates perspectives from different communities in Viet Nam, including climatologists, researchers of climate impacts and adaptation to climate change, and disaster risk management practitioners. Each community brings different viewpoints and vocabularies, and SREX Viet Nam attempts to agree and unify some of the concepts.

Box SPM-1. The main concepts used in SREX Viet Nam

Climate Change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate extreme (extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Exposure (to climate hazards) refers to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage. (IPCC, 2012a page 32).

Vulnerability is the propensity or predisposition to be adversely affected. Such predisposition constitutes an internal characteristic of the affected element. In the field of disaster risk, this includes the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events (Wisner và nnk, 2004). Vulnerability is a result of diverse historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes. (IPCC, 2012a page 31).

Disasters are severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012a page 31).

Disaster risk management (DRM) is defined in this report as the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC, 2012 page 34).

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2012a page 36).

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012 page 34).

Figure SPM-1. The principal concepts used in SREX Viet Nam

The report assesses how exposure and vulnerability to extreme climate events determine impacts and the likelihood of disasters (disaster risk).

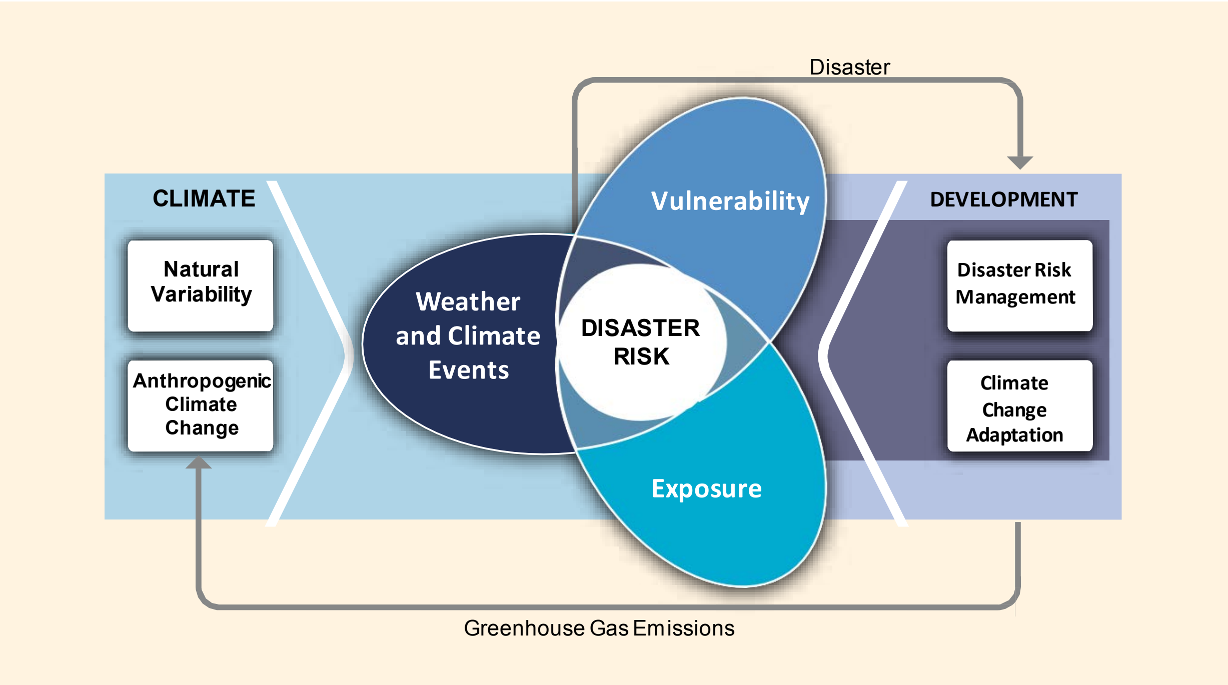
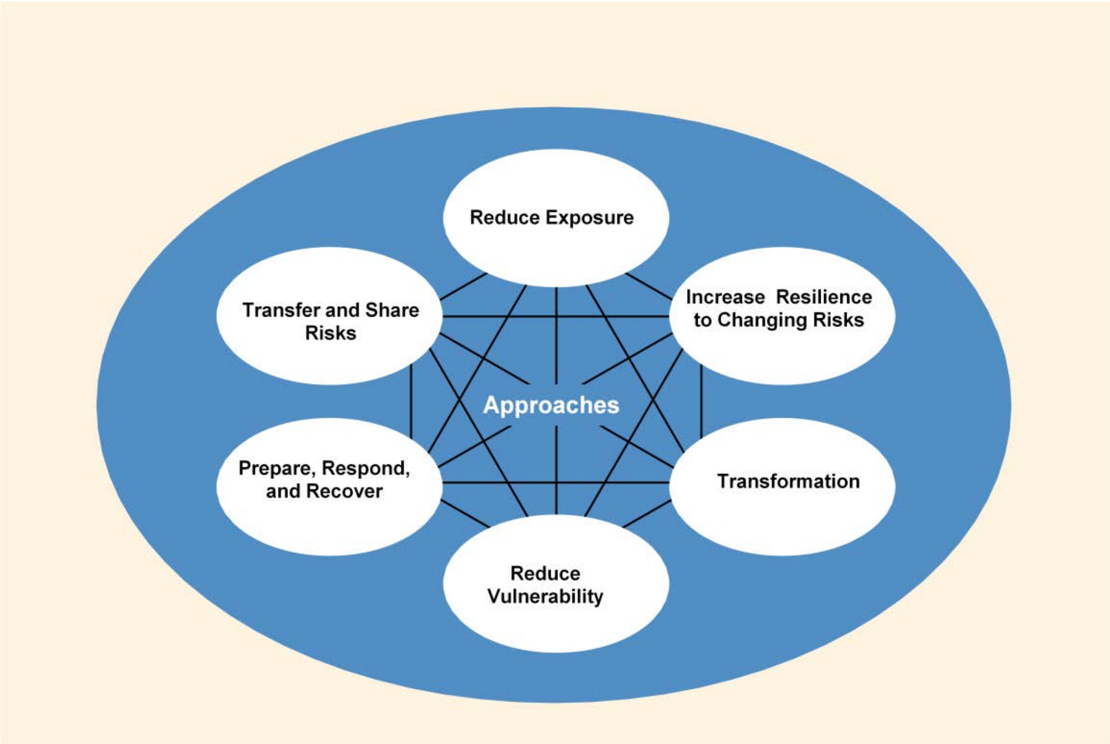


Figure SPM-2. Adaptation and Disaster Risk Management Approaches for reducing and managing disaster risk in a changing climate



Exposure and vulnerability are key determinants of disaster risk and of impacts when risk is realized. A typhoon can have very different impacts depending on where and when it makes landfall, as was demonstrated in 1997 when typhoon Linda exceptionally hit the southern part of the Mekong Delta and caused many casualties and major devastation (Section 9.2.1). Extreme impacts on human, ecological, or physical systems can result from individual extreme weather or climate events (Section 4.2.1). Extreme impacts can also result from non-extreme events where exposure and vulnerability are high or from a compounding of events or their impacts. For example, the phenomenon of prolonged heat combined with lack of rain can lead to drought (Ninh Thuan, Binh Thuan, Central Highlands ...) and forest fires (Northwest, Central Highlands, the South West ...) strongly harming many social-economic sectors, especially agriculture, and thereby making these entire regions vulnerable. The Mekong Delta region is under "double" threat because it is affected by climate change as well as upstream development including dams. Future dry season salt water intrusion into the Mekong Delta will be exacerbated by such development and sea level rise. (Section 4.2.1)

Extreme and non-extreme weather or climate events affect vulnerability to future extreme events by modifying resilience, coping capacity, and adaptive capacity. (Section 1.1.2, 2.4.2) In particular, the cumulative effects of disasters at local or sub-national levels can substantially affect livelihood options and resources and has become for example one of the (new) reasons for out-migration from certain sites in the Mekong Delta, as floods, salt water intrusion and river bank erosion affect livelihoods and threaten property, homes and lives. (Section 5.1)

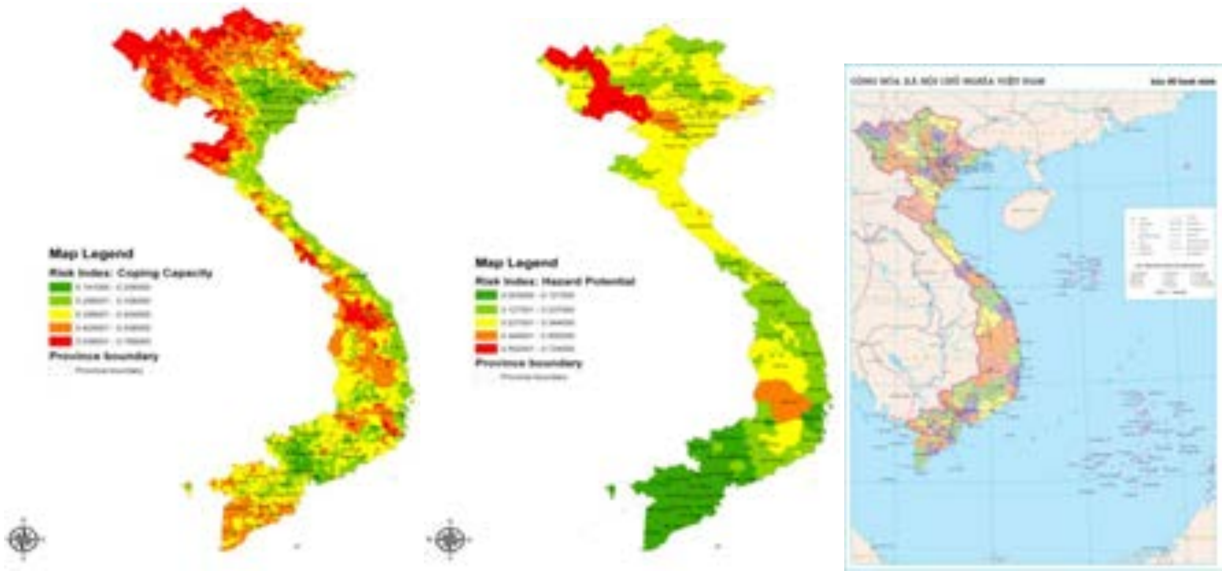
A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events. Changes in extremes can be linked to changes in the mean, variance, or shape of probability distributions, or all of these. Some climate extremes (such as droughts in the South Central region) may be the result of an accumulation of weather or climate events that are not extreme when considered independently. Many extreme weather and climate events continue to be the result of natural climate variability. Natural variability will be an important factor in shaping future extremes in addition to the effect of anthropogenic changes in climate. In general, the extreme events are not simple and not only the effect of anthropogenic climate change, because these events could still happen in the absence of climate change. (Section 1.2.2.2).

B. Observations of Exposure, Vulnerability, Climate Extremes, Impacts, and Disaster Losses

Table SPM-1 presents examples in Viet Nam of observed and projected trends in exposure to hazards, vulnerabilities and climate extremes, and how risks have been addressed, and gives information on strategies, policies and measures for risk management and adaptation. (Chapter 1, 2, 3, 4, 5, 6, 8, 9)

The impacts of climate extremes and the potential for disasters depend on the extreme climate events, the level of exposure to hazards, and the vulnerability of human and natural systems. Observed changes in climate extremes reflect the influence of anthropogenic climate change in addition to natural climate variability, with changes in exposure and vulnerability influenced by both climatic and non-climatic factors. (Figure SPM-3) (Section 4.2.2)

Figure SPM-3. Risk index: (a) the capacity to cope with natural disasters; and (b) potential hazards of Viet Nam



a) b)

Exposure and Vulnerability

Exposure and vulnerability are dynamic, varying across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Individuals and communities are differentially exposed and vulnerable based on inequalities expressed through levels of wealth and education, disability, and health status, as well as gender, age, class, and other social and cultural characteristics. (Section 1.1.2, 2.2, 2.5, 4.2.1, 5.5.1, 8.2.3, 9.2.11.2)

Settlement patterns, urbanization, and changes in socioeconomic conditions have all influenced observed trends in exposure and vulnerability to climate extremes. For example, coastal settlements, including the central coast region, the Mekong Delta and settlements in the Northern Mountains and Central Highlands regions are particularly exposed and vulnerable to climate extremes. Rapid growth of cities and towns is leading to vulnerable urban communities, for example in Ho Chi Minh City. (Section 2.5.1, 8.5.2.1)

Climate Extremes and Impacts

According to SREX (IPCC, 2012b) there is evidence that some extremes have changed as a result of anthropogenic influences, including increases in atmospheric concentrations of greenhouse gases. It is *likely* that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale. There is *medium confidence* that anthropogenic influences have contributed to intensification of extreme precipitation at the global scale. It is *likely* that there has been an anthropogenic influence on increasing extreme coastal high water due to an increase in mean sea level.

The uncertainties in the historical tropical cyclone records, the incomplete understanding of the physical mechanisms linking tropical cyclone metrics to climate change, and the degree of tropical cyclone variability provide only *low confidence* for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences. Attribution of single extreme events to anthropogenic climate change is challenging.

There is evidence from observations in Viet Nam of changes in climate extremes. However, extreme events are rare, which means there are few data available to assess changes in their frequency or intensity. The more rare the event the more difficult it is to identify long-term changes. The following provides details for specific climate extremes from observations in Viet Nam. (Chapter 3)

There has been a **significant decrease** nationwide in the number of **cold days and nights** in the 1961-2010 period, particularly in the Northern region and the Central Highlands. Data from 1981 to 2009 indicate that hoar frost occurred later and lasted shorter and the number of hoar frost days decreased rapidly in the last decade. **The number of freezing and damaging cold days is decreasing, especially in the last two decades. However, cold weather spells have shown complex change and strong fluctuations from year to year.** In particular, in recent years freezing cold spells appeared with fairly low temperatures, including a record cold spell. Ice and snow occurred with greater frequency in the higher mountains in the North such as Sa Pa, Mau Son, etc. (Chapter 3).

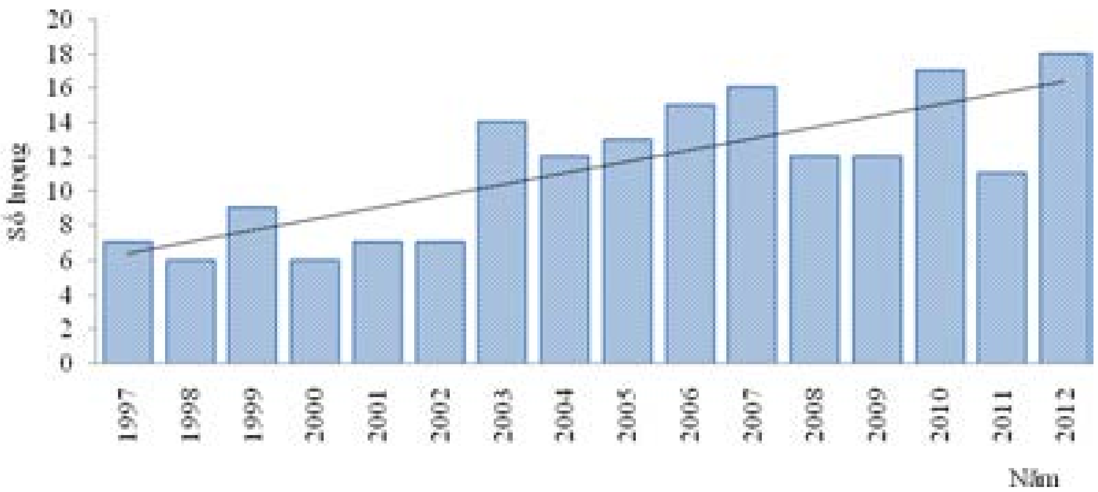
The number of **hot days** increased in most observation stations, especially in the North-East, Northern Delta, and the Central Highlands, but decreased in some stations in the North-West, South Central and the Southern regions. The number of heatwaves increased nationally (Chapter 3; Figure SPM-4)

Extreme rainfall events show an upward trend over the period of 1961-2010 in Viet Nam. There is a decrease in the North-East and Northern Delta regions, but increase in Central and South Central provinces. Extreme rainfall mainly occurred in the period April to July, though somewhat earlier in the North and later in the South. (Section 3.3.2)

There is medium confidence that some regions of the world have experienced more intense and longer **droughts**. In Viet Nam the number of consecutive dry days increased over the period 1961-2010 in the northern regions, while this decreased in the southern regions (Section 3.5.2). The total precipitation also decreased in the northern regions and increased in the southern regions. However, in the 1996-2010 period, the summer monsoon onset was earlier by 10-15 days compared to the period 1981-1995, leading to increase in early rains in May in the southern regions in particular, whereas the rainfall in June in the southern regions decreased. (Section 3.4.1)

The risk of **salt water intrusion** is increasing, especially in the Mekong Delta. As a result of rising sea levels, drought and steadily increasing consecutive dry days as well as the changing water resources due to climate change in the upstream areas, saline water is penetrating deeper inland in the downstream areas of the Red river, Thai Binh and Dong Nai river and the Mekong river basin. At the end of the 21st century, the inland penetration depth corresponding to 1 ‰ salinity can become more than 20 km on the Dong Nai, Tien and Hau rivers, and above approximately 10 km in the Thai Binh river. (Section 4.2.1)

Figure SPM-4. Number of heat waves observed in Viet Nam



There is globally low confidence in any observed long-term (i.e. 40 years or more) increases in tropical **typhoon activity** (i.e., intensity, frequency, duration). In Viet Nam, over the period 1961-2010, there was no evident variability in the frequency of tropical cyclones including typhoons and tropical depressions making landfall. However, typhoons of medium strength tended to decrease and those with very high intensity increased. The typhoon season at present tends to end later than before and more landfalls occurred in the southern regions in recent years. (Section 3.4.2)

Globally there is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of **floods**, because the available records of floods are limited, and because of the effects of changes in land use and engineering, so that the effects of climate change are often unclear. Records of most rivers in North and in North Central Viet Nam in the past 3 decades show an increase in the number of flood peaks, except peaks in the lower stretches of the Red River and Thai Binh River, which decreased due to major reservoirs that control floods. Records from rivers in Central Viet Nam in the past 3 decades also show an increase in the number of flood peaks per year, except in the downstream stretches of the Ba River, probably due to an upstream reservoir that reduces flood levels. There was a considerable increase of the number of flood peaks in the Dong Nai river in the South East in the past 3 decades, which is mainly explained by infrastructure changes in the river basin. The water level in the Mekong River in the past 30 years also suggest a marked increase of flood heights which is associated with climate change, but there are also major dam building plans that could reduce future flood peaks. (Section 3.5.4)

It is likely that there has been an increase in **extreme coastal high water** related to increases in mean sea level, across the world and also in Viet Nam. According to records in Viet Nam mean sea level is rising in the East Sea and along Viet Nam's coast at a rate of about 2.8 mm per year, although satellite observations indicate an average rise in the vicinity of Viet Nam of a rise of 4.7 mm/year in the 1993-2010 period. Mean sea level rise observations suggest that the rise is strongest in the Central and South-west coastal areas. The annual highest sea levels observed, which include effects of the tide, typhoons and surf is increasing at most coastal observation stations. Recent studies show that the highest sea water levels tend to fluctuate at a higher rate in most stations and extreme sea level (storm surges due to a combination of storm and spring tide) are projected to exceed the current design heights of sea dyke systems more frequently. (Section 3.5.6)

Disaster Losses

Economic losses from weather- and climate-related disasters have increased, but with large spatial and inter-annual variability. Global weather- and climate-related disaster losses reported over the last few decades reflect mainly monetized direct damages to assets, and are unequally distributed. Estimates of annual GDP losses and casualties to climate related disasters have been included in a global index in which Viet Nam came seventh in the period 1994-2013 (Section 2.2.2). Loss estimates are low estimates because many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are difficult to value and monetize, and thus they are poorly reflected in estimates of losses. Impacts on the informal or undocumented economy as well as indirect economic effects can be very important in some areas and sectors, but are generally not counted either. (Section 4.1, 4.2.2, 4.3.5)

Increasing exposure of people and economic assets has been the major cause of long-term increases in economic losses from weather- and climate-related disasters. This is also happening in Viet Nam as cities and rural settlements, coastal tourism and industrial zones, transport infrastructure and aquaculture are growing in zones where they are exposed to storms and floods in particular. **Long-term trends in economic disaster losses adjusted for wealth and population increases have not been clearly attributed to climate change, but a contribution by climate change has not been excluded.** In particular in developing countries such as Viet Nam the economic value of exposed assets is increasing rapidly, whereas changes in extremes are comparatively slow and the effects of climate change on climate extremes are not yet fully clear. (Section 3.1).

C. Disaster Risk Management and Adaptation to Climate Change: Past Experience with Climate Extremes

Past experience with climate extremes contributes to understanding of effective disaster risk management (DRM) and adaptation approaches to manage risks.

The severity of the impacts of climate extremes depends strongly on the level of the exposure and vulnerability to these extremes. (Section 2.2.2) Understanding the multi-faceted nature of both exposure and vulnerability is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies. Vulnerability reduction is a core common element of disaster risk management in Viet Nam, as witnessed by the National Programme on Community Based Disaster Risk Management (CBDRM) (Section 5.4, 5.6.2, 6.3.1.2, 6.5.1.2). Reduction in exposure is a core element of existing policies of for example resettlement of people living in flood or erosion prone sites (Section 2.5.2, 5.2.2).

Development practice, policy, and outcomes are critical to shaping disaster risk, which may be increased by shortcomings in development. (Section 2.2.2, 2.5) High exposure and vulnerability can be an outcome of for example rapid and unplanned urbanization in hazardous areas, and scarcity of livelihood options for the poor. Coastal and low land towns and cities need to consider redirecting urban development into less hazardous areas. Many resettlement areas and resettled people may need to be moved again if the new places do not ensure sustainable livelihoods and the environment is not stable under the impact of natural disasters (Section 1.3.2, 4.3.4.1). Effective disaster risk reduction requires integration of DRM and climate change adaptation into national social-economic development strategies and plans, as well as sectoral plans, and implementation of those strategies and plans must support vulnerable areas and groups. (Section 6.3)

The management of disasters and climate extremes at the local level is critical for enhancing resilience, adaptation, and recovery from extreme events that materialized. However, data on disasters and disaster risk reduction are lacking at the local level, which can constrain improvements in local vulnerability reduction. (Section 5.7) The national DRM and climate change adaptation systems and programmes must explicitly integrate knowledge of and uncertainties in projected changes in exposure, vulnerability, and climate extremes. Most provinces have developed action plans to respond to climate change, which refer to the integration of climate change into the planning of local socio-economic development. For example, An Giang province, where river water enters the Vietnamese Mekong Delta, is often affected by floods and it succeeded in integrating DRM with social and economic development policy, notably the programme to construct population clusters in the face of floods. This is appropriate policy and consistent practice in the Mekong Delta. Nghe An province developed guidance manuals for climate change adaptation, land use issues, gender and community development to ensure socio-economic development at the commune level organizations (Section 6.3.2.1).

Inequalities influence local coping and adaptive capacity, and pose disaster risk management and adaptation challenges from the local to the national level. Socio-economic inequalities and for example health-related differences, differences in access to livelihoods or land, and other factors determine vulnerabilities of households and communities (Section 5.5.1.1). Viet Nam faces challenges in assessing, understanding, and responding to projected changes in climatic extremes, for example as it has not yet fully integrated climate related vulnerabilities in policies and programmes for poverty reduction and the evolving social protection system. (Chapter 5, 8)

Post-disaster recovery and reconstruction provide an opportunity for reducing weather- and climate-related disaster risk and for improving adaptive capacity. Any effort to rebuild houses, reconstructing infrastructure, and rehabilitating livelihoods should avoid to recreate existing exposure, and should reduce vulnerabilities of people and communities, and contribute to long-term resilience and sustainable development. (Section 5.2.3).

Risk sharing and transfer mechanisms at local and national, as well as international scales can increase resilience to climate extremes. Mechanisms include informal and traditional risk sharing mechanisms, micro-insurance, insurance, and international reinsurance (Section 5.6.3, 7.4.4.2, 9.2.10.2). These mechanisms are linked to disaster risk reduction and climate change adaptation by providing means to finance relief, recovery of livelihoods, and reconstruction; reducing vulnerability; and providing knowledge and incentives for reducing risk. (Section 5.2.3).

Attention given to the temporal and spatial dynamics of exposure and vulnerability is important because design and implementation of adaptation and DRM strategies and policies can reduce risk in the short term, and must avoid increasing exposure and vulnerability over the longer term. For instance, dike systems can reduce flood exposure by offering immediate protection, but may also increase flooding in other parts (as is happening in the Mekong Delta), and because they offer a sense of safety they encourage settlement patterns that could increase risk in the long term (Section 2.6.2, 5.3.2).

DRM and adaptation to climate change in Viet Nam should be implemented in a 2-way approach: from the national level down to the local level; whilst simultaneously the specific local situation at the lower level should be reflected as the higher level adjusts the strategy. This two-way relationship must ensure that activities are most effective (Section 5.1).

Closer integration of DRM and climate change adaptation, along with the integration of both into national and local development policies and programmes, could provide benefits at all scales. (Section 5.4.2, 5.6.1, 6.3, 7.2.4, 8.6.2). Addressing social welfare, quality of life, infrastructure, and livelihoods, and incorporating a multi-hazards approach into planning and action for disasters in the short term, facilitates adaptation to climate extremes in the longer term, as is increasingly recognized internationally. Strategies and policies are more effective when they acknowledge multiple stressors, different prioritized values, and competing policy goals.

Viet Nam's DRM system is at the core of its capacity to meet the challenges of observed and projected trends in exposure, vulnerability, and weather and climate extremes, but it must reach out to other communities of practice to mainstream disaster risks and climate change adaptation. The national DRM system with the central committee for flood and storm control (CCFSC) and local committees for flood and storm control (CFSCs) comprise multiple actors from national and sub-national governments, including the Fatherland Front, the Viet Nam Women's Union and the Viet Nam Red Cross. There is also a community of practice on climate change adaptation but that is smaller and recently formed, including the establishment of the National Steering Committee on Climate Change. These systems must reach out to departments and agencies working on climate change, social protection, and for example resettlement, as well as the private sector, research bodies, and civil society including community-based organizations, who play differential but complementary roles to manage risk, according to their functions and capacities. (Chapter 5, 6)

Coordination of the implementation of DRM between sector ministries and localities still has limitations, lacking synchronized planning and timely adjustments, and lacking resource mobilization policies for disaster prevention and disaster reduction. There is a need to strengthen the operational coordination between sector ministries and localities, from policy formulation to implementation. (Section 6.2.5).

D. Future Climate Extremes, Impacts, and Disaster Losses

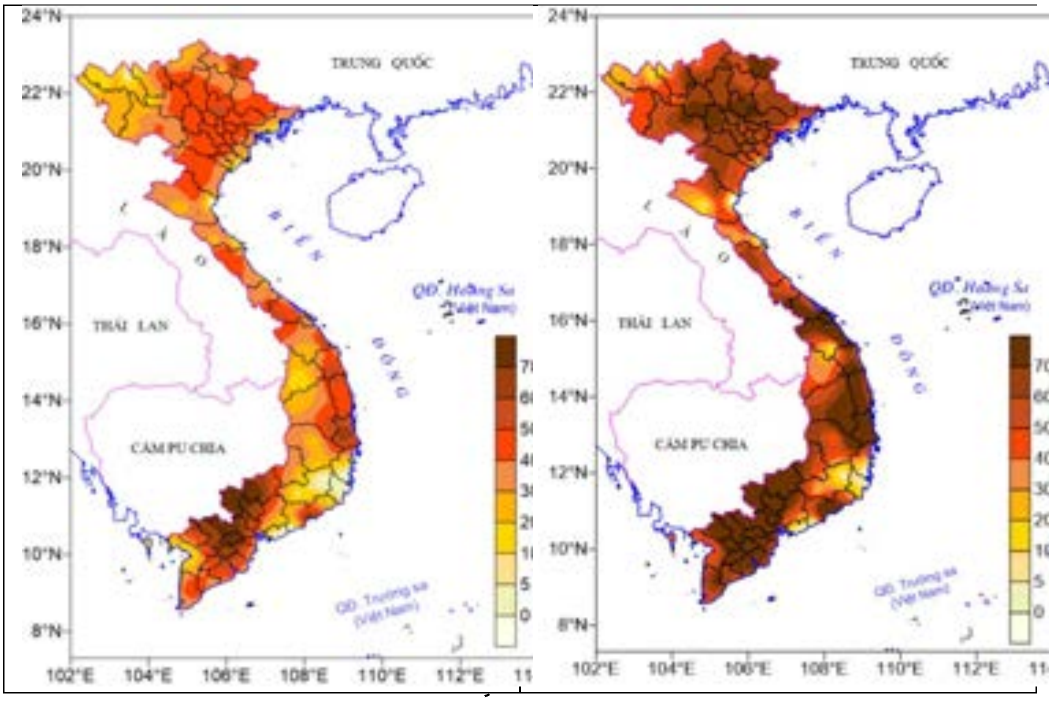
Changes in exposure, vulnerability, and climate extremes resulting from natural climate variability, anthropogenic climate change, and socioeconomic development can alter the impacts of climate extremes on natural and human systems and the potential for disasters.

Climate Extremes and Impacts

Confidence in projecting changes in the direction and magnitude of climate extremes depends on many factors, including the type of extreme, the region and season, the amount and quality of observational data, the level of understanding of the underlying processes, and the reliability of their simulation in models. Projected changes in climate extremes under different emissions scenarios generally do not strongly diverge in the coming two to three decades, and the climate change signals are relatively small compared to natural climate variability over this time frame. The projected changes by the end of the 21st century are more pronounced, but there are uncertainties associated with model uncertainty or the emissions scenarios used, depending on the extreme. The model assessments of projections are generally for the end of the 21st century and relative to the climate at the end of the 20th century. They are based on many data and in particular on modelling with the AGCM/MRI model (Japan), the PRECIS model of the Hadley Centre (United Kingdom), and the CCAM model of the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia). (Section 3.2)

The projected number of hot days and number of heat waves will increase in most areas, especially the Central region. According to the higher greenhouse gas concentrations scenario RCP 8.5, the number of hot days in the Southern region is projected to increase by the middle of the 21st century by 20-30 days compared to 1980-1999; and by the end of the 21st century the increase is in the range of 60-70 days in the North East, Northern Delta, Central, South Central and Southern regions, whereas other regions increase less. The number of heat waves (3 consecutive hot days) is expected to increase in most regions of Viet Nam by the end of the 21st century, especially in the Southern region and the and south of the Central Highlands, with an increase of 6 to 10 heat waves; in the remaining regions the expected increase is 2 to 6 heat waves. (Section 3.5.1) (Figure SPM-5).

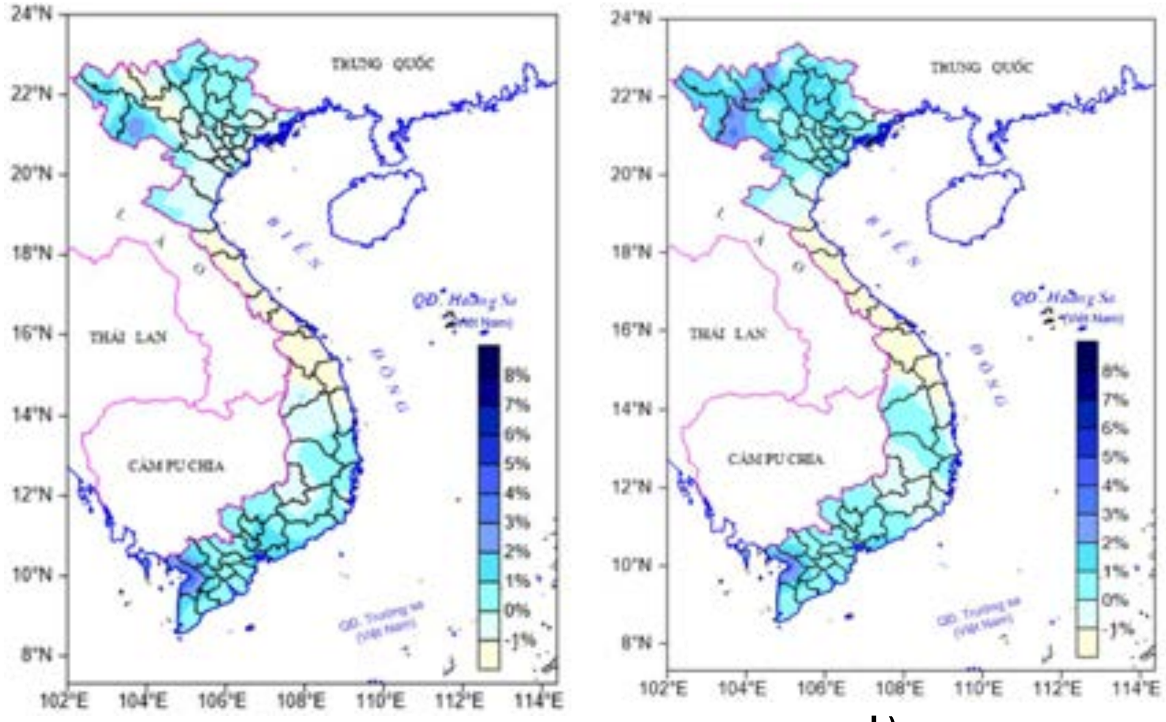
Figure SPM-5. Estimated change in number of hot days by the middle of the 21st century (left) and the end of the 21st century (right) compared to the 1980-1999 average



The frequency of projected heavy rainfall will increase in the 21st century in many parts of Viet Nam. Heavy rainfall will increase landslide risks in mountainous areas. According to observed data, the occurrence of heavy rainfall is increasing. The number of days of heavy rainfall shows a decreasing trend in the northern climate regions; but increased somewhat in the South and sharply in the South Central and Central Highlands regions. **Projected heavy rainfall:** the number of days with precipitation greater than 50 mm in the 21st century is expected to increase in the North and the

South, especially the North West region. The Central region shows a slightly downward trend (Section 3.5.3) (Figure SPM-6). Note that estimating future heavy rainfall is very difficult and the current results are uncertain. **Projected future extreme rainfall:** The model projections for the regional highest amount of rain for one day (RX1day) show an increase in most parts of the North West, North East and the Southern part of the Central Highlands and the Mekong Delta; and a reduction in the Northern Delta, North Central and South Central coast regions. However, if averaged over the whole territory, the degree of change is relatively small. The highest 5-day precipitation (RX5day) shows that increases can be expected notably in the southern Central Highlands (Section 3.3.2) (Figure SPM-7).

Figure SPM-6. Projected change in the number of rainy days over 50 mm (a) in the middle of the 21st century and (b) at the end of the 21st century

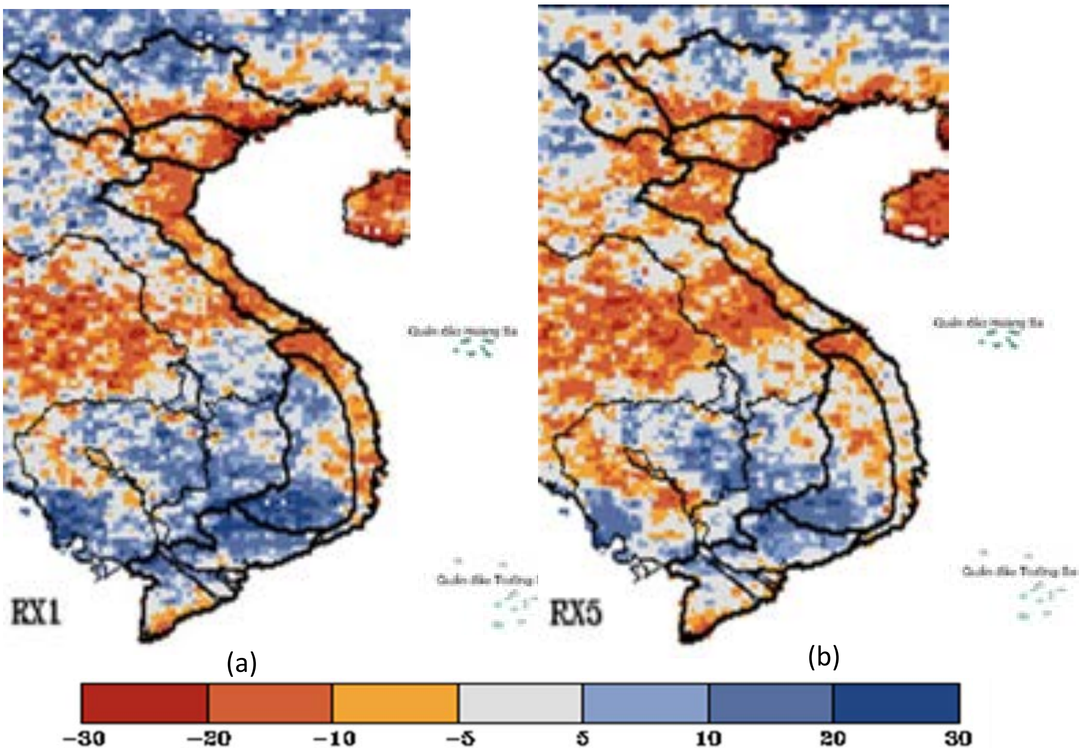


a) b)

The expected future change in rainfall and temperature leads to expected changes in floods, but there is a low level of confidence in predicting the change of river flooding as a result of changes in climate extremes, because socioeconomic changes such as dam construction will affect peak discharges. Floods in the country may however become increasingly frequent, severe, unusual, and with wider impact, sometimes covering a large area, even a region of the country. (Section 3.5.4)

Drought is likely to increase in the 21st century in some seasons and in most climate zones of Viet Nam, due to reduced precipitation and / or increased evaporation. Severe drought has appeared more often in many places, especially extremely harsh droughts; with the highest frequency occurring in Spring (from January to April) and the Summer-Autumn season (from May to August). Projections into the 21st century, based on model runs with the high-greenhouse gas concentrations scenario RCP 8.5, suggest that droughts may occur more often and longer in most climate zones of Viet Nam. (Section 3.5.2)

Figure SPM-7. Projected change in (a) one day highest rainfall (RX1), (b) 5 days highest rainfall (RX5), by the end of the 21st century under an high greenhouse gas concentrations scenario - RCP 8.5 (%)



The projected changes in the number of typhoons in the East sea that affect Viet Nam in the mid and late 21st century is uncertain. The frequency of storms could reduce but intensity could increase. **The number of strong typhoons is likely to increase.** The typhoon season is expected to end later and the landfall of storms tends to move southward. The wind speed of typhoons may increase slightly. (Section 3.4.2)

El Nino / La Nina phenomena impact strongly on the weather and climate in Viet Nam. According to records of ENSO events in the last 100 years, the frequency and intensity of El Nino and La Nina has shown an upward trend. Model projections into the 21st century suggest that the frequency of El Nino anomalies of ocean surface temperatures in the equatorial central Pacific region are likely to increase (Section 3.4.3).

It is very likely that average sea level rise will contribute to an increase in extreme coastal water levels in the future. Places that are currently experiencing adverse effects such as erosion and flooding will continue to be affected in the future due to rising sea levels. It is very likely that the rise in average sea level will increase extreme coastal water levels, and combined with the likelihood of an increase in maximum wind speed of typhoons, this is a particular threat for coastal areas. (Section 3.5.6).

Human Impacts and Disaster Losses

Extreme events will have greater impacts on sectors with closer links to climate, such as water, agriculture and food security, forestry, health, and tourism. However, climate change is in many instances only one of the drivers of future changes, and is not necessarily the most important driver at the local scale. Climate extremes are also expected to produce large impacts on infrastructure, although detailed analysis of potential and projected damages is still limited in Viet Nam. (Section 4.3.4, 5.2.3, 5.3.2)

The main drivers of future increases in economic losses due to climate extremes will be socioeconomic in nature. Climate extremes are only one of the factors that affect risks, but few studies have specifically quantified the effects of changes in population, exposure of people and assets, and vulnerability as determinants of loss. However, trends in human casualties and economic losses from natural disasters have been estimated over the past decades and indicate the seriousness of the situation in Viet Nam. (Section 2.2.2; Chapter 4, 5)

Increases in exposure will result in higher direct economic losses from tropical cyclones. These losses will also depend on future changes in the frequency and intensity of tropical cyclones. (Chapter 3)

Future losses from future floods in many locations will increase in the absence of additional protection measures. (Chapter 3, 4, 5)

Disasters associated with climate extremes influence population mobility and relocation, affecting host populations and the communities of origin. If disasters occur more frequently and/or with greater magnitude, some local areas will become increasingly marginal as places to live or in which to maintain livelihoods. In such cases, climate change may become the main determinant for migration and displacement and provide new pressures in areas of relocation. (Chapter 2, 4, 5).

E. Managing the Changing Risks of Climate Extremes and Disasters

Adaptation to climate change and DRM provide a range of complementary approaches for managing the risks of climate extremes and disasters (Figure SPM-2). The consideration of the broader challenge of sustainable development will help to effectively apply and combine the approaches.

Low-regrets measures provide benefits under current climate and different future climate change scenarios, and are important for addressing projected trends in exposure, vulnerability, and climate extremes. Many low-regrets strategies produce co-benefits, help address other development goals, such as improvements in livelihoods, human well-being and biodiversity conservation, and help minimize the scope for mal-adaptation. Potential low-regrets measures include further strengthening early warning systems; risk communication; sustainable land management, including land use planning; and ecosystem management and restoration. Other low-regrets measures include improvements to health surveillance, water supply, sanitation, and irrigation and drainage systems; climate-proofing of infrastructure; development and enforcement of building codes; and better education and awareness. (Chapter 4, 5, 6, 8, 9)

Effective risk management generally involves a portfolio of actions to reduce and transfer risk and to respond to extreme events and disasters, as opposed to a singular focus on any one action or type of action. Integrated approaches are more effective when they are informed by and customized to specific local circumstances. Successful strategies include a combination of hard infrastructure-based responses and soft solutions such as individual and institutional capacity building and ecosystem-based responses. (Chapter 4, 5, 8)

Multi-hazard risk management approaches provide opportunities to reduce complex and compound hazards. Considering multiple types of hazards reduces the likelihood that risk reduction efforts targeting one type of hazard will increase exposure and vulnerability to other hazards, in the present and future. (Chapter 8)

The support from international and regional mechanisms and policies offers opportunities for the implementation of DRM and adaptation to climate change in Viet Nam, but there are also barriers to legal, financial, technology transfer, disaster risk sharing, and dissemination of knowledge. Review of the opportunities, constraints and challenges of international policy, international finance and other issues will help provide an overview of the barriers, opportunities and options for DRM and climate change adaptation, internationally and in Viet Nam. (Section 7.4.2.4)

The cooperation and coordination among DRM and climate change adaptation agencies is critical, in order to formulate suitable policies and integrate them into strategies, master plans and development plans. DRM is coordinated in Viet Nam by the Central Committee for Flood and Storm Control, with a permanent agency in the Ministry of Agriculture and Rural Development. Meanwhile, the agency and the focal point for responses to climate change is in the Ministry of Natural Resources and Environment. DRM and climate change adaptation should both be integrated into policies and plans of Viet Nam and it is necessary to do further research to better harmonize international, national, sectoral and local interests. (Section 7.5)

Opportunities exist to create synergies in international finance for DRM and adaptation to climate change, but these have not yet been fully realized. International funding for disaster risk reduction remains relatively low as compared to the scale of spending on international humanitarian response, and DRM is not benefiting from the larger portion of adaptation funding allocated under the Support Programme to Respond to Climate Change (SPRCC) in Viet Nam (Section 7.4.2.4). Technology transfer and cooperation to advance disaster risk reduction and climate change adaptation are important. Coordination on technology transfer and cooperation between the fields of DRM and climate change adaptation have been lacking, which has led to fragmented implementation. (Section 7.4.3)

Stronger efforts at the international level do not necessarily lead to substantive and rapid results at the local level. There is room for improved integration across scales from international to local (Section 7.5.4). Integration of local knowledge with additional scientific and technical knowledge can improve disaster risk reduction and climate change adaptation. Local analysis of responding to the changing climate, particularly extreme climate events, can demonstrate existing capacity within the community and current shortcomings. Community-based adaptation and especially disaster risk management is being supported by NGOs and UN agencies in Viet Nam and there is a national Community Based Disaster Risk Management (CBDRM) programme. However, improvements in the availability of human and financial capital and of disaster risk and climate information customized for local stakeholders can enhance community-based adaptation (Chapter 5, Section 7.5.1)

Appropriate and timely risk communication is critical for effective adaptation and DRM. Explicit characterization of uncertainty and complexity strengthens risk communication. Perceptions of risk among individual stakeholders and groups are driven by psychological and cultural factors, values, and beliefs. Effective risk communication builds on exchanging, sharing, and integrating knowledge about climate-related risks among all stakeholder groups. (Section 2.6.3, 7.4.3.2; Chapter 4, 5, 6, 8)

An iterative process of monitoring, research, evaluation, learning, and innovation can reduce disaster risk and promote adaptive management in the context of climate extremes. Adaptation efforts benefit from iterative risk management strategies because of the complexity, uncertainties, and long time frame associated with climate change. Addressing knowledge gaps through enhanced observation and research can reduce uncertainty and help in designing effective adaptation and risk management strategies. (Section 1.4.2, Chapter 6, 7, 8)

Implications for Sustainable Development

Social, economic, and environmental sustainability can be enhanced by disaster risk management and adaptation approaches. Where vulnerability is high and adaptive capacity low, changes in climate extremes can make it difficult for systems to adapt sustainably without transformational changes. Vulnerability is often concentrated in poor communities or groups, although other rural communities and cities can also be vulnerable to climate extremes. A prerequisite for sustainability in the context of climate change is addressing the underlying causes of vulnerability, including the structural inequalities that create and sustain poverty and constrain access to resources. This involves integrating DRM and climate change adaptation into all social, economic, and environmental policy domains. (Chapter 5, 8)

At the macro level, the issue of DRM and adaptation to climate change **must be integrated into sustainable development**. At the micro level, development projects, poverty reduction, natural resource management and biodiversity conservation should apply approaches to community-based disaster risk reduction and adaptation to climate change. (Chapter 4, 5, 8)

The most effective adaptation and disaster risk reduction actions are those that offer development benefits in the short term, as well as reductions in vulnerability over the longer term. There are tradeoffs between current decisions and long-term goals linked to diverse values, interests, and priorities for the future. Short- and long-term perspectives on DRM and adaptation to climate change thus can be difficult to reconcile. Such reconciliation involves overcoming the disconnect between local risk management practices and national institutional and legal frameworks, policy, and planning. (Chapter 8)

Successfully addressing disaster risk, climate change, and other stressors often involves embracing broad participation in strategy development, the capacity to combine multiple perspectives, and contrasting ways of organizing social relations. (Chapter 4, 5, 8; Table SPM-1)

The interactions between climate change adaptation and DRM may have a major influence on resilient and sustainability (Section 7.5.4; Chapter 8). There are many approaches and pathways to a sustainable and resilient future. However, limits to resilience are faced when thresholds or tipping points associated with social and/or natural systems are exceeded, posing severe challenges for adaptation. (Chapter 8)

Based on practical DRM and climate change adaptation in Viet Nam, three lessons are about the importance of: (1) strong commitment of the Government to disaster risk reduction and adaptation to climate change; (2) raising awareness and mobilizing community participation in disaster risk reduction and adaptation to climate change; and (3) mobilizing resources for international cooperation. (Chapter 8)

Summary of priority actions

There are several approaches to adaptation and DRM that reduce disaster risk (Figure SPM-2). DRM and climate change adaptation priorities in Viet Nam are mainly low regret actions to reduce the level of exposure and vulnerability to climate extremes (Table SPM-1; Chapter 4, 5, 6, 8, 9):

1. Mapping various climate risks
2. Mapping exposure, vulnerabilities and adaptation measures
3. Improving forecasting capacities and early warning systems
4. Poverty reduction programmes
5. Strengthening social protection and social care networks to reach vulnerable groups
6. Integrating disaster risk reduction and climate change adaptation in urban & land use planning
7. Developing integrated plans for water resource management in river basins and key areas
8. Raising community awareness, building capacities, local plans (CBDRM programmes)
9. Strengthening resettlement programmes, to reduce exposure, and also reduce vulnerabilities
10. Strengthening infrastructure construction standards (climate proofing)
11. Strengthening building codes, designs of houses, buildings
12. Developing local, national and international scale risk-pooling
13. Strengthening forestry, including mangrove conservation, restoration, and replanting
14. Supporting conservation agriculture, e.g. new crop rotations, drought and flood tolerant crop varieties
15. Improving practices for water saving, water demand management, rainwater and groundwater harvesting, and water storage systems
16. Upgrading irrigation and drinking water systems, also drainage
17. Developing policies and management mechanisms associated multi-purpose reservoirs, especially hydroelectric works

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Table SPM-1. Examples of options for risk management and adaptation in the context of changes in exposure, vulnerability, and climate extremes

In each example, information is characterized at the scale directly relevant to decision making. The examples were selected based on availability of evidence in SREX Viet Nam on exposure, vulnerability, climate information, and risk management and adaptation options. They are intended to reflect relevant risk management themes, rather than to provide comprehensive information of every region of Viet Nam.

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales: Observed (from 1961) and projected (to 2100) changes	Information on climate extremes across spatial scales: Scale of risk management	Options for risk management and adaptation
Inundation related to extreme local rainfall	The main cause of flooding in Hanoi is prolonged or heavy local rain in the wider Hanoi area, or a combination of those, while the drainage system does not meet the requirements for rapid drainage. Research showed that the majority of heavy rains that caused flooding are prolonged events of extreme rainfall. The floods in 2008 are historical in Hanoi with a record rainfall in more than 100 years. Total rainfall in 3 days in the Hanoi area ranged between 350 and 550mm, with some areas recording larger amounts including 633mm in Gia Lam, 812mm in Ha Dong, and 914mm in Thanh Oai district. (Section 9.2.4.2, Table 9-4)	**Observed:** The highest one day rainfall (RX1day) and highest 5 day rainfall (RX5day) increased slightly in the South and showed a significant increase in the North Central, South Central, and Central Highlands regions. The highest daily rainfall increased or decreased unevenly in the North West, North East and Northern Delta. **Projected future precipitation extremes**: in the 21st century the phenomenon of widespread heavy rainfall and number of days with heavy rainfall is expected to increase. Highest one day rainfall (RX1day) will increase in most areas of the North West and North East. Increases in the highest 5-day precipitation (RX5day) can be expected notably in the southern Central Highlands. But estimating future extreme rainfall is very difficult because it depends on many factors and processes; thus the projected results remain uncertain. (Section 3.3.2; Table 3.9 to 3.15).	The spatial and time density of the monitoring network on the mainland is still thin on the regional scale and observation time. The network for ocean observations is even more limited. However, observations by satellites have improved in recent decades.	Low regret options to reduce the level of exposure and vulnerability to extreme local rainfall include: – Mapping vulnerabilities and adaptation measures – Integrating disaster risk reduction and climate change adaptation in urban planning – Upgrading, maintenance of drainage system – Improving early warning systems – Micro-insurance and other risk-sharing mechanisms – Resettlement programs with a focus on developing livelihoods to not only reduce the level of exposure, but also reduce the vulnerability. (Section 5.6.3, 9.2.4.4)

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
Inundation related to extreme sea levels / storm surges	Coastal zones and deltas are vulnerable to rising sea levels and especially storm surges associated with a combination of tropical storms and high tides. For example, storm surges in 1881 in Hai Phong killed about 300,000 people. Records show that the biggest surge caused by storm Dan in 1989 was 3.6m. Storm surges that appear when spring tide combines with a storm lead to waves that are the main cause of dike failures, as happened in Nam Dinh and Thanh Hoa in 2005 during typhoon Damrey. Between late October and early December 2013, surges in Ho Chi Minh exceeded alarm level 3 and caused severe flooding in areas along rivers, canals and low-lying areas. On 20 October 2013, the tide at 1,68m was the highest observed in the past 61 years. On 5 and 6 December 2013, the tide peaked between 1,63 and 1,65m. A section of embankments in Binh Thanh District ruptured and water burst into suburbs, causing widespread flooding. Some flood protection works are not effective. Because many levees broke during the night, the quickly rising water spilled into homes, disrupting all social economic activity. These events cause erosion, inundation, shoreline change, saltwater intrusion; and	**Observed:** Sea level in the East Sea and coastal Viet Nam are increasing markedly with an average value along the entire coast of Viet Nam is about 2.8 mm / year. Satellite data show that the average water level in one part of the East Sea increased by about 4.7 mm / year between 1993 and 2010. The annual highest sea levels occur when high tides combine with storms, causing storm surges, which show an upward trend in most coastal observation stations of Viet Nam. **Projected towards the end of the 21st century:** the average sea level rise throughout Viet Nam is expected to be in the range of 78 cm to 95 cm by the end of the century, modelled with the high emissions scenario A1FI. The areas with the highest expected rise are from Ca Mau to Kien Giang (85 cm to 105 cm) and the areas with the lowest rise are in Mong Cai (66 cm to 85 cm)	Changes in frequency and strength of typhoons may contribute to changes in extreme coastal high water levels, but there is limited geographical coverage so that the impact of changes in storm surges cannot be accurately assessed. (Section 9.2.1.3, 9.2.1.4)	Low regret options to reduce the level of exposure and vulnerability to high sea levels and storm surges include: – Mapping risks of storm surges – Mapping exposure, vulnerabilities and adaptation measures; – Raising community awareness about the dangers; – Improving early warning systems, including forecasting and local communication systems for alerting, alarming – Reducing vulnerability to high-risk areas (resettlement away from coastal areas; build storm and flood resistant houses; etc.). (Section 9.2.1.4)

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales: Observed (from 1961) and projected (to 2100) changes	Information on climate extremes across spatial scales: Scale of risk management	Options for risk management and adaptation
	impacts on coastal communities, tourism, transport, businesses, ecosystems, agriculture and aquaculture. This is leading to economic losses and migration. (Section 9.2.4.2)			
Inundation related to river basin wide heavy rainfall	Major floods in the Mekong Delta happen on average about every 4 to 6 years. The main causes of flooding in this area are heavy rainfall in the upstream or the entire river basin, flood discharge from upstream dams, deforestation, irrigation canal system and dykes to protect from salt water, inappropriate urban development, etc. In the past 45 years there were major floods in 1961, 1978, 1984, 1991, 1994, 1996, 2000, 2001 and 2011. (Section 9.2.2)	**Observed**: Nationwide there are annually on average about 25 spatially large-scale heavy rains, mainly in the period April to December, but earlier in the northern region and gradually later in the southern region. This spatially large-scale rainfall shows a strong upward trend in the last 20 years, with 56 events the highest in 2008. These spatially large-scale rainfall events caused frequent widespread flooding and unusual impact in a wider area or region. **Projected**: The number of days with more than 50 mm rainfall will be increasing in the 21st century in the North and the South, but the Central region shows a slightly downward trend. (Section 3.5.3, Figure SPM-7).	The flooding in the Mekong Delta is unique, but although the residential area and the range show very large impacts and the effects last for several months, the impact is not as high as fierce floods in Central and the Northern Delta.	Recognizing the problems in the Mekong Delta, Viet Nam invested in a basic system with adaptation measures, to ensure “actively living with floods” and mitigate losses. The primary motto to prevent disaster in the Mekong Delta is to adapt, prevent and partially limit the impact of flooding through structural and non-structural measures. Overall area planning is necessary. The construction of levees in many cities and towns should consider that they are changing flood levels throughout the region and the area cannot be protected by the current dyke system against increased flood levels. (Section 9.2.2.3)
Flash	Heavy rain causes high intensity flash floods in mountainous provinces in Viet	**Observed:** Mountainous, sloping terrain is extensive and flash floods are	Flash floods appear in local,	Low-regret options that reduce exposure and vulnerability to flash floods in the mountains,

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
floods in the mountains	Nam, especially in the northern mountainous provinces. Flash floods often occur unexpectedly, creating channels, threatening lives, destroying infrastructure and impacting negatively on socio-economic development and people's lives. Flash floods have become increasingly serious in recent decades in Viet Nam. The annual average number of flash flood events was approximately 12 in the period 1990-2010. A typical example is flash floods in Lao Cai in the night of 8 August 2008 when 88 people were killed. Flash floods in August 2012, also in Lao Cai, killed 11 people and injured 9. (Section 9.2.3, Table 9.3)	a common form of natural disaster; and risks are increasing because of heavy rainfall events and land use changes. **Projected**: Increased extreme rainfall will increase future risks of flash floods. However, there are many ways to reduce vulnerability the degree of exposure to this hazard. (Section 3.3.2)	narrow areas and there is little information, so the ability to predict flash floods at the local scale is limited. Extreme rainfall increase in localities often cause flash floods in Viet Nam, including all mountainous areas, and especially the Northwest and Southern Central Highlands. (Figure SPM-6, SPM-7)	are: – Mapping the risk of flash floods – Mapping vulnerabilities and adaptation measures; – Strengthening the standards for design and construction of infrastructure (roads, bridges, irrigation systems ...) – Strengthen regulations on the design and construction of housing and public buildings (schools, hospitals, ...) – Implement planning and actual relocation from high-risk areas – Implementation of poverty reduction plans – Linking development of agriculture and forestry to flash flood mitigation
Losses from tropical storms, typhoons	Exposure and vulnerability to storms is increasing due to population growth and the increasing value of exposed assets, particularly in coastal cities where planning does not often take the mitigation of climate change into account. Many resettlement areas do not ensure sustainable livelihoods and the living environment is not stable under the impact of natural disasters and therefore	**Observed**: Over the last 50 years (1961-2010), change in the frequency of tropical cyclones, including typhoons and tropical depressions affecting Viet Nam is not clear. However, the number of average level typhoons is decreasing, but the number of very strong typhoons are increasing. The typhoon season in recent years ends later and the landfall of the storms is shifting southward.	More than 3,000 km of Viet Nam's coastline is exposed to the risk of typhoons and tropical depressions, especially in the central region. All coastal settlements,	Low regret options to reduce the level of exposure and vulnerability to typhoons and tropical depressions are: – Mapping vulnerability and adaptation measures – Introducing and enforcing construction standards – Improving capacities for forecasting and for operating early warning systems – Local, provincial and national scale risk-pooling

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales: Observed (from 1961) and projected (to 2100) changes	Information on climate extremes across spatial scales: Scale of risk management	Options for risk management and adaptation
	people may need be moved again. For example, in Quy Nhon city 3,000 households were resettled to avoid erosion and storms, but the resettlement area is low-lying and flood-prone. (Section 4.3.4.1)	**Projected**: Model results for the mid and late 21st century of the number of typhoons in the East Sea and impacts on Viet Nam does not show a clear trend. The projections suggest a possible decrease in frequency but increase in storm intensity. The number of strong typhoons (Vmax> 70 ms-1) is almost certainly increasing. (Section 3.4.2.; Figure 3-6 to 3-10, Table 3-19)	especially in big cities, need to carefully consider the risks to socio-economic development planning.	– Consider future risks and strengthen the provisions for planning, design and construction of infrastructure, housing and public works, especially in case of relocation and construction of new urban areas. In the context of high uncertainty regarding trends, options must include flexible, adaptive management.
Impacts of heat waves	The factors affecting the level of exposure and vulnerability to heat waves include age, health status, level of outdoor activities, and socio-economic factors such as poverty, social isolation, adaptation and urban infrastructure. Typical examples are the two fierce and prolonged heat waves (> 35ºC) in June-July 2010 in the North, North Central and Central regions, where hot days occurred longer than one month. In provinces of the Northern Delta and the North Central region temperatures reached up to 40-41 ºC, and in some places up to 42 °C. Heat waves may damage economic and in particular agricultural production. In the Northern region, heat waves occur in the summer, causing water shortages and	**Observed:** Recent data show that the annual number of hot days and number of heat waves is rising almost nationwide, especially in the central region. Some places observed record high temperatures. The heat spreads as a rule from north to south and from west to east. The highest frequency of hottest and most acute heat waves in Viet Nam is in the central coastal provinces, especially in the North Central region. (see Figure SPM-4) **Projected:** The number of hot sunny days (>35°C) are expected to increase in the 21st century, with a significant increase in the Northern Delta, South Central region and South. By the mid-21st century the number of hot days may typically rise by 20-30 days compared to 1980-1999 in the	The number of heat waves is rising during the 21st century, with high rates in the South and the southern Central Highlands.	Low regret options to reduce the level of exposure and vulnerability to heat waves: – Mapping vulnerability and adaptation measures – Early warning systems that reach particularly vulnerable groups (e.g., the elderly, children, people with chronic illnesses ...) – Awareness raising of heat waves as a public health concern and information supply to the community about the measures to prevent and deal with heat waves – Using social care networks to reach vulnerable groups – Making changes in urban infrastructure and land use planning, for example, increasing urban green space; changes in approaches to cooling for public facilities; and adjustments in energy generation and

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
	affecting life, seriously affecting health and causing increased energy consumption for pumping irrigation water and cooling. In the South and Central Highlands regions frequently experience hot, dry periods at the end of the dry season, affecting production. At the Central Coast, prolonged dry heat usually appears in mid-summer, causing water shortages in the sowing season. (Section 9.2.6.1, 6.2.6.2; Table 9-6) (Figure SPM-4)	Southern region. By the end of the 21st century the increase will be in the range of 60-70 days in the North East, North Delta, Central, South Central, and South. The number of heat waves (3 consecutive hot days) is expected to increase in most regions, particularly in the South and southern Central Highlands with an increase of up to 6 to 10 events; in the remaining regions the increased will be 2 to 6 events. (Section 3.5.1) (Figure SPM-5)		transmission infrastructure. (Section 9.2.6.3; 6.2.6.4)
Droughts	Some years with major social-economic damage because of drought were 1997-1998, 2004-2005 and 2010. The period 2000-2007 was considered to be volatile to drought, occurring increasingly throughout the country. Less advanced agricultural practices render a region vulnerable to increasing variability in seasonal rainfall, drought, and weather extremes. Vulnerability is exacerbated by population growth, degradation of ecosystems, and overuse of natural resources, as well as poor standards for health, education, and governance. (Section 9.2.5)	**Observed:** Drought appeared more severe in many areas in Viet Nam, especially in the 2000-2007 period. **Projected:** Droughts may occur more often and longer in most climatic regions of Viet Nam. Drought will increase during the 21st century, at a high rate, with more severe droughts lasting longer in regions such as the South Central region, the Central Highlands.	Winter droughts occur mainly in the North, South and Central Highlands; summer drought is common in the North Central and South Central regions. Measuring equipment and monitoring data have improved, but information dissemination to at-risk people is still limited.	Low-regrets options that reduce exposure and vulnerability to drought: – Mapping vulnerability and adaptation measures – Rainwater and groundwater harvesting and storage systems – Manage water demand and improve water use efficiencies. – Conservation agriculture, crop rotation, use of drought-tolerant crop varieties. and livelihood diversification – Maintain and upgrade irrigation and water supply systems to minimize losses – Encourage the use of water saving, alternating sprinklers – Strengthen early warning systems, integrating seasonal forecasts with drought projections, and involving extension services

Type of event	Examples, with exposure and vulnerability at scale of risk management	Information on climate extremes across spatial scales		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
				– Develop integrated plans for water resource development in river basins and key regions. Plan exploitation, rational use of water resources for localities and sectors, including structural and non-structural measures – Protection and development of forest and water recycling; – Develop policies and management mechanisms, operate and regulate the distribution of water resources and associated multi-purpose reservoirs, especially hydroelectric works; – Risk pooling at the regional or national level (Section 9.2.5.3; 9.2.5.4)

SECTION 2 –

SREX VIET NAM CHAPTERS

Chapter 1
Climate change: New Dimensions in Disaster Risk, Exposure, Vulnerability, and Resilience

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Executive Summary

The ***Viet Nam*** *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* presents and analyses the Vietnamese situation in light of the concepts and findings of the IPCC *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (IPCC, 2012a). Chapter 1 presents the basic concepts.

Disasters are extreme impacts suffered when hazardous physical events interact with vulnerable social conditions, and severely alter the normal functioning of a community or a society. Social vulnerability and exposure are key determinants of disaster risk [Figure 1-1]. Extreme weather and climate events will lead to disaster if communities, households that are exposed to those events are highly vulnerable. In earlier analysis, globally and in Viet Nam, vulnerability was seen as a function of exposure, sensitivity and adaptive capacity of systems. Separating vulnerability and exposure particularly helps to explain better why non-extreme physical events and chronic hazards can also lead to extreme impacts and disasters, while some extreme events do not.

Extreme impacts on social systems, ecosystems and the physical environment may be associated with successive physical phenomena such as several heavy rainfall events in the centre of Viet Nam in 1999 [Box 1-2], instead of a single ‘event’. A variety of feedbacks and other interactions connect extreme events and the physical system and ecological responses in a way that may amplify physical impacts. But whether this results in extreme impacts on social systems depends on the degree of exposure and vulnerability to the extremes, in addition to the magnitude of the physical events.

Management strategies based on the reduction of risk associated with non-extreme and recurring events facilitates the reduction of disaster risk to extremes. Effective adaptation to climate change requires an understanding of the diverse ways in which social processes and development pathways shape disaster risk. Disaster risk is often caused by ongoing, chronic, or persistent environmental, economic, or social factors that determine or increase vulnerability and/or exposure.

Disaster risk is socially constructed. The exposure and vulnerability to hazards (i.e. climate extremes) are shaped by political, economic, social, cultural, physical, and psychological factors, and thus disaster risk and disaster are ‘social constructions’ that result from societal action and inaction. Disaster risk management must take into account the social variables, and social interventions can reduce the component of risk that is socially constructed.

Climate change will pose added challenges for the appropriate allocation of efforts to manage disaster risk. Climate change may shift the mean in climate variables, resulting in for example fewer extremely cold days and more extremely hot days in a locality; increase the variability, resulting in for example more very dry as well as very more very wet summers; and/or change the distribution of a climate variable, resulting for example in fewer average temperature summers and more very hot summers [Figure 1-2]. The potential for changes in all characteristics of climate will complicate the evaluation, communication, and management of the resulting risk.

Disaster risk management (DRM) and adaptation to climate change differ in terms of the degree to which the focus is on extreme events, and the spatial and time scales that are considered. Previously the focus in Viet Nam was on DRM and in particular on the physical events whereas currently the social as well as physical aspects of disaster risk are considered and adaptation to climate change is a core aspect of climate policy.

Development policy, practice, and outcomes are critical to shaping disaster risk, and DRM and adaptation to climate change must be mainstreamed in plans and investments. Reductions in the rate of depletion of ecosystem services, improvements in spatial planning and urban land use, the strengthening of rural livelihoods, and advances in urban and rural governance enable poverty reduction, disaster risk reduction, and adaptation to climate change.

Risk assessment is one starting point for adaptation to climate change and disaster risk reduction and transfer. The assessment and analysis process may employ a variety of tools, depending on context, access to data and technology, and stakeholders involved. These tools will vary from formalized probabilistic risk analysis to local level, participatory risk and context analysis methodologies.

Many of the risks and extreme impacts associated with climate change must be understood at the local level, for men, women, children, households and communities, as crises can affect attitudes and ways of approaching complex problems. Perceptions of risk are driven by psychological and cultural factors, values, and beliefs. Effective risk communication thus requires exchanging, sharing, and integrating knowledge about climate-related risks among all stakeholder groups. [Box 1-1]

Management of the risk associated with climate extremes benefits from an integrated systems approach, as opposed to separately managing individual types of risk or risk in particular locations. Effective risk management generally involves a portfolio of actions to reduce and transfer risk and to respond to events and disasters, as opposed to a singular focus on any one action or type of action.

Learning is central to adaptation to climate change. Furthermore, the concepts, goals, and processes of adaptation have much in common with DRM. Disaster risk management and adaptation to climate change offer frameworks for, and examples of, advanced learning processes that may help reduce or avoid barriers that undermine adaptation efforts or lead to implementation of maladaptive measures. Due to uncertainty, complexity and a long timeframe associated with climate change, robust adaptation efforts would require iterative risk management strategies. [Box 1-1; Figure 1-3]

Projected trends and uncertainty in future hazards, exposure, and vulnerability associated with climate change and development make return to the status quo an insufficient goal for DRM and adaptation to climate change. New approaches to resilience of social-ecological systems include the ability to self-organize, learn, and adapt over time.

Because of the new dimension of climate change, greatly improved DRM and adaptation will be needed, as part of development processes, in order to reduce future risk. Efforts must be informed by the experience and success with DRM in different regions of Viet Nam during recent decades [Box 1-1, Box 1-2], and additional, new approaches for risk identification, reduction, transfer, and disaster management are needed. Future practices of DRM and adaptation can benefit from stronger institutional, financial, policy, strategic, and practical linkages.

Community participation in planning, including participation of both men and women, the use of local and community knowledge and capacities, and the decentralization of decision-making, supported by national and international policies and actions, are critical for disaster risk reduction and adaptation to climate change. The use of local level risk and context analysis methodologies, inspired by DRM and now accepted by many civil society and government agencies in adaptation work, would foster greater integration between, and greater effectiveness of, both adaptation to climate change and disaster risk management.

1.1. Introduction

1.1.1. Purpose and Structure of this Report

This report builds on the IPCC *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* ***('SREX')*** (IPCC, 2012a). The ***Viet Nam*** *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* ***("SREX Viet Nam")*** presents and uses the SREX concepts, and analyses the Vietnamese situation in light of the global *SREX* findings.

SREX considers climate change and its implications for extreme (weather and climate) events, disaster, and disaster risk management (DRM); how human responses to extreme events and disasters could contribute to adaptation objectives and processes; and how adaptation to climate change could be more closely integrated with DRM practice. *SREX Viet Nam* will do the same, but with its focus firmly on the Vietnamese situation. *SREX Viet Nam* aims to present the latest evidence of vulnerabilities, impacts of climatic extremes, risk management strategies, and adaptation options for a sustainable and resilient future of Viet Nam. *SREX Viet Nam* will also address the three specific goals of *SREX*, but for Viet Nam:

- To assess the relevance and utility of the concepts, methods, strategies, instruments, and experience gained from the management of climate-associated disaster risk under conditions of historical climate patterns, in order to advance adaptation to climate change and the management of extreme events and disasters in the future, in the Vietnamese situation.
- To assess the new perspectives and challenges that climate change brings to the disaster risk management field, specifically for and in Viet Nam
- To assess the mutual implications of the evolution of the disaster risk management and adaptation to climate change fields, particularly with respect to the desired increases in social resilience and sustainability that adaptation implies, for and in Viet Nam.

All the main concepts and definitions from *SREX* are also applied in *SREX Viet Nam*, with additional explanations and illustrations when deemed useful. Some *SREX* figures are repeated and explained in *SREX Viet Nam*, and some of the *SREX* analysis of climatic extremes, vulnerabilities and disaster risks is summarized or quoted; with this introductory chapter borrowing substantially from SREX Chapter 1 (Lavell et al., 2012; IPCC, 2012a). Similarly, we have used the concepts and some of the analysis from *SREX* in the other chapters of *SREX Viet Nam*, though to varying degrees. The text indicates in numurous places which parts of SREX were used and quoted, but for reasons of readability it does not refer to absolutely every statement in *SREX* and the references used for *SREX* that we have summarized and translated into Vietnamese.

SREX provides projections for changes in the frequency, intensity, spatial extent, or duration of weather and climate extremes, including climate and hydro-meteorological events such as heat waves, heavy precipitation, drought, and tropical cyclones, particularly in Chapter 3. New, improved or strengthened processes for anticipating and dealing with the adverse effects associated with weather and climate events will be needed, despite important advances over recent decades in the reduction of loss of life because of improved early warning systems, in Viet Nam and elsewhere.

The *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* (UNISDR, 2005) was adopted by 168 governments including Viet Nam. It articulates agreed principles, policies and practice of DRM. The need for closer integration of disaster risk management and adaptation to climate change has prompted the IPCC and the United Nations International Strategy for Disaster Reduction (UNISDR) to undertake SREX. This need also applies to the specific situation in Viet Nam.

The main audience for *SREX Viet Nam* includes Vietnamese decision makers and the professional staff of Government agencies as well as Vietnamese Political, Social, Professional and Mass Organizations (PSPMOs) that are concerned with climate change and natural DRM. *SREX Viet Nam* also serves the two communities of practice from where the main authors hail: (a) the scientific community with an interest in environmental, social and/or economic aspects of climate change; and (b) the disaster risk management community including Government officers at different levels, staff of PSPMOs and international development agencies with a presence in Viet Nam. The summary for policy makers of *SREX Viet Nam* presents the main findings and provides all policy recommendations that follow from the analysis; and it will also be of interest to the media and public.

The rest of Section 1.1 presents some of the key concepts and definitions that are used throughout this report, and frames the relationships between DRM and climate change adaptation. Section 1.2 provides the basic concepts and definitions of extreme events, extreme impacts and disasters. Section 1.3 discusses the challenges in quantifying the changes in risks as a result of climate change. Section 1.4 introduces basic concepts related to climate change adaptation.

Based on the concepts and definitions provided in the rest of Chapter 1, Chapter 2 describes and analyzes exposure and vulnerability further, i.e. the determinants of risk. In chapter 3 we present the observed climatic extremes in Viet Nam and the projected changes in climate extremes, as well as some of their impacts on physical environmental phenomena. Chapter 4 discusses impacts of climate extremes on human systems and ecosystems. In chapter 5 local risk management in Viet Nam is presented and chapter 6 discusses the national risk management systems. The international dimensions as they are relevant to Viet Nam are addressed in chapter 7. Chapter 8 presents a range of conclusions and recommendations that should help Viet Nam move towards a sustainable and resilient future, as climate extremes are becoming more extreme. Chapter 9 presents a range of case studies that demonstrate challenges and lessons learned from extreme climate related events in Viet Nam's history.

1.1.2. Key Concepts and Definitions

The concepts and definitions that relate to disaster risk and adaptation to climate change presented in this chapter draw on *SREX* (IPCC, 2012a). The main concepts and definitions are given in both Vietnamese and English in the glossary (Annex 1).

1.1.2.1. Definitions Related to General Concepts

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2013).

Extreme (weather and climate) events and disasters are the two central risk management concerns of *SREX-Viet Nam*.

Extreme events are defined as the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends ('tails') of the range of observed values of the variable (IPCC, 2012a p.30).

Disasters: severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012a p.31).

The **hazardous physical events** referred to in the definition of disaster may be of natural, socio-natural (originating in the human degradation or transformation of the physical environment), or purely anthropogenic origins (IPCC, 2012a p.31).

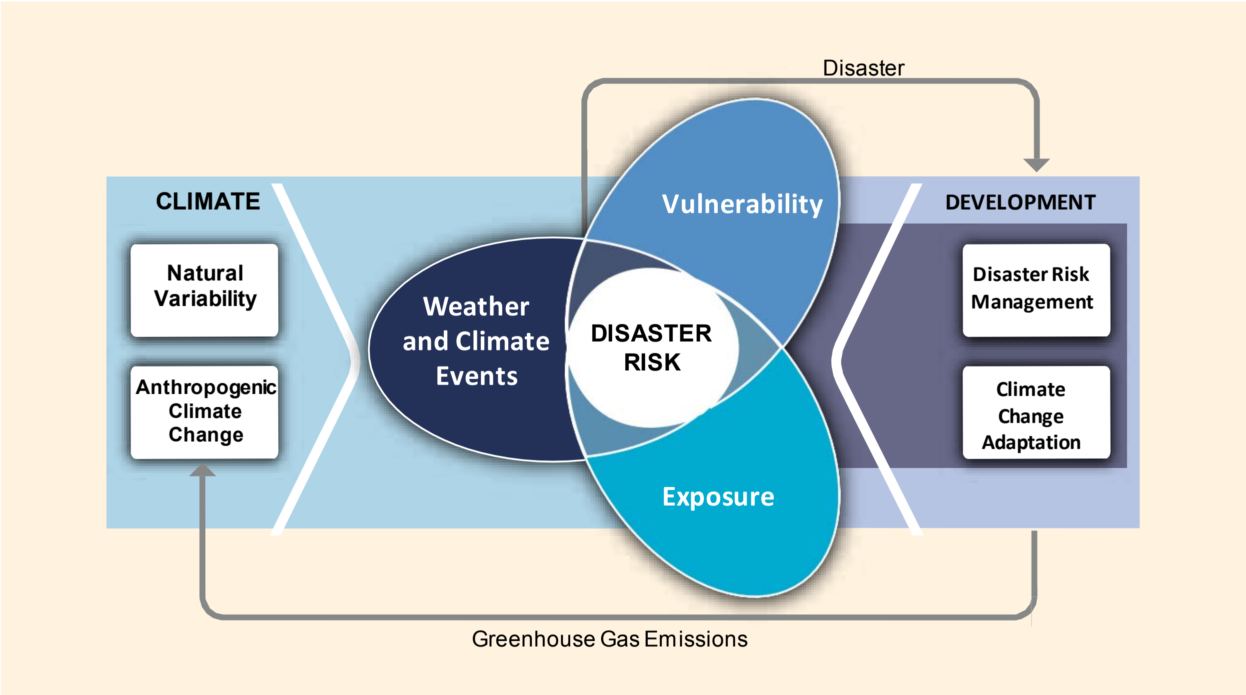
Disaster risk is defined as the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012a p.32). **Disaster risk** derives from a combination of physical hazards and the vulnerabilities of exposed elements and will signify the potential for severe interruption of the normal functioning of the affected society once it materializes as disaster (See Chapter 2).

The above definitions of disaster risk and disaster do not include the potential or actual impacts of climate and hydrological events on ecosystems or the physical Earth system per se. In this report, such impacts are considered relevant to disaster if they comprise one or more of the following situations: i) they adversely impact on livelihoods by seriously affecting ecosystem services and the natural resource base of communities; ii) they have consequences for food security; and/or iii) they have impacts on human health.

Social disaster: extreme impacts on social systems that may or may not impact on the physical and ecological systems (IPCC, 2012a p.32). A **social disaster** occurs when there is direct impact on human activities and natural processes are the underlying cause (with direct effect on the social system) (IPCC, 2012a p.32).

In order to understand the concept of disaster risk (and thus disaster) it is important to consider the notions of hazard, vulnerability, and exposure (See Figure 1-1).

Figure 1-1. The main concepts of SREX and SREX Viet Nam



Source: (IPCC, 2012a p.31)

Hazard: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012a p.32).

Exposure refers to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage (IPCC, 2012a p.32).

Vulnerability is the propensity or predisposition to be adversely affected. Such predisposition constitutes an internal characteristic of the affected element. In the field of disaster risk, this includes the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events (Wisner et al., 2004). Vulnerability is a result of diverse historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes (IPCC, 2012a p.31).

The fundamentally social connotation and 'predictive' value of vulnerability is emphasized in the definition used in this report. However, the earlier IPCC definition of vulnerability refers to 'the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2007 p.883; see also IPCC, 2001 p.995). This definition makes physical causes and their effects an explicit aspect of vulnerability while the social context is encompassed by the notions of sensitivity and adaptive capacity. This earlier IPCC definition has also been used in Vietnamese literature, in which authors applied the equation V = f (E, S, AC) (vulnerability = function of the level of (Exposure, Sensitivity and Adaptive Capacity)) as a basis for their analysis (see for example: Ngô Thị Vân Anh et al., 2013). Nevertheless, in the definition used in this report, the social context is emphasized explicitly, and vulnerability is considered independent of physical events (IPCC, 2012a p.33).

Capacity refers to the combination of all the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to achieve established goals (IPCC, 2012a p.33). This includes the conditions and characteristics that permit institutions, local groups, individuals, etc. access to and use of social, economic, psychological, cultural, and livelihood-related natural resources, as well as the information necessary to reduce vulnerability and deal with the consequences of disasters.

The lack of capacity may be seen as one dimension of overall vulnerability, while it is also seen as a separate notion that is not part of vulnerability per se, but that contributes to an increase in vulnerability. The existence of vulnerability does not mean an absolute, but rather a relative lack of capacity.

Capacity was promoted in disaster recovery work by Anderson và Woodrow (1989) as a means to shift the analytical balance from the negative aspects of vulnerability to the positive actions by people, and the notion of capacity is also fundamental to a conceptual shift favoring disaster risk reduction and adaptation to climate change.

Coping is defined as the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term.

Resilience is defined as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012a p.34).

There is no one-to-one relationship between extreme events and disasters (see Figure 1-1). Extreme weather and climate events will lead to disaster if (1) communities, households are exposed to those events; and (2) exposure to potentially damaging extreme events is accompanied by a high level of vulnerability. High exposure and vulnerability levels will lead to a disaster due to extreme weather and climate events. Recurrent small- or medium-scale events affecting the same communities as they erode the development base and livelihood options and increase vulnerability. The impact of repeated lesser events is exacerbated by physical, ecological, and social conditions that may increase exposure and / or vulnerability. These events disproportionately affect resource-poor men, women and children with limited ability to reduce the hazard, their exposure, and their vulnerability to the hazard.

1.1.2.2. Concepts and Definitions Relating to Disaster Risk Management and Adaptation to Climate Change

Disaster risk management (DRM) is defined in this report as the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC, 2012a p.34).

Disaster risk management can be divided to comprise two related but discrete sub-areas or components: disaster risk reduction (DRR) and disaster management.

Disaster risk reduction (DRR) denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk, reducing hazard, existing exposure, or vulnerability, and improving resilience. DRR includes reduction of vulnerability of people, livelihoods, assets, and ensuring the appropriate sustainable management of land, water and other components of the environment (IPCC, 2012a p.34).

Disaster management refers to social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels. This includes the activation of early warning systems, contingency planning, emergency response, and recovery. Disaster management addresses the disaster risks that disaster risk reduction processes did not eliminate or prevent completely.

Risk transfer refers to the process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise, or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party (IPCC, 2012a p.35).

The **disaster management cycle** depicts the sequences and components of so-called disaster management. In addition to considering preparedness, emergency response, rehabilitation, and reconstruction, it also included disaster prevention and mitigation as stated components of 'disaster management' and utilized the temporal notions of before, during, and after disaster to classify the different types of action (IPCC, 2012a p.35). However, this notion has been criticized for its mechanistic depiction of the intervention process, as it does not consider the different ways in which different components and actions merge and can act synergistically with each other.

Therefore, in many parts of the world, a more comprehensive approach and concept of disaster risk management with distinct risk reduction and disaster intervention components is now favoured. This led to development of the notion of a '**disaster risk continuum'**, in which risk is seen to evolve and change constantly, requiring different modalities of intervention over time, from pre-impact risk reduction through response to new risk conditions following disaster impacts and the need for control of new risk factors in reconstruction. The disaster risk continuum considers the ways different components and actions merge and can act synergistically with and influence each other, and for its incorporation of DRR considerations. The form and method of response to disasters may affect future disaster risk and therefore future needs for preparedness and response, i.e. disaster risk reduction efforts (IPCC, 2012a p.35).

Adaptation is a goal and management of extreme events and disaster risks are methods for supporting and advancing that goal. In human systems, **adaptation** is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2012a p.36).

These definitions modify the definition used in the Fourth Assessment of the IPCC, which was that adaptation to climate change is the adjustment in natural or human systems in response to actual and expected climatic stimuli, such as to moderate harm or exploit beneficial opportunities (IPCC, 2007 p.869). This earlier definition implies that natural systems can (always) adjust to expected climate stimuli, but this implication is avoided in the new definitions. The IPCC Fifth Assessment built on SREX and modified the definition of adaptation further (IPCC, 2014 p.1758), but the definition used here remains that of *SREX*.

Disaster preparedness measures, including early warning and the development of contingency or emergency plans, may be considered a component of, and a bridge between, disaster risk reduction and disaster management (IPCC, 2012a p.36). Preparedness accepts the existence of residual, unmitigated risk, and attempts to aid society in eliminating certain of the adverse effects that could be experienced once a physical event occurs (for example, by the evacuation of persons and livestock from exposed and vulnerable circumstances). At the same time, it provides for better response to adverse effects (for example, by planning for adequate shelter and potable water supplies for the affected or destitute persons or food supplies for affected animal populations).

Disaster mitigation is used to refer to actions that attempt to limit further adverse conditions once disaster has materialized (IPCC, 2012a p.36). This refers to the avoidance of what has sometimes been called the 'second disaster' following the initial physical impacts such as adverse effects on health and livelihoods due to inadequate disaster response and rehabilitation plans, inadequate enactment of existing plans, or unforeseen or unforeseeable circumstances.

Disaster risk prevention and **disaster prevention** refer, in a strict sense, to the elimination or avoidance of the underlying causes and conditions that lead to disaster, thus precluding the possibility of either disaster risk or disaster materializing (IPCC, 2012 p.36). This assumes that disaster risk is manageable and its materialization is preventable to an extent. **Prospective (proactive) DRM** can contribute in important ways to avoiding future, and not just reducing existing risk and disaster (IPCC, 2012a p.36).

1.1.2.3. The Social Construction of Disaster Risk

The notions of hazard, exposure, vulnerability, disaster risk, capacity, resilience, and coping, reflect that disaster risk and disaster are 'social constructions' which are the result of social choice, social constraints, and societal action and inaction. The notion of social construction of risk implies that management can take into account the social variables involved and work toward risk reduction, disaster management, or risk transfer through socially sustainable decisions and concerted human action. Some risks may be too great to reduce significantly through human intervention, and others may in fact be exacerbated by social construction processes, but the component of risk that is socially constructed can be reduced by social interventions.

The explicit recognition of the political, economic, social, cultural, physical, and psychological elements or determinants of risk leads to a spectrum of potential outcomes of physical events, including **extreme impacts**. Accordingly, risk assessment using both quantitative and qualitative (social and psychological) measures is required to render a full description of risk and risk causation processes. This means that some of the established indicators of human vulnerability need to be reconsidered or complemented by other indicators in order for risk assessment to be an effective tool.

For example, an integrated risk index for all communes in Viet Nam was developed with nationally available data (Trung, 2013), capturing 'hazard potential', 'hazard exposure' and 'coping capacity'. Exposure and capacity sub-indexes were based on national poverty data and the 2009 census (household-level data in both cases). The coping capacity index is constructed from three indicators, including: (i) poverty headcount at the district level; (ii) a (household) asset index, and (iii) the proportion of 'temporary houses' in the commune. The results are based on nationally available data and are extremely useful for understanding how disaster risk at the commune level varies across the country. However, vulnerabilities and (coping) capacities are specific to hazards, which vary between communities and regions. Indicators that are useful for assessing vulnerabilities and adaptation capacities in relation to specific hazards could include: (a) the rate of households in the community who have taken flood-damage prevention measures such as food storages; (b) the proportion of children in the community who know how to swim (in flood prone communities); (c) the rate of households with interrupted water supplies during normal dry seasons (in drought-prone communities). Such vulnerability-capacity data could be aggregated to the national level if they remain specific to the hazards.

1.1.3. Framing the Relation between Adaptation to Climate Change and Disaster Risk Management

Adaptation to climate change and DRM are both dealing with existing and future climate-related risk. Disaster preparedness is a function of disaster risk management and of adaptation to climate change. However, these two practices have followed independent paths of development and have employed different interpretations of concepts, methods, strategies, and institutional frameworks.

Disaster policy, concepts of disaster, and disaster risk management approaches have undergone significant changes over the last 30 years. These changes are reflected in international agreements such the 2005 Hyogo Framework for Action (UNISDR, 2005). Chronic or everyday risk disproportionately affects poorer persons and families, and to achieve poverty reduction, disaster risk reduction, as well as adaptation to climate change requires sustained ecosystem services, the strengthening of rural livelihoods, improvements in urban land use, and advances in urban and rural governance.

Pathways toward resilience include incremental as well as transformational approaches to development, which emphasize addressing risk and bring disaster risk management into development goals, policy, and practice. This transformation builds on a legacy of progressive, socially informed disaster risk research. However, advances in the reduction of the underlying causes – the social, political, economic, and environmental drivers of disaster risk – remain insufficient to reduce hazard, exposure, and vulnerability in many regions.

The transition to more comprehensive DRM raises challenges for the allocation of efforts among disaster risk reduction, risk transfer, and disaster management efforts. Viet Nam does address the need for disaster risk management and not just disaster responses in its national social economic development strategies and plans (with a 10 year and 5 year time period, respectively) and also in equivalent plans at the provincial level. However, these strategies and plans also demonstrate that mainstreaming of risk in sectoral policies is still limited whilst there are many priorities competing for limited resources, and mainstreaming in plans and investments must be strengthened (Bộ KH và ĐT, 2013).

Globally, the increasing emphasis placed on disaster risk management as a dimension of development has been accompanied by increasing emphasis on proactive disaster risk prevention as opposed to reactive disaster risk mitigation. The shift from the notion of disaster to the notion of disaster risk reduction can be seen in the increasing importance placed on developing **resistance** to the potential impacts of physical events at various social or territorial scales, and in different temporal dimensions, and to increasing the resilience of affected communities. **Resistance** refers to the ability to avoid suffering significant adverse effects (IPCC, 2012a p.38).

Disaster risk reduction and adaptation to climate change are closer than when emergency or disaster management objectives dominated the discourse and practice. By considering the developmental basis of both adaptation to climate change and disaster risk management, along with the role of vulnerability in the constitution of risk, and the corrective as well as prospective nature of disaster risk reduction, the similarities between the two become evident.

1.1.4. Framing the Processes of Disaster Risk Management and Adaptation to Climate Change

The phenomena and social processes that concern DRM on the one hand, and adaptation to climate change on the other, differ in terms of: (1) the degree to which the focus is on extreme events, instead of all physical events with potential for damage, the social contexts in which they occur, and the potential for such events to generate ‘extreme impacts’ or disasters; and (2) consideration of the appropriate social-territorial scale that should be examined in order to foster a deeper understanding of the causes and effects of the different actors and processes at work.

Notions of DRM and adaptation developed from a focus on the physical events to one considering the social as well as physical aspects of disaster risk. Notions now include the role of small- and medium-scale disasters leading to cumulative disaster loss and damage, and they look across the different scales. This is consistent with the aim of reducing vulnerability and increasing resilience to climate-related disaster by focusing on exposure, vulnerability, and socially-determined propensity to adverse effects across a range of risks.

Many of the extreme impacts associated with climate change, and their attendant additional risks and opportunities, must be understood and responded to principally at the scale of the individual, the individual household, and the community. Everyday life, history, and a sequence of crises can affect attitudes and ways of approaching more extreme or complex problems (see Box 1-1 for a case of this regarding the Mekong Delta in Viet Nam). In contrast, many agents and institutions of DRM and climate change adaptation activities remain highly centralized and hierarchical in many parts of the world today.

Box 1-1. Changes in attitudes and approaches to risk

A study in 2002 concluded the following: *"The people's own efforts* were the most important reason for better preparedness for the floods in the Mekong delta in 2001, for reduced loss of life, reduced damage to property, and for quicker recovery from the devastation, when compared to 2000. The people affected by the floods reinforced their efforts because of higher awareness of what floods can do, and what can be done to live with the floods – and they became their own saviours. Their personal experience of the historical floods of 2000 was the main reason for their higher awareness in 2001 and today. They were greatly helped by timely warning about flood levels, and information about prevention, protection, and survival in the face of prolonged and high floods. This information and training was delivered by member-agencies of the provincial Committees for Flood and Storm Control, including several mass organisations, and especially the Viet Nam Red Cross. Many national and local agencies took part in flood preparedness, relief and rehabilitation efforts."
Source: (Neefjes, 2002)

DRM has been modified over the past decades, and with a long history of DRM, Viet Nam has also transited towards more comprehensive understanding of DRM, as witnessed for example by the DRM Law adopted in 2013 (Law 33/2013/QH13). However, adaptation to climate change is a more recent issue and globally there is limited experience whilst in Viet Nam there is only a very small scientific literature on adaptation, with experience mostly described in documentation on adaptation projects. Nevertheless, human adaptation to prevailing climate variability and change, and climate and weather extremes in past centuries and millennia provides a wealth of experience from which the field of adaptation to climate change can draw.

Disaster risks are not created only by specific local or micro processes but also by environmental, economic, social, and ideological influences whose sources are to be found at scales from the international through to the national, sub-national and local. Deforestation in the upper reaches of river basins, and land use changes in urban hinterlands are examples of 'extra-territorial' (non-local) influences on local risk. Moreover, disasters have ripple effects that can go well beyond the directly affected zones. DRM and adaptation policy, strategies, and institutions therefore require understanding and interventions that are based on multi-territorial and social-scale principles and where phenomena and actions at local, sub-national, national, and international scales are interacting and linked.

1.2. Extreme Events, Extreme Impacts, and Disasters

1.2.1. Distinguishing Extremes, Extreme Impacts and Disasters

Both the DRM and climate change adaptation literature define 'extreme weather' and 'extreme climate' events and discuss their relationship with 'extreme impacts' and 'disasters.' This section provides the definitions of different classes of extreme weather events, what characteristics determine that an impact is extreme, and how climate change affects the understanding of extreme climate events and impacts.

1.2.2. *Extreme Events Defined in Physical Terms*

1.2.2.1. Definitions of Extremes

In this report, 'extreme (weather or climate) event' refers to the initial and consequent physical phenomena including some that may have human components to causation other than that related to the climate (for example, flooding is affected by land use or land cover change or changes in water management; see Glossary).

Weather and climate phenomena reflect the interaction of dynamic and thermodynamic processes over a very wide range of space and temporal scales. This complexity results in highly variable atmospheric conditions, including temperatures, wind, and precipitation, a component of which is referred to as 'extreme events.' Extreme events include the passage of an intense tornado lasting minutes and the persistence of drought conditions over decades. Similarly, the spatial scale of extreme climate or weather varies from local to continental.

The extremity of a weather or climate event of a given magnitude depends on geographic context (see Chapter 3). For example: a month of daily temperatures corresponding to the expected January climatological daily maximum in the South-central region of Viet Nam, would be termed a heat wave in the Northern Mountains region. Similarly, average rainfall in An Giang province in the quarter July-September would be extremely unusual in Ninh Thuận.

1.2.2.2. Extremes in a Changing Climate

An extreme event in the present climate may become more common, or more rare, under future climate conditions. When the overall distribution of the climate variable changes, what happens to mean climate may be different from what happens to the extremes (see Figure 1-2) (IPCC, 2012a p.40-41). For example, a warmer mean climate could result from fewer cold days, leading to a reduction in the variance of temperatures, or more hot days, leading to an expansion in the variance of the temperature distribution, or both.

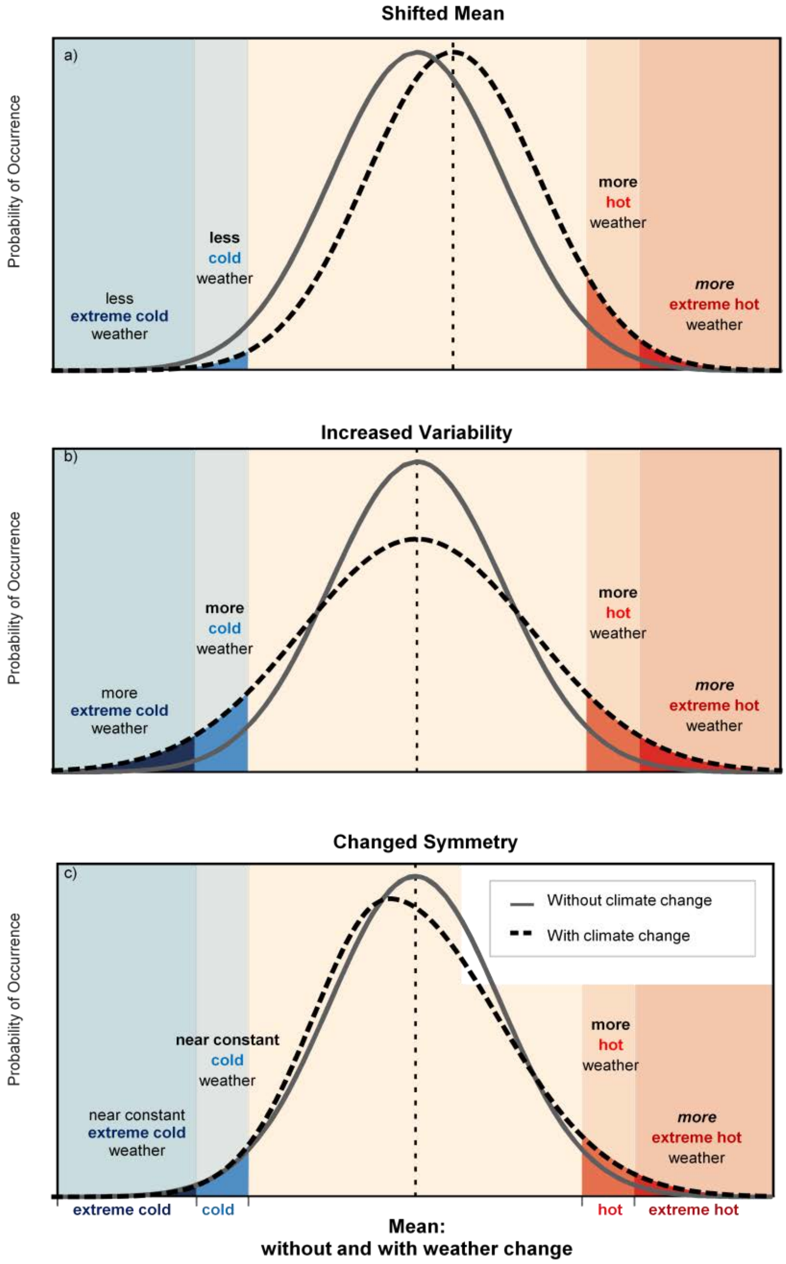
In general, single extreme events cannot be simply and directly attributed to *anthropogenic* climate change, as there is always a possibility the event in question might have occurred without this. But for certain classes of regional, long-duration extremes (of heat and rainfall) climate model outputs demonstrate that the probability of extremes has changed due to anthropogenic climate forcing.

Extremes sometimes result from the interactions between two unrelated geophysical phenomena such as a moderate storm surge coinciding with a spring tide. Climate change may alter both the frequency of extreme surges and cause gradual sea level rise, compounding such future extreme floods.

1.2.2.3. The Diversity and Range of Extremes

The specification of weather and climate extremes relevant to the concerns of individuals, communities, and governments depends on the affected stakeholder, whether in agriculture, disease control, urban design, infrastructure maintenance, etc. Accordingly, the range of such extremes is very diverse and varies widely. Among the more widely documented hydro-climatic extremes are (IPCC, 2012a p.41):

Figure 1-2. The effects of changes in temperature distribution on extremes



Nguồn: (IPCC, 2012b)

- Large cyclonic storms that generate wind and pressure anomalies causing coastal flooding and severe wave action.
- Floods, reflecting river flows in excess of the capacity of the normal flow channel, often influenced by human intervention and water management, usually resulting from intense precipitation in a river basin. River systems have characteristic response times depending on the characteristics of the catchment area. Urban drainage systems respond to heavy rainfall within a few hours, and peak flows in major rivers such as the Mekong or the Red river may last weeks, reflecting regional precipitation extremes.
- Long-term reductions in precipitation, or for example increased evapotranspiration from higher temperatures, often exacerbated by human groundwater extraction, contributing to drought.
- Landslides when triggered by raised groundwater levels after excess rainfall.

1.2.3. Extreme Impacts

1.2.3.1. Three Classes of Impacts

SREX presents three classes of impacts (IPCC, 2012a p.41): (1) changes in the natural physical environment, like beach erosion from storms and mudslides; (2) changes in ecosystems, such as the blow-down of forests in hurricanes, and (3) adverse effects on human or societal conditions and assets.

An **extreme impact** reflects highly significant and typically long-lasting consequences to the natural physical environment, ecosystems, or society. Extreme impacts can be the result of a single extreme event, successive extreme or non-extreme events, including non-climatic events (e.g., wildfire, followed by heavy rain leading to landslides and soil erosion), or simply the persistence of conditions, such as those that lead to drought.

Whether an **extreme event** results in extreme impacts on humans and social systems depends on the degree of exposure and vulnerability to that extreme, in addition to the magnitude of the physical event. Extreme impacts on human systems may be associated with non-extreme events where vulnerability and exposure are high. **Disaster** signifies extreme impacts suffered by society, which may also be associated with extreme impacts on the physical environment and on ecosystems.

Box 1-2. November 1999 historical floods in Central Viet Nam

On 20 October 1999 the central region experienced more than normal rainfall due to tropical storm Eve, affecting Ha Tinh and provinces further southwards with 100mm to 470 mm of rainfall, exceeding their monthly averages. The heavy rains continued in the days after and rivers in Quang Binh, Quang Tri, Quang Nam as well as Thua Thien Hue province reached extreme levels. In early November, the combined effect of a low pressure area over the East Sea and a cold front caused further heavy rainfall over the central region, severely flooding central provinces. Total cumulative rainfall recorded at Dong Ha station in Quang Tri between 1 and 4 November was about 800mm, compared to the long-term average of only 100mm for the same period.

As the water levels were high, the additional heavy rains caused extreme floods between 1 and 6 November in Central Viet Nam, said to be worse than historic floods in 1886, 1924, 1953 and 1983. The floods resulted in 825 deaths; an estimated USD380million in property damage with serious long-term social, economic and environment consequences in the Central provinces (BCĐ PCLBTƯ, 2000), including serious disruption of food supply, household incomes and business activities. All districts of Thua Thien Hue Province and many districts of Quang Tri, Quang Nam, Quang Ngai, Quang Binh, Da Nang, and Binh Dinh provinces were deeply inundated with many parts 2-4 m under water; National Highway 1A was 2 m under water and transportation from the North to the South was blocked for many days.

(source: ADPC, 2003).

1.2.3.2. Complex Nature of an Extreme 'Event'

The term 'event' does not adequately capture the compounding of outcomes from successive physical phenomena, such as a series of storms tracking across the same region. For example, there were two successive heavy rainfall events in the centre of Viet Nam in 1999, even though the resulting extreme floods are widely known as one major event. The aftermath of one extreme event may precondition the physical impact of successor events. High groundwater levels and river flows can persist for months, increasing the probability of a later storm causing flooding (see Box 1-2).

1.2.3.3. Metrics to Quantify Social Impacts and the Management of Extremes

Metrics to quantify social and economic impacts (i.e. extreme impacts) in Viet Nam include specific indicators in the following categories (See http://www.ccfsc.gov.vn/KW6F2B34/Co-so-du-lieu-thien-tai.aspx).

- Human casualties and injuries
- Damage of houses
- Damage of schools and health posts / hospitals
- Damage of other (public) infrastructure
- Damage of crops and livestock
- Damage of water management and coastal protection infrastructure
- Damage of transport infrastructure
- Damage of communication infrastructure
- Damage of energy infrastructure
- Damage of materials (including industrial products)
- Financial losses (by valuing specific losses in the above categories)

In addition, other metrics, which would enable more comprehensive analysis of impacts of extremes could also be included (IPCC, 2012a p.42):

- Number of permanently or temporarily displaced people
- Number of directly and indirectly affected persons
- Impacts on ecosystem services
- Impacts on disease vectors
- Impacts on psychological well being and sense of security
- Impacts on coping capacity and need for external assistance.

Information on direct, indirect, and collateral impacts is generally available for many large-scale disasters in Viet Nam recent history and is systematized and provided by the Central Committee for Flood and Storm Control (CCFSC; see above). In addition, the global Desinventar database (see: http://online.desinventar.org/ ; http://www.dmc.gov.vn/News/tabid/38/language/vi-VN/Default.aspx và http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=vnm), also includes some Viet Nam data whilst more data are being put in. Nevertheless, data availability is still limited and in particular the data on social and economic impacts of smaller-scale disasters is not comprehensively available for analysis.

The quantified metrics of impacts of extreme events may be used in probabilistic risk analysis, in order to inform policies. Probabilistic risk analysis defines risk as the product of the probability that some event (or sequence) will occur and the adverse consequences of that event. Equation (1) provides a quantitative representation of the qualitative definition of disaster risk.

$$\text{Risk} = \text{Probability} \times \text{Consequence} \qquad (1)$$

The DRM community often expresses risk as a product of hazard, exposure, and vulnerability, as in Figure 1-1, and those three factors contribute to 'consequences' in Equation (1). Hazard and vulnerability can both contribute to the 'probability' too: the former to the likelihood of the physical event (e.g., a river flooding a town) and the latter to the likelihood of the consequence resulting from the event (for example casualties and economic disruption).

Probabilistic risk analysis according to Equation (1) enables ranking of alternative sets of actions by their ability to reduce overall risk. However, probabilistic risk analysis is often not possible due to data limitations; satisfactory results may be achieved with less effort; and the need to address a wide range of factors that affect judgments about risk. For example, as part of a risk reduction effort a water management agency might invest into building a reservoir of sufficient size so that, if the largest drought observed in their region over the last 100 years (or some other timeframe) occurred again in the future, the agency would nonetheless be able to maintain a reliable supply of water. However, the water management agency may not perform a full probabilistic risk analysis, but instead apply a hybrid decision rule in which it estimates whether the consequences of running out of water would be so large, so as to justify any reasonable investment needed to keep the probability of that event below the chosen probabilistic threshold.

1.2.3.4. Traditional Adjustment to Extremes

Natural systems adapt to the prevailing climate including variability and extremes through for example natural selection of species. Human systems also adapt, for example communities traditionally facing periodic droughts may use boreholes, pumps, dams, and water harvesting and irrigation systems. Those with houses exposed to high temperatures may construct thick walls (passive cooling systems), and adapt their lifestyles. DRM and climate change adaptation may thus be seen as attempts to duplicate, promote, or improve upon adjustments that society and nature have accomplished in the past, as extremes are getting worse and also as (locally) un-usual hazards become more common, for which local traditional experience may not be available. The 'spontaneous' natural and human system adjustments can thus be enhanced with explicit measures that are taken to reduce risk from an expected range of extremes.

For example, typhoon threats in central Viet Nam are common in Central Viet Nam, with the strong winds, associated flooding and also storm surges causing destruction. After the historical floods in 1999 house designs an actual constructions were improved, to make them suitable for strong winds and storm surges, including houses of poor and vulnerable households (DWF, 2007). Typhoon Linda hit the southern tip of Viet Nam in 1997, a region where typhoons are unusual, which caused an exceptionally high number of casualties as well as destruction, because people and systems were unprepared. This was followed by efforts of "proofing" buildings for strong winds, for example schools. River floods are annual in the Mekong Delta but were extreme in 2000, which increased awareness and was followed by a range of improved DRM measures that also help adapt to longer-term climate change effects, including resettlement of particularly exposed and vulnerable households (Neefjes, 2002).

1.3. Disaster Management, Disaster Risk Reduction, and Risk Transfer

One important component of both DRM and adaptation to climate change is the appropriate allocation of efforts among disaster management, disaster risk reduction (DRR), and risk transfer. The *risk governance* framework helps judgments about disaster management, risk reduction, and risk transfer. It consists of four phases – pre-assessment, appraisal, characterization/evaluation, and management – in an open, cyclical, iterative, and interlinked process that is consistent with the UNISDR Hyogo Framework for Action (UNISDR, 2005).

Risk reduction aims to reduce exposure and vulnerability as well as the probability of occurrence of some events. *Risk transfer* aims to compensate losses suffered by those who directly experience an event. *Disaster management* aims to respond to the immediate consequences and facilitate reduction of longer-term consequences.

Risk governance uses concepts from probabilistic risk analysis to help judge the appropriate level of effort on risk reduction, risk transfer, and disaster management actions, i.e. compare the efficacy of alternative actions to manage risk. For instance, equivalent levels of risk reduction may result from reducing an event’s probability or by reducing its consequences by equal percentages. Since the costs of available risk reduction, risk transfer, and disaster management actions will in general differ, probabilistic risk analysis can help inform judgments about an effective mix of such actions in any particular case.

Probabilistic risk analysis is difficult because quantitative estimates of hazard and vulnerability are not always available and numbers are dependent on the individuals making those estimates. Estimates are determined by a combination of direct physical consequences of an event and the interaction of psychological, social, institutional, and cultural processes. People may ignore predictions of extreme events and basic needs may be a more pressing concern than attention to longer-term disaster risk. Personal beliefs influence which sources of forecasts of extreme climate events will be trusted, and how receptive people are to different types of interventions. Factual information interacts with social, institutional, and cultural processes in ways that may amplify or attenuate public perceptions of risk and extreme events. The public’s estimates of risk are often influenced by extreme events in recent history, or their absence.

Given this social construction of risk, effective allocations of efforts among risk reduction, risk transfer, and disaster management may best emerge from an integrated risk governance process, which includes the pre-assessment, appraisal, characterization/evaluation, and ongoing communications elements. DRM and adaptation to climate change each represent approaches that could be improved by the use of this risk governance process. For the effective prioritization of efforts to manage risks in both DRM and adaptation to climate change it is stressed that:

- Vulnerability, exposure, and hazard are each critical for determining disaster risk and the efficacy of actions taken to manage that risk.
- Effective DRM will require a portfolio of many types of risk reduction, risk transfer, and disaster management actions appropriately balanced in terms of resources applied over time.

- Participatory and decentralized processes that are linked to higher levels of territorial governance (regions, nation) are a crucial part of all the stages of risk governance that include identification, choice, and implementation of these actions.

1.3.1. Climate Change Will Complicate Management of Some Disaster Risks

DRM has historically operated under the premise that future climate will resemble that of the past. Climate change is very likely to increase the occurrence and vary the location of some physical events. This will increase the exposure faced by many communities, as well as their vulnerability so we expect an increase in disaster risk. Climate change also adds greater uncertainty to the assessment of hazards and vulnerability. This will make it more difficult to anticipate, evaluate, and communicate disaster risk.

1.3.1.1. Challenge of Quantitative Estimates of Changing Risks

Extreme events pose a particular challenge for probabilistic approaches because their relative infrequency makes it difficult to obtain adequate data for estimating the probabilities and consequences. Climate change exacerbates this challenge because it contributes to potential changes in the frequency and character of such events.

The likelihood of extreme events is most commonly described by the return period, the mean interval expected between one such event and its recurrence. For example, we speak of a 100-year flood or a 50-year windstorm. These intervals are inversely proportional to the 'annual exceedance probability,' the likelihood that an event exceeding some magnitude occurs in any given year. Thus the 100-year flood has a 1% chance of occurring in any given year, and there is a 37% chance of a century passing without at least one such flood ($(1-0.01)^{100} = 37\%$). Extreme events, by definition, have a low probability of being represented in past experience and thus will be relatively unavailable in observed data, i.e. the long return period of extreme events can make it difficult to estimate their frequency. In addition, climate change may reduce the accuracy of past observations as predictors for future risk, whereas it poses the challenge of non-stationarity (i.e. the statistical properties of weather events do not remain constant over time).

Estimating the likelihood of different consequences and their value is even more challenging. Projecting future vulnerability and response capacity involves predicting the trends and changes in underlying causes of human vulnerability and the behavior of complex human systems under stresses. For instance, actions to manage risk may affect future risk, whilst assigning a quantitative value to the consequences of a disaster is difficult, including both the expected **direct losses** and **indirect losses**.

1.3.1.2. Processes that Influence Judgments about Changing Risks

Effective risk governance engages a wide range of stakeholder groups – such as scientists, policymakers, private firms, nongovernmental organizations, media, educators, and the public. These groups have various perceptions and judgments about low-probability, high-severity events which complicates risk governance.

Experts often employ quantitative estimates of both probability and consequence in making judgments about risk. Expert estimates of changes in disaster risk due to climate change are often based on the results of complex climate models. In contrast, non-experts often rely on their own experiences, stories communicated through the news media, as well as their subjective judgment as to the importance of such events. When extreme events do occur with severe consequences, people's estimates of their future risks may become inflated. The gaps between expert and non-expert understanding of extreme events present important communication challenges and may adversely affect judgments about the allocation of efforts to address risk.

1.3.2. Adaptation to Climate Change Contributes to Disaster Risk Management

Adaptation to climate change attempts to anticipate future impacts on human society and ecosystems. Climate-related choices are based on the expected effects of climate change on ecological, economic, and social systems. An example of a climate-related decision is that Quy Nhon city put on hold its plans for expansion into the northern flood plains adjacent to the Thi Nai Lagoon, following a storm and flood in 2009; and mangrove restoration as a protective measure was initiated (Brown et al., 2012 p.549). A subsequent in-depth study recommended, amongst others, to "limit new residential, industrial and infrastructure development in the floodplain of the Ha Thanh River" (DiGregorio, 2013 p.45). Thus disaster risk management may receive added impetus from the context of a changing climate.

The DRM community can benefit from the adaptation literature about how to best incorporate information about current and future climate into climate-related decisions, although predictions of future climate impacts are uncertain whereas many communities do not sufficiently manage current risks, let alone future risks. The adaptation literature offers an **iterative risk management framework** that recognizes that the process of anticipating and responding to climate change does not constitute a single set of judgments at some point in time, but rather a continuous process of assessment, action, reassessment, and response. Iterative risk management recognizes that the estimates of future risk and future patterns of human vulnerability and the capability to respond are imprecise.

This international adaptation literature has explored approaches that can help making decisions despite uncertainties including decision rules based on the concept of robust adaptive policies that go beyond 'no regrets' by suggesting how in some cases relatively low-cost, near-term actions and explicit plans to adjust those actions over time can significantly improve future ability to manage risk (IPCC, 2012a p.48). Examples of this in Viet Nam would be full funding and reinforcement of the national plan on "Community awareness raising and community-based disaster risk management (CBDRM)" (Prime Minister Decision 1002/QD-TTg of 13 July 2009). This targets "6000 communes and villages frequently affected by disasters" by 2020, with an official budget of less than 1 trillion VND from different sources, which means on average about VND167 million or less than USD 8,000 per commune or village.

The adaptation and the resilience literatures can help highlight such issues as the tension between resilience to specific, known disturbances and novel and unexpected ones; the tension between resilience at different spatial and temporal scales; and the tension between the ability of a system to persist in its current state and its ability to transform to a fundamentally new state

(IPCC, 2012a p.48). Many less-developed regions will have limited success in reducing overall vulnerability solely by managing climate risk because vulnerability, adaptive capacity, and exposure are critically influenced by existing problems such as poverty and lack of access to health and education, which affect many vulnerabilities. For example, during floods in the Mekong Delta many of the poorest people manage to eat and earn some money if they have access to fishing nets and boats. The fishing net and boat distribution programmes during the historical floods in 2000 had limited scale, but the quality of boats was better than some earlier aid efforts, meaning they lasted several years. Furthermore, experience of floods in 2000 prompted other improvements in disaster preparedness and response, the success of which is suggested by reduced mortality during the (similarly severe) floods in 2001 and 2011, when compared with the effects of the floods in 2000. One response measure that improved in 2001, based on experience in 2000, concerned Child Care Centres run by the Vietnamese Women's Union (Neefjes, 2002), and resettlement programmes as a structural adaptive measure to reduce exposure to floods were reinforced through the 2000s and after 2011 (UN-Viet Nam, 2014).

1.3.3. Disaster Risk Management and Adaptation to Climate Change Share Many Concepts, Goals, and Processes

The effectiveness of the mix of actions used by communities to reduce, transfer, and respond to disaster risk could be substantially increased, across the world and also in Viet Nam. Exploiting the potential synergies between DRM and adaptation to climate change theory and practice will improve management of both current and future risks. DRM and adaptation to climate change both seek appropriate allocations of risk reduction, risk transfer, and disaster management efforts, for instance balancing pre-impact risk management or adaptation with post-impact response and recovery. In general, DRM can help those practising adaptation to climate change to learn from addressing current impacts. Adaptation to climate change can help those practising disaster risk management to more effectively address future conditions that will differ from those of today.

The two fields often use different terminology and they are the responsibility of different government organizations in Viet Nam as in other countries, but they also share many concepts, goals, and processes, whilst synergies could arise from their differences. Potential synergies from the fields' different emphases include the following (IPCC, 2012a trang 49-50):

- DRM covers a wide range of hazardous events, including non-climate hazards. Adaptation to climate change could benefit from experience in managing other disaster risks. For example, relocation and other responses to sea level change can be informed by experience with relocation away from earth quake prone areas; and public health challenges due to modifications in disease vectors due to climate change may be able to learn lessons from outbreaks of viruses circulating in animals that pose threats to human health, such as the ongoing efforts in Viet Nam to fight Avian Influenza. Moreover, like DRM, adaptation to climate change will often take place in areas also affected by other persistent and recurrent hazards. Learning from DRM can help adaptation, by increasing its focus on future changes in climate extremes.
- DRM has tended to encourage a bottom-up, grass roots approach, emphasizing local and community-based risk management. Much literature on adaptation to climate change focuses on social and economic sectors and macro ecosystems over large

regional scales, though another part is locally focused. Both fields could benefit from the body of work on the determinants of adaptive capacity that focus on the interaction of individual and collective action and institutions that frame their actions.

- The DRM literature emphasizes the social conditioning of risk and the construction of vulnerability as a causal factor in explaining loss and damage. Adaptation literature prioritizes physical events and exposure, seeing vulnerability as what remains after all other factors have been considered, although community-based adaptation work has considered social causation. Both fields could benefit from further integration of these concepts.

The DRM and adaptation to climate change literatures both emphasize the value of a holistic, integrated, trans-disciplinary approach to risk management. An integrated approach recognizes complex relationships in different contexts; highlights the importance of participatory decision processes; and emphasizes that many organizations face climate-related decisions whether they recognize them or not.

The following areas have been proposed for integration between adaptation to climate change and DRM (IPCC, 2012a p.50):

- Development of a common lexicon of concepts and terms used
- Government policymaking that jointly considers the two topics
- Evolution of national and international organizations and institutions that merge and synchronize around the two themes. This could mean for Viet Nam, for instance closer coordination and cooperation between climate change (adaptation) units in the Ministry of Environment and Natural Resources (MONRE) and the Disaster Management structures coordinated by the Ministry of Agriculture and Rural Development (MARD), as well as their affiliates at provincial and lower levels.
- Merging and/or coordinating DRM and adaptation financing mechanisms.
- The use of participatory, local analysis methodologies inspired by disaster risk management is now accepted by many civil society and government agencies, including analysis of vulnerabilities, capacities and social discrimination according to gender and age (UN-Viet Nam and Oxfam, 2009; Neefjes and Nelson, 2010). The use of this approach is also being institutionalized in the national plan for Community Based Disaster Risk Management (CBDRM) mentioned above.
- Implementing bottom-up approaches whereby local communities integrate adaptation to climate change, DRM, and other concerns in a single intervention framework.

1.4. Coping and Adapting

This section aims (a) to clarify the relationship between adaptation and coping, particularly the notion of coping range; (b) to highlight the role of learning in an adaptation process; (c) to discuss barriers to successful adaptation and the issue of mal-adaptation; and (d) to highlight examples of learning in the DRM community that have already advanced climate change adaptation.

1.4.1. Definitions, Distinctions, and Relationships Coping, Capacity, Adaptive Capacity, and the Coping Range

The current UNISDR definition of **coping** is the "ability of people, organizations, and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters" (UNISDR, 2009). Emergencies and disasters are post facto circumstances, but 'adverse conditions' is an indeterminate concept that could include negative pre-impact livelihood conditions and disaster risk circumstances or merely post-impact effects.

Coping focuses on the moment, constraint, and survival; **adapting** (in terms of human responses) focuses on the future, where learning and reinvention are key features and short-term survival is less in question (although it remains inclusive of changes inspired by already-modified environmental conditions). As noted in Table 1-1, contrasting the two terms highlights several important dimensions in which they differ – exigency, constraint, reactivity, and orientation (IPCC, 2012a p.51).

Table 1-1. The various dimensions of coping and adapting

Dimension	Coping	Adapting
Exigency	Survival in the face of immediate, unusually significant stress, when resources, which may have been minimal to start with, are taxed.	Reorientation in response to recent past or anticipated future change, often without specific reference to resource limitations.
Constraint	Survival is foremost and tactics are constrained by available knowledge, experience, and assets; reinvention is a secondary concern.	Adjustment is the focus and strategy is constrained less by current limits than by assumptions regarding future resource availability and trends.
Reactivity	Decisions are primarily tactical and made with the goal of protecting basic welfare and providing for basic human security after an event has occurred.	Decisions are strategic and focused on anticipating change and addressing this proactively, even if spurred by recent events seen as forerunners of further change.
Orientation	Focus is on past events that shape current conditions and limitations; by extension, the focus is also on previously successful tactics.	Focus on future conditions and strategies; past tactics are relevant to the extent to which they might facilitate adjustment, though some experts believe past and future orientation can overlap and blend.

Source: (IPCC, 2012a p.51)

For example, a community cannot adapt its way through the aftermath of a disastrous typhoon; it must cope instead. Its coping capacity is a function of currently available resources that can be used to cope, and determines the community's ability to survive the disaster intact. Repeated use of coping mechanisms without adequate time and provisions for recovery can reduce coping capacity, shift a community into poverty and make them increasingly vulnerable to future hazards. Adaptation to future typhoons, however, can limit the need for coping that may be required to survive the next storm. A community's adaptive capacity will determine the degree to which adaptation can be pursued. Adaptive capacity focuses on longer-term and more sustained adjustments.

The **coping range** is defined as “the capacity of systems to accommodate variations in climatic conditions” (IPCC, 2007b p.142). This refers to a range of circumstances within which no significant consequences are observed, so a community can survive and even thrive with natural hazards, especially if historical distribution of hazard intensity is well known and relatively stable. A community’s coping range is partly determined by prior adaptation. As climate change alters future variability and the occurrence of extreme events, and as societal trends change human systems’ vulnerability, adaptation is required to adjust the coping range.

1.4.2. Learning

Risk management decisions are made within **social-ecological systems** (i.e. social systems intimately tied to and dependent on environmental resources and conditions). The ability to cope with extreme stress and resume normal function is an important component of **resilience** of social-ecological systems, but learning, innovation, reorganizing, and changing over time are important for making systems more resilient (IPCC, 2012a p.53).

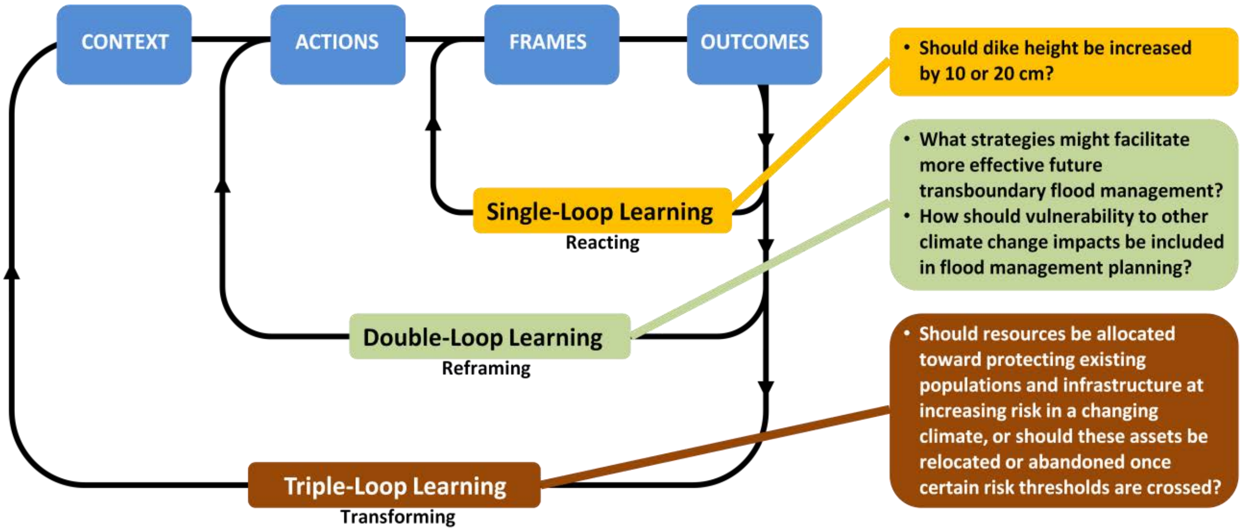
The literature on adaptation to climate change emphasizes iterative learning and management plans that are explicitly designed to evolve as new information becomes available. The field of DRM provides important examples of learning that could be instructive to adaptation practitioners.

Some learning strategies include the use of knowledge co-production (scientists, policymakers, and other actors work together to exchange, generate, and apply knowledge), and action research (researchers develop hypotheses about real-world problems and revise management strategies based on the results). Prior work on learning theories emphasize the importance of action-oriented problem-solving, learning-by-doing, concrete learning cycles, and how these processes result in reflection, reconsideration of meaning, and re-interpretation of value structures. The learning loop framework integrates these theories and divides learning processes into three different loops depending on the degree to which the learning promotes transformational change in management strategies. Figure 1-3 outlines this framework and its application to the issue of flood management (IPCC, 2012a p.53).

- **Single-loop learning** focuses primarily on actions; data are integrated and acted on but the underlying mental model used to process the data is not changed.
- **Double-loop learning** assesses whether management goals and strategies are appropriate. Data are used to promote critical thinking and challenge underlying mental models of what works and why. It will prompt questions about whether the increased likelihood of losses justifies different risk management decisions, ranging from increased investments to changed insurance policies for the vulnerable populations.
- **Triple-loop learning** questions the underlying principles. In response to evidence that management strategies are not serving a larger agreed-upon goal, that is, they are maladaptive, triple-loop learning questions how the social structures, cultural norms, dominant value structures, and other constructs that mediate risk and risk management might be changed or transformed.

Different types of learning are more or less appropriate in given circumstances. For example, single-loop learning may be problematic in rapidly changing circumstances as it draws on existing skills and memories specific to particular circumstances. Double- and triple-loop learning are better suited to situations with new hazard regimes and for populations exposed to multiple risks and stressors. Triple-loop learning can lead to recasting social structures, institutions, and constructions that contain and mediate risk to accommodate more fundamental changes in world view.

Figure 1-3. Learning loops: pathways, outcomes, and dynamics of single-, double-, and triple-loop learning and applications to flood management



Source: (IPCC, 2012a p.53)

1.4.3. Learning to Overcome Adaptation Barriers

Learning focused on barriers to adaptation can be particularly useful. Resource limitations are a significant impediment in pursuing adaptation strategies, depending on the context.

Research on barriers has generally focused on adaptation as a process, recognizing the difficulty in giving a universally acceptable definition of successful adaptation outcomes. Some researchers have considered whether particular activities should be considered **maladaptive**, defined as an "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors, or social groups" (Barnett and O'Neill, 2010 trang 211). This could include, for example, flood protection measures that reduce flood risks for some localities in the Mekong Delta but that could amplify the risk to those who are not protected and will be exposed to higher flood levels because the flood plains and water storage capacity of the overall delta reduce in size. In the case of coastal dykes that protect from storm surges there is also a potentially false sense of security. As the overall likelihood of a catastrophic flood overwhelming the dykes' protective capacity increases over time as a result of climate change, what can be considered 'adaptive' in the present time may be maladaptive later.

The Dutch have created "room for the river" plans to get ready for higher peak water discharges, which requires additional space, land purchase and relocations; and they plan for a higher water level in the central IJsselmeer lake for increased natural drainage to the sea and as a reserve in years of extreme drought (Deltacommissie, 2008). The Mekong Delta Plan was inspired by this Dutch approach of "working together with water" and includes recommendations for protection against flooding, managed inundation, and provision of temporary water retention capacity, also in urban centres, as comparatively high water levels would allow for low-tide (urban) water drainage without pumping. In the longer term a river bypass system is proposed to lower the Mekong river peak flows (that are expected to increase because of climate change), which will require "high investments" and "tough spatial planning" to reserve the space for a large bypass canal, and considerable additional study (Anonymous, 2013 pp.88-90).

Risk sharing through insurance schemes requires proper pricing of risk so that, in the event risk is realized, there is an adequate pool of capital available to fund recovery. When risk is improperly priced and risk sharing is not adequately regulated and monitored, an adequate pool of reserves may not accumulate. An insurance system designed to motivate adaptation by for example individual homeowners or flood protection agencies can function properly only if technical rates that properly reflect empirically determined levels of risk can be established. Insurers may be reluctant to charge the full technical rate because consumers have come to assume that insurance costs should be relatively consistent in a given location, but levels of risk vary in space and time. Without charging technical rates that apply to specific situations it is difficult to use pricing to motivate adaptation strategies such as flood proofing or elevating the ground floor of a new development, restricting where properties can be built, or justifying the construction of communal flood defenses. In places where risk levels are rising due to climate change under prevailing negative conditions of exposure and vulnerability, planning and management could promote more adaptive risk management. Otherwise, maladaptive risk management decisions may commit (public or private) resources to coping and recovery rather than successful adaptation and may force some segments of society to cope with disproportionate levels of risk.

1.4.4. 'No Regrets,' Robust Adaptation, and Learning

The mismatch between adaptation strategies and projected needs has been characterized as the potential for **regret**, that is, opportunity costs associated with decisions that are optimal for one or a small number of possible climate futures but not necessarily robust over a wider range of scenarios. '**No regrets**' adaptation refers to decisions that have net benefits over the entire range of anticipated future climate and associated impacts. To address the challenge of risk management in the complex context of climate change and development, as well as under conditions where probabilistic estimates of future climatic conditions remain imprecise, several authors have advanced the concept of robustness, of which 'no regrets' adaptation is a special case. **Robustness** is a property of a plan or strategy that performs well over a wide range of plausible future scenarios even if it does not perform optimally in any particular scenario. Robust adaptation plans may perform relatively well even if probabilistic assessments of risk prove wrong because they aim to address both expected and surprising changes, and may allow diverse stakeholders to agree on actions even if they disagree about values and expectations (IPCC, 2012a p.56).

To be effective, adaptation should prioritize measures that increase current as well as future resilience to threats. Robustness over time would increase if learning were a central pillar of adaptation efforts, including learning focused on addressing current vulnerabilities and enhancing current risk management. Single-, double-, and triple-loop learning will all improve the efficacy of management strategies. This is illustrated by case studies in Chapter 9 and throughout this report, with examples of learning in DRM relevant to a wide range of climate-sensitive threats and a variety of sectors.

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Chapter 2

Determinants of Risk: Exposure and Vulnerability

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Summary

Disaster risk is not fixed but is a continuum in constant evolution. A disaster is one of its many 'moments' signifying unmanaged risks [2.2.1]. Disaster risk derives from a combination of 3 determinants: (1) **physical hazards**; (2) **exposure**; and (3) **vulnerability**. **Changes in exposure and vulnerability determine the severity of the disaster risk** [2.2.2].

Vulnerability and exposure are dynamic and varying across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Individuals and communities are differentially exposed and vulnerable and this is based on factors such as the settlement area, health status, ethnicity, gender, age, social networks and their resource dependent livelihoods [2.2, 2.3, 2.5].

To minimize disaster risk, it is important to reduce both exposure and vulnerability. The reduction of exposure without vulnerability reduction does not help reduce the disaster risk. Therefore, resesttlement program should pay more attention on livelihood development and vulnerability reduction of community after the resettlement process. To avoid the relocation several times, the selection of specific area for resettlement should fully assess the exposure and vulnerability in the future based on different climate change scenarios [2.2.2].

The existence of vulnerability does not mean an absolute, but rather a relative lack of capacity. Capacity needs for each phase of disaster risk management are different: Capacity to anticipate and reduce risk before disasters, capacity to respond in disasters, and capacity to recover and change after disasters. Capacity is dynamic and changes in different circumstances. Extreme and non-extreme weather and climate events also affect vulnerability to future extreme events, by modifying the recovering, coping, and adaptive capacity of communities, societies, or social-ecological systems affected by such events [2.4].\

High vulnerability and exposure are generally the outcome of skewed development processes, such as those associated with environmental mismanagement, rapid and unplanned urbanization in hazardous areas, failed governance, and the scarcity of livelihood options for the poor [2.2.2, 2.5].

Vulnerability reduction is a core common element of adaptation and disaster risk management [2.2, 2.3]. Adaptation and risk management policies and practices will be more successful if they take the dynamic nature of vulnerability and exposure into account, including the explicit characterization of uncertainty and complexity at each stage of planning and practice [2.4.2, 2.5.4, 2.6.2].

2.1. Introduction

Chapter 1 defines disaster and disaster risk, as well as other important concepts including hazard, exposure and vulnerability. This chapter aims to provide understanding and assessment, by further detailing and indepth analysis the determinants of risk, as well as the interaction between these determinants.

The first section of this chapter (Section 2.2) elucidates the similarity and differences between disaster and disaster risk based on international and Vietnamese literatures. Some main disasters in Viet Nam including typhoon, flood and drought are referred. Section 2.3 analyzes drivers changing vulnerability; whereas, section 2.4 highlights the role of coping and adaptive capacities, as well as resilience to climatic extremes. The following section (2.5) describes different dimensions and trends of vulnerability and exposure including environmental, economic and social areas, as well as their interaction and cross-cutting themes. Given that exposure and vulnerability are highly context-specific, this section is by definition limited to a general overview. Section 2.6 identifies and assesses climate risks and the chapter concludes with a discussion of risk accumulation (section 2.7).

2.2. Defining Determinants of Risk: Hazard, Exposure and Vulnerability

2.2.1. Disaster and Disaster Risk

As detailed in chapter 1 (section 1.1.2.1), **disasters** are defined as severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012 page 31). Law on Natural Disaster Prevention and Control (33/2013/QH13) defines disaster as "abnormal natural phenomena which may cause damage to human life, property, the environment, living conditions and socioeconomic activities" (Viet Nam National Assembly, 2013). In fact, disasters are not only abnormal natural phenomena, but also include all adverse effects of those phenomena on societies and communities. Therefore, this report applies the definition used in IPCC's report.

Decree 14/2010/NĐ-CP (article 3) stipulating organization, duties and powers and coordination mechanism of central steering committee for flood and storm prevention and control, the steering committee for flood and storm prevention and control and search and resecue of minitries, sectors and localities lists 13 types of hazards: "heavy rain, tropical depression, storm, flood, flash flood, inundation, thunderstorm, whirlwind, lightning, landslide caused by flood, surges, earthquake, tsunami" (The Government of Viet Nam, 2010). However, the decree 14 does not include many different types of hazards, including drought, rock slide, storm surge, sea level rise, urban flooding… In the context of climate change, these types of hazards become more frequent.

Drought causes the third greatest loss in Viet Nam, following typhoon and flood (Lê Sâm and Nguyễn Đình Vượng, 2008 page 45; WHO, 2014 page 3). Although it rarely cause accidents and injuries, drought has major impacts on human health due to lack of clean water, poor sanitation and malnutrition (WHO, 2014 page 3) and on human lives and local agriculture production. The risk of drought is become more crucial in Viet Nam. Drought is likely to appear more frequent and severe in the future under the impact of climate change. The number of arid days will tend to longer in Viet Nam. The risk of drought and the duration of drought spells are tend to increase significantly in the 21st century, especially in the drough regions as Central Highlands and Southern Central Viet Nam (Nguyễn Văn Thắng et al., 2010; MONRE, 2013) (see Chapter 3).

Flood and typhoon are the most frequent and cause highest economic losses. In average, Viet Nam is affected directly by 6-7 tropical storms annually. According to the data from the Central Committee for Flood and Storm Control (CCFSC), in the period of 1990-2010, Viet Nam experienced 74 floods. Typhoons and floods always cause serious consequences. For example, the Linda typhoon in 1997 in Southern Viet Nam caused severe damage: 3,000 death and missing, 100,000 collapsed houses, and more than 300,000 damaged hectares of crops (CCFSC, 1997; The Government of Viet Nam, 2005); In Central Viet Nam, the Xangsane typhoon in 2006 made 76 death and missing, including 37 death and missing directed by the typhoon and the rest by heavy rains and floods after the typhoon, and 532 injured people. The dead-toll in floods was mostly children because of their carelessness. Central Provincies were damaged heavily and the total losses were estimated at around10,000 billion Viet Nam Dong, equivalent to nearly 677 million USD. Da Nang, Thua Thien Hue and Quang Nam are the most affected provinces (CCFSC, 2006). According to the report “High resolution climate projections in Viet Nam”, the frequency of typhoon in Eastern Sea tends to decrease, but the intensity cound increase (MONRE, 2013) (see section 3.4.2 in chapter 3). In recent years, flash flood occurs more frequently, often accompanied with landslides in mountainous regions in Viet Nam. The consequences of flash floods and rock slides have become more and more extreme because of their abnormality, unpredictability and occurence in a remote and inaccessible area (see chapter 9).

Law on Natural Disaster Prevention and Control (No. 33/2013/QH13) defines **natural disaster risk** means damage, which natural disasters may cause to human life, property, the environment, living conditions and socio-economic activities (Viet Nam National Assembly, 2013). However, disaster risk is the high possibility of disaster occurrence. Therefore, disaster risk is defined for the purposes of this study as the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012 page 32). **Disaster risk** is not fixed but is a continuum in constant evolution; a disaster is one of its many moments, signifying unmanaged risks (IPCC, 2012 page 69). UNDP is supporting Viet Nam in developing and completing the disaster risk map, with detailed information for each commune. For further understanding disaster risk, the following section analyses different determinants of risk.

2.2.2. The Factors of Risk

In Global Climate Risk Index 2015, the Climate Risk Index thus indicates a level of exposure and vulnerability to extreme events that countries should understand as warning to be prepared for more frequent and/or more severe. With 24 scores in the Long-Term Climate Risk Index, Viet Nam ranks the 7th over the period of 1994-2013 (Kreft et al., 2015 page 6).

According to SREX of IPCC, disaster risk derives from a combination of 3 determinants: (1) physical hazards; (2) exposure; and (3) vulnerability. Without one of the three determinants, there is no disaster risk. Figure 1-1 in chapter 1 provides a schematic of the relationships and interaction among the three determinants of disaster risk.

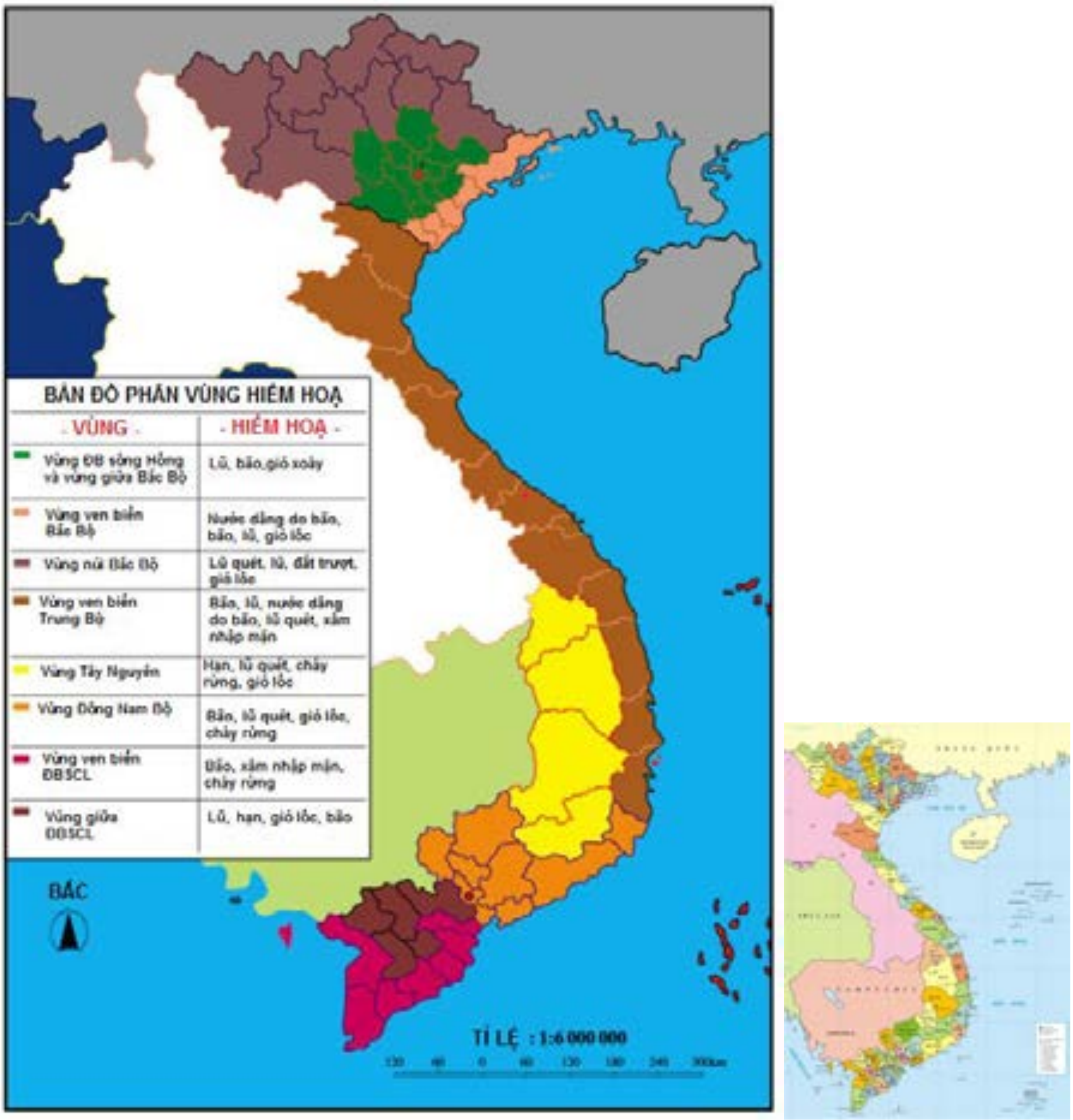
Hazard refers to the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements (IPCC, 2012 page 32 and 69). A climatic event is considered as a hazard if social or ecological factors are vulnerable and exposed to severe impacts of the climatic event. In this research, hazard is a potential threat with disadvantage impacts, and not the nature of that event. Hazard is a component of disaster risk and not risk or disaster itself.

According to the ODI report on the geography of poverty, disasters and climate extremes in 2030, Hazards may occur in different parts of a single country, but can affect the whole of that country from an economic and governance perspective. The ODI report based on global hazard indicators including drought, extreme temperature, flood, tropical cyclone and earthquake shows that India, Mexico and United States have the highest multi-hazard rating. Viet Nam and other four countries (Bangladesh, Laos, Myanmar and Thailand) rank fourth over in the historic period (1971-2000). Viet Nam also ranks fourth in the expected mutli hazard rating in 2030s (Shepherd *et al.*, 2013 page 40). Figure 2-1 shows the map of hazard zones in Viet Nam

Exposure is employed to refer to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage (IPCC, 2012 page 32). Exposure is necessary, but not sufficient to determine the risk. A person may be exposed to hazards, but may not be vulnerable (for example, a person living in the flood-prone area may have all facilities to change the building structure and limit losses). There is no risk if a person is vulnerable, but donot expose to hazards.

Timing and spatial scales are important in determining the exposure to hazards. If a person only visits a place to be exposed to hazards, their exposure increases. Conversely, early warnings and people are evacuated timely, their exposure to hazards decreases (IPCC, 2012 page 237). For example, evacuation of 60,000 people (about 16,000 households) in Quang Nam Province before the Ketsana typhoon in late September 2009 reduced the losses of people and properties (JANI, 2011 page 28) (see further information on Ketsana typhoon in section 5.2 chapter 5). Timing and spatial scales are further analyzed in section 2.5.4.

Figure 2-1. Map of hazard zones in Viet Nam



(Source: The Government of Viet Nam, 2005)

In Viet Nam, resettlement programs for people in flooded and erosion areas, specifically the program of residential clusters and areas along the dykes in the Mekong Delta, relocating households in vulnerable areas to a higher area help reducing their exposure to hazards (Lebel and Bạch Tân Sinh, 2009; UN-Việt Nam, 2014 page viii and 17). However, relocation only helps to reduce the exposure, not vulnerablilty of communities. If the flood level is higher than residential clusters and dykes, disaster risk is still there. Therefore, to minimize the disaster risk, it is important to reduce both the exposure and vulnerability.

Vulnerability is an important concept of disaster risk management and climate change. This concept is also used in many sectors. Nguyễn Thanh Sơn and Cấn Thu Văn (2012, page 116-117) analyze three schools of thoughts on vulnerability. The first one "focuses on exposure to physical hazards, including hazardous sites where people are living, the scope of damage and characteristics of impacts”. The second “focuses on social aspects and social vulnerability to cope with adverse impacts on community including resilience and the capacity to recover. The last one combines both above schools of thoughts and determines vulnerability as a combination of risk and social adaptation (Nguyễn Thanh Sơn and Cấn Thu Văn, 2012 page 117). Vulnerability os interpreted differently among sociologists and climatologists. Sociologists tent to understand vulnerability as a combination of socioeconomic factors determing cope capacity to stresses or changes; meanwhile, the climatologist often consider vulnerablily in terms of likelihoods and impacts of weather and climate events (Brooks, 2003 page 2-3). Vulnerability is also understood as a function of the exposure, sensitivity and adaptive capacity (IPCC, 2007 page 883; see IPCC, 2001 page 995). However, as indicated in section 1.1.2.1 chapter 1, vulnerability should be independent with physical phenomena (IPCC, 2012 page 33).

Vulnerability can be seen as situation-specific, interacting with a hazard event to generate risk. Vulnerability refers to the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events (IPCC 2012, page 69). Vulnerability is how adverse impacts affect the capacities to prevent and respond to a hazard of an individual, a household or a community and how the impacts of climate change lead to losses and damages (Adger, 1999; IWE, 2009; McElwee, 2010; Mai Trọng Nhuận et al, 2009). There are many drivers of vulnerability which are further analyzed in section 2.3.

Maplecroft publish annual climate change and environmental risk atlas in which climate change vulnerability index forms the central part of the Atlas. Climate change vulnerability index showes the exposure, the sensitivity, development, agricultural dependency, research and development, the effectiveness of government and education (Maplecroft, 2013).

In 2013, Maplecroft’s Climate Change Vulnerability Index (CCVI) evaluates 50 cities that were chosen for their current and future importance to global business. HCMC rank 6th in 7 cities most vulnerable and facing most risk from climate extremes (Maplecroft, 2012). Viet Nam is also evaluated as one of the countries facing ‘high’ or ‘extreme risks’ from the impacts of climate change (Maplecroft, 2013).

Exposure and vulnerability are two distinct concepts but closely link with each other. Therefore, in many cases, people mistakenly conflate the two concepts and consider one as a part of the other (IPCC, 2012 page 69). This also happens in Viet Nam. In many literature and common usage, exposure is considered as a part of vulnerability or is rarely mentioned. For example in the “Training material: diaster risk reduction and climate change adaptation”, exposure is ignored and considered as one part of vulnerability (MARD and UNDP, 2012 page 5, 70-71). Đặng Đình Khá (2011) assessed the vulnerability to flood in Thanh Han River, Quang Tri Province; Đỗ Thị Ngọc Hoa (2013) assessed the vulnerability to flood in Thu Bồn River, Quảng Nam province, or Nguyễn Thanh Sơn and Cấn Thu Văn (2012) assessed the vulnerability to flood in Central region. All these studies considered exposure as one part of vulnerability.

High vulnerability and exposure are mainly an outcome of skewed development processes (IPCC, 2012 page 70), including those associated with investment policies, environmental mismanagement, demographic changes, rapid and unplanned urbanization, and the scarcity of livelihood options for the poor (see section 4.2 chapter 4).

2.3. The Drivers of Vulnerability

This section analyses factors driving vulnerability to climate extremes, as well as to climate change. Identifing these factors is important for vulnerability assessement of a local community to climate change.

Currently all studies on vulnerability assessment mostly focus on exposure to hazards, numbers of poor households, etc. However, these above factors are not suficient to measure the vulnerability of a household or a community. SREX report of IPCC describes vulnerability is a set of conditions of people that derive from the historical and prevailing cultural, social, environmental, political, and economic contexts (IPCC, 2012 page 31 and 71). Therefore, Thus, the effects of a disaster on any particular household result from a complex set of drivers and interacting conditions.

Training Material on Disaster Risk Management and Climate Change Adaptation (MARD and UNDP, 2012 page 5 and 78-80) classifies five broad categories contributing to vulnerability, including physical factors, social-cultural factors, economic factors, environmental factors and governance factors. Aspects of socio-cultural vulnerability include access to food and water, health status and access to healthcare, levels of literacy and education, social equity and marginalization, age, and cultural aspects. Economic factors influence the vulnerability of households, communities and nations to the impacts of disasters. Poverty is often associated with not only incomes, but also lack of access to better quality of life, opportunities, physical assests, socio-cultural and environmental assets, and collective resources to provide basic services. Multi-dimensional poverty method helps provide a general concept of poverty. Multi-dimension approach of UNDP has 8 dimensions of poverty which are income, education, health, social security, housing services, housing quality/area, physical safety, and social inclusion (UNDP-Việt Nam, 2010 page 18-19).

Füssel (2007 page 158) distinguishes four groups of vulnerability factors based on sphere (or scale) and knowledge domain (see table 2-1). Regarding to sphere/scale, there are two groups of internal and external vulnerability groups. However, the designation of a specific factor as internal or external may depend on the scope of the vulnerability assessment. Provincial development policies, for instance, would be regarded as internal in a provincial assessment but as (largely) external in a local assessment (community, village, commune, and provincial levels) in that province.

Table 2-1. Examples for vulnerability factors

Scale	Vulnerability factors	
	Socio-economic	Biophysical
Internal	Gender, household income, livelihoods, education, social networks, access to information …	Topography, geography, environmental condition, biological diversity, land use …
External	Government policies, price fluctuation, international aid, economic globalization…	Floods, inundation, storms, sea level rise, salinization, landslide …

2.4. Coping and Adaptive Capacities

Capacity refers to the combination of all the strengths, attributes, andresources available to an individual, community, society, or organization that can be used to achieve established goals (IPCC, 2012 page 33). Capacity is dynamic and changes in specific conditions. Capacity is an important factor in conceptual frameworks of vulnerabilities and risks. Capacity strengthening is identified as a target of several policies and projects as it is considered to lead to risk reduction. Capacity plays an important role in reducing the impacts of climate change (IPCC, 2012 page 72).

Disaster risk management and climate change adaptation requires both coping and adaptive capacities. Coping is the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term (IPCC, 2012 page 558). Coping is used for actions happened after a disaster, while adaptation is associated with actions before a disaster. It means that coping capacity refers to the ability to react to and reduce the adverse effects of experienced hazards, whereas adaptive capacity refers to the ability to anticipate and transform structure, functioning, or organization to better survive hazards (IPCC, 2012 page 72). Coping strategies are short-term responses, and adaptive strategies are long-term responses (Tạ Thị Thanh Hương , 2010). Berkes and Jolly (2001) coping strategies as "the bundle of short-term responses to situations that threaten livelihood systems, and they often take the form of emergency responses in abnormal seasons or years". Adaptive strategies are described as "the ways in which individuals, households, and communities change their productive activities and modify local rules and institutions to secure livelihoods". Although coping capacity is often considered to be part of adaptive capacity, the capacity to cope does not infer the capacity to adapt. Table 1-1 in section 1.4.1, chapter 1 highlights some of the differences between coping and adaptation.

ODI report on the geography of poverty, disasters and climate extremes in 2030 shows that Viet Nam's adaptive capacity and disaster risk management are quite good with opportunities to reduce the impacts of disasters now and in the future, although it is a high hazard and high poverty country (Shepherd et al., 2013).

2.4.1. Different capacity needs

The resilience perspective emerged from ecology in the early 1970s through the study of ecological systems and their stability and ability to absorb change (Holling, 1973). Then, it became an essential theory which influenced various fields outside ecology, especially interdisciplinary studies (Folke, 2006), biodiversity (Folke et al., 1996), property rights and commons property (Berkes and Folke, 1998; Hanna et al., 1996), and socioeconomic systems (Levin et al., 1998). The resilience perspective also shifts policy approaches from controlling change in systems to managing the capacity of social-ecological systems to cope with and adapt to changes and disturbances (Berkes, 2003; Folke, 2006; Smit and Wandel, 2006). **Resilience is defined as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions** (IPCC, 2012 page 34). Levels of resilience are defined by three criteria: (1) the amount of change the system can undergo and still retain the same controls on function and structure; (2) the degree to which the system is capable of selforganization; and (3) the ability to build and increase the capacity for learning and adaptation(The Resilience Alliance, 2002). In the field of disaster risk reduction, resilience building and lack of resilience are used and link up with the capacity of communities and societies to cope with the impacts of hazards and the capacity to learn and strengthen resilience.

Capacity needs for each phase of disaster risk management are different: Capacity to anticipate and reduce risk before disasters, capacity to respond in disasters, and capacity to recover and change after disasters. Capacity is dynamic and changes in different circumstances.

Capacity to anticipate risk is very important to prevent and reduce risks before a hazard occurs (IPCC, 2012 page 74). Early warning system is considered as one of the most important measures to reduce human losses and economic damages due to floods, drought, storms, forest firer, and other hazards. Effective early warning requires the comprehensive coordination from central to local governments and suitable policies which help strengthen risk prevention capacity at the local level (see section 5.3.1 in chapter 5 and section 9.2.8 in chapter 9). In addition, indigenous knowledge, specifically community experiences, also plays an important role in anticipating and preventing climate risks (see section 5.4.4 in chapter 5).

Capacity to anticipate risk depends on how they learn from their past experiences, apply lessons learnt to reduce the impacts of future climate risks. For example, the storing of food in Tay Giang district, Quang Nam province provided sufficient food for villages and households in almost half of a month during Typhoon Ketsana. (JANI, 2011 page 29). Capacity to anticipate and reduce risk can be understood as several factors, measures and tools to reduce current and future risks. Development plans such as landuse planning, urban development, river management, and ecosystem protection help reduce exposure and vulnerability. For example, urban development in high risk areas should have adaptive landuse planning and appropriate building standard to reduce risk effectively. (Storch *et al.*, 2013) (see section 5.3.3 chapter 5).

Capacity to respond encompasses everything necessary to be able to react once an extreme event takes place, in particular during emergency response (IPCC, 2012 page 74-75). However, effective response requires substantial planning and significant investment in disaster preparedness and early warning (not only in terms of financial cost, but particularly in terms of awareness raising and capacity builing) (IFRC, 2009). Furthermore, there are also response phases for gradual changes in ecosystems or temperature regimes caused by climate change.

Capacity to recover and change is required after climate disasters. In the context of natural hazards, the opportunity for changing is often greatest during the recovery phase, when physical infrastructure has to be rebuilt and can be improved, and behavioral patterns and habits can be contemplated (IPCC, 2012 page 75). This is an opportunity to rethink whether the crops planted are the most suited to the climate and whether it is worthwhile rebuilding hotels near the coast, taking into account what other sorts of environmental changes may occur in the area. Capacity to recover is not only dependent on the extent of a physical impact, but also on the extent to which society has been affected, including the ability to resume livelihood activities. This capacity is driven by numerous factors, including mental and physical ability to recover, financial and environmental viability, and political will. Reconstruction processes often do not take people’s livelihoods into account, instead focusing on their safety. For example, in the resettlement process to resettled dykes and clusters, peopled are located where people donot want to be, where there is no opportunities for livelihood development. The process may bring change, but not necessarily change that leads to sustainable development. Therefore, many people return back to their original location or move to a new appropriate area (UN-Việt Nam, 2014).

2.4.2. Resilience and Vulnerability

Relationship between resilience and vulnerability is complex and understood in many different ways. Vulnerability is, among other things, the result of a lack of resilience, or vulnerability is the opposite of resilience (i.e. high capacity means low vulnerability). Resiliene and vulnerability are interpreted differently in climate change community of practice and in the disaster risk management community of practice. Vulnerability is the central focus of actions on disaster reduction, whereas resilience is not fully considered in the field of disaster management (IPCC, 2012 page 73) (Davis et al., 2004). In many climate change-related studies, resilience is considered as the opposite of vulnerability. However, recent studies note that resilience and vulnerability are not necessarily opposite, because communities that are highly vulnerable may in fact display high capacity in certain aspects (IPCC, 2012 page 73, 74).

The existence of vulnerability does not mean an absolute, but rather a relative lack of capacity. A vulnerable community, for example, may lack in capacity to anticipate risks; it is highly vulnerable, but may have capacity to recover after a climate disaster. Therefore, resilience and vulnerability are two seperate concepts, lack of one or more capacities will increase vulnerability.

2.5. Dimensions and Trends of Vulnerability and Exposure

Vulnerability and exposure are multidimensional and differential that is, it varies across physical space and among and within social groups; scale-dependent with regard to space and units of analysis such as individual, household, region, or system; and dynamic – characteristics and driving forces of vulnerability change over time.

In the three determinants of risks, vulnerability and exposure are changeable. The reality proved that the reduction of exposure and vulnerability significantly help reducing disaster losses, especially of extreme events. The following text analyses and assesses the impacts of environmental, social and economic dimensions, as well as other cross-cuting themes, which influence vulnerability and exposure. Appropriate adaptive measures will help reducing vulnerability and exposure.

2.5.1. Environmental Dimensions

Vulnerability and exposure closely link with environment. Environment dimensions include potential vulnerable natural systems such as low-lying islands, coastal zones, mountain regions, drylands, deserts and impacts on these systems, e.g., flooding of coastal cities, saltwater intrusion. Physical exposure refers to a location-specific context for human-environment interaction, as well as for patterns of settlement and development trajectories (IPCC, 2012 page 77, 78). Many rural livelihoods are reliant to natural resources. Therefore, environmental degradation reduces people’s coping and adaptive capacities to extreme climate events.

Environmental dimensions also include appropriate adaptive measures in each specific environmental condition. For example, at the same area, people who stay in a higher location have lower exposure level than those settling in lower location. As another example, the construction of the antisalinity dyke in Mekong Delta will make significant changes in local environmental dimensions.

Settlement patterns and development trajectories significantly influence exposure and vulnerability. Urbanization is an important trend in human settlement. However, urbanization with high population densities, particularly in low-lying coastal zones, has led to greater disaster risks, especially climate extreme events. Development policies, urban planning and landuse management directly affect to exposure and vulnerability of urban populations. For example, Ha Noi and HCMC experience urban flooding problems. Ha Noi began suffering from large-scale flooding after heavy rain (for example, above 20,000 household sufffered inundation after the extreme rain in November 2008). HCMC faces high tides at areas near the mouth of the rivers and adjacent inner city. Each city has its own characteristics and different causes of floodings, requiring appropriate coping and adaptive measures. Infrastructure, houses and living conditions are very important in reducing exposure and vulnerability of urban residents to hazards. However, in Viet Nam, rapid population growth in urban areas has made the infrastructure insufficient to meet the needs of the people. According to urban poverty assessment in Ha Noi and HCMC, Approximately a third of the cities' populations still live in cramped conditions, and a sixth living in temporary houses (UNDP-Việt Nam, 2010 page 82). Overcrowding and uncertainty about housing in the two cities is becoming more urgent for the low-income people and migrants. Only about 50% of households have water lines to their homes. ¼ of households use well water, in which only a half has some preliminary water treatment (UNDP, 2010). Such living conditions increase vulnerability and exposure of urban people to hazards, specifically extreme urban flooding.

2.5.2. Social Dimensions

The social dimension is multi-faceted and cross-cutting, focusing primarily on aspects of societal organization and collective aspects rather than individuals. However, some assessments also use the "individual" descriptor to clarrify issues of scale and units of analysis. The social dimension includes demorgraphy (such as migration and resettlement and social groups); education, health and social welfare, culture, institutions, and governace aspects (IPCC, 2012 page 80).

Certain population groups or communities may be more vulnerable than others to climate variability and extremes. For example, aging popupations and children are more vulnerable to high temperature than others. Pregnants are especially vulnerable to waterborne diseases (such as diarrhoea and cholera). Impacts of natural disasters and extreme events affect men and women differently. However, in Viet Nam, data on gender and disasters are not comprehensive statistics. Unspecific figures are difficult to analyze how men and women are affected by disasters. It leads to a limitation in gender equality plan. According to the gender report of UN-Việt Nam and Oxfam (2009), more men than women were reported as dying as a result of natural disasters, at least partly due to their role in search and rescue. Men have higher exposure to hazards than women. However, women are more vulnerable to hazards than men because they do not have opportunities to access new knowledge and skills to respond to disasters in trainings and participate in local flood and storm prevention committees. Female headed families have few opportunities to access resources helping women in coping to extreme events.

Migration and resettlement play a very important role in changing exposure and vulnerability to hazards of local people. According to the IDMC's report (2013) on global estimate of people displaced by disasters, with over a million displaced people in the period of 2008-2012, Viet Nam ranked 17th of 82 countries with the most displacement by natural disasters.The degree to which climatic stress is an important driver of migration depends also on the nature of the hazard. Rapid-onset climatic phenomena, especially extreme events, such as tropical cyclones, storms, and floods, tend to capture the media headlines and may result in mass temporary displacement, but are often not a reason for people to migrate. Slow-onset climatic phenomena, such as repeated drought, desertification, coastal and soil erosion, and sea level rise, tend to be less dramatic and therefore attract less attention than rapid-onset phenomena. However, slow-onset phenomena tend to affect a large number of people, impact on livelihoods and may trigger different types of migration, including permanent migration. Migration may increase or decrease the vulnerability of each person to hazards. Migration can heighten or lessen an individual’s vulnerability. It can be a coping strategy which contributes to income diversification and enhances overall capacity of households and communities to cope with the adverse effects of environmental and climate change stresses (UN-Viet Nam, 2014). In Viet Nam, reselttelment program is considered as an adaptation strategy to relocate people living in unsafe conditions. A substantial body of policy documents relates to resettlement efforts to reduce exposure to climate related and other environmental stresses, notably since 1996. A significant number of residential clusters with basic infrastructure have been established and households were relocated. According to the Implementation Plan of the National Strategy for Natural Disaster Prevention, Response, and Mitigation of 2009, by 2015 another 130,000 households should be relocated, of which around 70% from flooded areas in the Mekong River Delta. However, exposure is not the only determinant of risk, and vulnerability and resilience depend on many social economic conditions, in particular access to livelihoods (UN-Việt Nam, 2014). Resettlement programs can only be successful if reducing both exposure and vulnerability.

Education, health and education welfare systems play an important role in reducing exposure and vulnerabilities of local people. Extreme events cause adverse impacts on physical and emotional health of people, but it is difficult to estimate the impacts on emotional health as they are secondary impacts and happen in a long period of climatic pressure. In Viet Nam, health services and health facilities do not meet the needs of a large number of vulnerable patients, and health infrastructure has been frequently and strongly damaged by natural disasters (Tạ Thị Thanh Hương and Neefjes, 2010). To reduce the vulnerability of local communities, it is important to increase the resilience of health and education sectors to ensure the continuity of the services during disasters, and especially extreme events. To ensure service continuity means that measures are needed to protect staff and key assets such as equipment, to maintain essential functions and minimize or prevent service interruptions; and also to provide for orderly recovery during and after a disaster and re-establish full functioning. Critical is also that clients must retain access to the facilities and service providers (Tạ Thị Thanh Hương and Neefjes, 2010). Specifically, in health sector, a resilient health system requires adequate infrastructure with universal access to primary health care, meaning for example that health stations must be built in areas that are accessible even during floods. In education sector, it is needed to prevent the interruptions of education services and people should have access to necessary information to reduce exposure and vulnerability.

Culture is a broad and complex social factor but very important to influence exposure and vulnerability to hazards of a society or a social group. Culture is the whole social, physical and mental lifestyle of each community (Trần Quốc Vượng et al., 1998). Each ethnic group with diverse cultural values and historical development should have to cope differently with extreme climate events. Indigenous knowledge and community initiatives play an important role in reducing the vulnerabilities and exposure to hazards. Indigenous knowledge is often dynamic and complemented with new knowledge. For example, after the flash floods and landslides in 2004 and 2005, residents in Van Chan and Tram Tau districts, Yen Bai province self-assess the risk to landslides and flooding and relocate themselves before the hazards occur (Mai Thanh Sơn et al., 2011). However, although local knowledge is endless, many studies show that local knowledge and community initiatives are not always fit with massive changes in social-natural conditions (Mai Thanh Sơn et al., 2011) and the emergence of more extreme climate events. Warnings about the extreme climate events and coping methods can not reach the ethnic minorities because of the language barriers (many minority people do not understand the Kinh language).

Social relations play an important role in reducing exposure and vulnerability of local people, such as supports from relatives, friends, neighbors, as well as local social organizations, or non-governmental organizations. Relatives and neighours can help each other to reinforece houses before the storm season, while local social organizations, such as Farmer's Union, Women's Uninon, Veterian Union, Youth Union, Elderly Union, etc., also help their members by contribution in rotation fund or irregular support in disasters (ADPC, 2003).

2.5.3. Economic Dimensions

Annual climate disasters significantly affect to the economic development in Viet Nam. The World Bank report cited a research from Monash University that the impact of climate change on real GDP by 2050 will be 1-3 percent compared with a baseline situation that assumes no climate change (World Bank, 2010a page 25). ADB predicts that by 2100 the potential losses caused by climate change to Indonesia, the Philippines, Thailand, and Viet Nam may be as high as $230 billion, or 6.7% of annual GDP (projected GDP in 2100), double the global everage. For example, transportation infrastructure is often damaged or destroyed by storms and floods. During the period of 2001-2005, extreme weather events cost the transportation sector VND 2,571 billion in damage (MONRE, 2010 page 85). A World Bank assessment of the economics of adaptation concludes that as a result of climate change impacts on agriculture the total GDP in 2050 could be reduced by 0.7%-2.4%, depending on which greenhouse gas emissions scenarios and climate change models are chosen. The models used also suggest that by that date the benefits of adaptation measures are 1.3-1.6% of total GDP and so could outweigh the costs (World Bank, 2010b).

Particular extreme events have caused great economic losses in Vietnam. Typically, the strong and rapid moving typhoon Ketsana in 2009 caused heavy rains and floods along rivers in the Central and Highlands, with a damage of 9,770 collapsed houses and over 14.000 billion Viet Nam Dong (CCFSC, 2009a, 2009b). Typhoon Xangsane in 2006 destroyed 24,000 houses and cause damage of 10.000 billion Viet Nam Dong (CCFSC, 2006). Typhoon Linda hit the southern region in 1997, which is rarely affected by the typhoon in Vietnam, caused nearly 3,000 death or missing and destroyed more than 100 thousand houses and damaged more than 7,200 billion (CCFSC, 1997) (See table 9-1, chapter 9).

At community level, economic losses impact directly on livelihoods and works of individuals and families. Households in rural areas whose livelihoods depend on natural resources such as farming and fishing are more vulnerable to extreme events than those in cities. These extreme weather events affect people's lives, especially the poor and more vulnerable people. A study carried out in Cao Phong district, Hòa Bình province shows that extreme climate events not only directly affect to incomes, but also to local habits, seasonal calendar, productivity and the quality of crops. Without winter crops, people loses considerable incomes (approximately 20% of the previous income) (Trần Hữu Hào, 2012). In many cases, natural disasters and extreme weather events make the non- and near-poor households become poor households (Mai Thanh Sơn et al, 2011).

2.5.4. Interaction, Cross-Cutting Themes and Integrations

Some certain factors are identified as cross-cutting thems, such as gender, disable people, the elderly, children, and psychosocial and health issues. Each issue can be examined independently; however, integration is important to achieve integrated perspectives about the impact of these issues on exposure and vulnerability. For example, gender analysis should be integrated in minority or livelihood or education studies. The selection of different issues is based on some specific context.

Timing and spatial scales are important to identify the exposure to hazards. Exposure can be increased by people visiting an exposed aerea, but can be decrease by early warning and evacuation of people (IPCC, 2012 page 237). For example, within 3 days (from 24 to 26 September 2005) before the Typhoon Damrey (storm No. 7 in 2005), 29,000 people were evacuated to strong, multi-storey concrete buildings within villages, schools and the district in Hau Loc District, Thanh Hoa Province (JANI, 2011 page 26). Similarly, Quang Nam Province had already evacuated about 60,000 people (app. 16,000 households) from vulnerable areas (JANI, 2011 page 28) (see more information on typhoon Ketsana in section 9.1.2, chapter 9).

At present most of the climate change scenarios focus on climatic change within the next 100 or 200 years, while often the projections of vulnerability just use present socioeconomic data. However, a key challenge for enhancing knowledge of exposure and vulnerability as key determinants of risk requires improved data and methods to project and identify directions and different development pathways in demographic, socioeconomic, and political trends, as the changes in the climate system related to many different physical-biogeochemical projections (IPCC, 2012 page 88).

Newer research underlines that exposure – especially the exposure of different social groups – is a highly dynamic element that changes not only seasonally, but also during the day and over different days of the week (IPCC, 2012 page 88). Therefore, time scales should be carefully considered when conducting risk and vulnerability assessment for extreme events in the context of climate change. Changes in the hazard frequency and timing of hazard occurrence during the year will have a strong impact on the ability of societies and ecosystems to cope and adapt to these changes. Especially, vulnerability will be increased if many extreme events happen simultaneously or successively.

Time is necessary in considering the differences between the disaster management and climate change communities in practice. To generalize somewhat, the former group typically deals with fast-onset events such as typhoon, flood requiring immediate action. The latter group typically focuses on conditions and slow-onset events which are much more challenging in their identification and measurement. Disaster risk management considers risk reduction within different time frames; it encompasses short term and long term (IPCC, 2012 page 88). The potential combination of DRM and CCA will improve current and future risk management (see more information on the link between DRM and CCA in section 1.3.3, chapter 1). Time is a cross-cutting theme that always has to be considered particularly with anthropogenic climate change (IPCC, 2012 page 88).

Spatial and functional scales are another cross-cutting theme that is of particular relevance when dealing with the identification of exposure and vulnerability to extreme events and climate change. In many areas of climate change and natural hazards, societies are confronted with dynamic vulnerability, meaning that processes and factors that cause vulnerability operate simultaneously at multiple scales making traditional indicators insufficient (IPCC, 2012 page 89). Resilience and vulnerable assessment should consider the impacts of globalization on national-level policies and local level coping measures. For example, in Viet Nam, rapid urbanization is an important pull factors for rural to urban migration, creating opportunities for livelihood diversification to cope with droughts (UN-Việt Nam, 2014). However, the practical application and analysis of these interacting influences on vulnerability from different spatial scales is a major challenge and in most cases not sufficiently understood (IPCC, 2012 page 89).

Vulnerability analysis particularly links to the identification of institutional vulnerability. In most cases, current disaster management instruments and measures of many sectors, such as urban or spatial planning or water management tools (specific plans, zoning …) operate on different functional scales, but are not comprehensive. Functional and spatial scale mismatches might even be part of institutional vulnerabilities that limit the ability of governance system to adequately respond to hazards and changes induced by climate change (IPCC, 2012 page 89).

Science and technology possess the potential to reduce vulnerability and exposure, as well as to assist with adaptation to extreme climate events. For example, the increasing integration of a range of emerging weather and climate forecasting products into early warning systems has helped reduce exposure to extreme climate events (IPCC, 2012 page 89), by evacuation people out of vulnerable areas.

There is an increasing use of technologies, such as information technology, for planning and climate risk management and development of a range of decision support tools for climate-related disaster management. Currently, there is a range of technologies, including “hard” technologies such as irrigation system, and “soft” technologies such as crop rotation patterns, new drought-resistant-varieties applied in many sectors including water resource management, agriculture and health (IPCC, 2012 page 89).

2.6. Risk Identification and Assessment

Current Current approaches to disaster risk management typically involve four distinct public components: (1) Risk identification; (2) Risk reduction; (3) Risk transfer; and (4) Disaster management. The first three actions are mainly *ex ante* – that is, they take place in advance of disaster – and the fourth refers mainly to *ex post* actions (IPCC, 2012 page 89). Risk identification, through vulnerability and risk assessment can produce common understanding by the stakeholders and actors. It is the first step for risk reduction, prevention, and transfer, as well as climate adaptation in the context of extremes.

2.6.1. Risk Identification

The key challenges include understanding risk factors, communicating risks due to climate change to decisionmakers and the general public, and developing an improved understanding of underlying vulnerabilities, and societal coping and response capacities (IPCC, 2012 page 90). The selection of appropriate vulnerability and risk assessment approaches depends on the decisionmaking context. The promotion of a higher level of risk awareness regarding climate change-induced hazards and changes requires an improved understanding of the specific risk perceptions of different social groups and individuals, including those factors that influence and determine these perceptions. This also requires attention for appropriate formats of communication, so that local people receive and understand information related to risks (IPCC, 2012 page 90).

Appropriate information and knowledge are essential prerequisites for risk-aware behavior and decisions. Based on the expertise of disaster risk research and findings in climate change adaptation community, requirements for risk understanding related to climate change and extreme events particularly encompass knowledge of various determinants of risks: exposure, vulnerability and hazads in the context of climate change (IPCC, 2012 page 90). Beside,

Different tools, methodologies, and scientific and indigenous knowledge are very important to allow capturing new hazards and risks. How risks and vulnerabilities can be modified and reconfigured through forms of risk governance, encompassing formal and informal rule systems and actor networks at various levels. Adaptive capacity status is important to enhance understanding on how different adaptation measures influence resilience and adaptive capacities (IPCC, 2012 page 90).

2.6.2. Vulnerability and Risk Assessment

Vulnerability and risk assessment encompass various approaches and techniques ranging from indicator-based global or national assessments to qualitative participatory approaches of vulnerability and risk assessment at the local level (IPCC, 2012 page 90). Risk assessment should be carried out at local level with a focus on identifying the most potential hazards, vulnerable groups in a community and what local capacities can be used to enhance the resilience of the community members (MARD and UNDP, 2012 page 105).

Risk assessment contributes to awareness raising and local ownership in how they respond to risk and mainstream climate change adaptation to local economic development planning. There are four aspects that a risk assessment should include: hazard assessment, vulnerability assessment, capacity assessment; and community risk measurement (MARD and UNDP, 2012 page 107).

Several participatory risk assessment methods, often based on participatory rural appraisal methods, have been adjusted to explicitly address changing risks in a changing climate (IPCC, 2012 page 91). In Viet Nam, UNDP Việt Nam support the Disaster Management Center in MARD to compile and publish the Training Material on Community based disaster management (MARD, 2014). Besides, a series of studies on vulnerability assessment were supported to carry out in Vietnam, for example, IUCN supported vulnerability assessment in 2 communes in Ben Tre Province and 2 communes in Song Trang Province (IUCN, 2012a, 2012b). CARE supported vulnerability essessment of ethnic minorities in northern mountainous provinces, including Lang Son, Bac Kan, Thanh Hoa and Yen Bai (CARE International, 2013). However, risk assessment at the local level presents specific challenges related to a lack of data (including climate data at sufficient resolution, but also socioeconomic data at the lowest levels of aggregation) but also the highly complex and dynamic interplay between the capacities of the communities and the challenges they face (IPCC, 2012 page 90-91).

Risk assessment is defined as a process to comprehend the nature of risk and to determine the level of risk and vulnerability, by means of gathering and systematizing data and information. A common goal of vulnerability and risk assessment approaches is to provide information about profiles, patterns of, and changes in risk and vulnerability in order to define priorities, select alternative strategies, or formulate new response strategies (IPCC, 2012 page 91).

Vulnerability and risk assessments are important for disaster risk management and climate change adaptation, which require the use of reliable methodologies that allow an adequate estimation of potential losses and consequences to the human systems in a given exposure time. Vulnerability assessment makes use of both quantitative and qualitative approaches to capture the full complexity and the various tangible and intangible aspects of vulnerability (IPCC, 2012 page 91).

To ensure that risk and vulnerability assessments are well understood, the key challenges for future vulnerability and risk assessment are, in particular, the promotion of more integrative and holistic approaches; the improvement of assessment methodologies that also account for dynamic changes in vulnerability, exposure, and risk; and the need to address the requirements of decisionmakers and the general public. Many assessments still focus solely on one dimension, such as economic risk and vulnerability. It is needed to have a more integrative and holistic perspective that captures a greater range of dimensions and factors of vulnerability and disaster risk (social, economic, environmental, and institutional aspects) (IPCC, 2012 page 94).

To enhance disaster risk management and climate change adaptation, risk identification and vulnerability assessment may be undertaken in different phases, that is, before, during, and even after disasters occur (IPCC, 2012 page 94). Until today, many post-disaster processes and strategies have failed to integrate aspects of climate change adaptation and long-term risk reduction. The design and implementation of adaptation and risk management strategies and policies can reduce risk in the short term, but may increase vulnerability and exposure over the longer term (IPCC, 2012 page 94). For example, spontaneous development of dyke systems in Mekong River Delta can reduce hazard exposure by offering immediate protection, but may increase risk in the long term.

2.6.3. Risk Communication

Vulnerability and risk assessment is closely linked to different types and strategies of risk communication. The failure of effective and people-centered risk communication can contribute to an increasing vulnerability and disaster risk. Knowledge on factors that determine how people perceive and respond to a specific risk or a set of multi-hazard risks is key for risk management and climate change adaptation. Risk communication is a complex cross-disciplinary field that involves reaching different audiences to make risk comprehensible, understanding and respecting audience values, predicting the audience's response to the communication, and improving awareness and collective and individual decisionmaking (IPCC, 2012 page 95). In the past, risk communication about typhoon Linda in 1997 was failed.

Although the forecasting agency warned of the influx of typhoon, local people and provincial governments were still subjective and lacking of necessary preparation due to insufficient awareness of the possibility of typhoon damage (MARD, 2011). Weak and insufficient risk communication as well as the loss of trust in government institutions in the context of early warning or climate change adaptation can be seen as a core component of institutional vulnerability (IPCC, 2012 page 95).

Risk communication is not solely linked to a top-down communication process, but also a tool to upscale local knowledge, experiences and needs (bottom-up approach). Effective risk communication achieves both informing people at risk about the key determinants of their particular upcoming risks and also engages different stakeholders in the definition of a problem and the identification of respective solutions.

2.7. Risk Accumulation

The concept of risk accumulation describes a gradual build-up of disaster risk in specific locations, often due to a combination of continous processes, such as successive disasters or responses of an earlier disaster become a driver for the next disaster. Risks are also accumulated by social drivers such as inequality, social isolation or inadequate development planning (IPCC, 2012 page 95). A typical example is the disaster risk in urban areas, especially for the poor. In the two largest cities of Vietnam, Hanoi and HCMC, the rapid population growth in urban areas makes infrastructure insufficient and unable to meet the needs of local people. Many people, especially low-income people and migrants, are living in cramped conditions without access ti water supply system (UNDP, 2010). The accumulation of disaster risk over time may be partly caused by a string of small day-to-day risks in urban areas, aggravated by limited resources to cope and recover from disasters when they occur – creating a vicious cycle of poverty and disaster risk. Analysis of disaster loss data suggests that frequent low-intensity losses often highlight an accumulation of risks, which is then realized when an extreme hazard event occurs (IPCC, 2012 page 96).

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Chapter 3

Changes in Climate Extremes and Impacts on the Natural Physical Environment

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Summary

This chapter discusses results of the assessment of changes in trends and variations in climate extreme events. Extreme weather or climate is defined as: (1) the occurrence of a value of weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable; (2) Large-scale circulation (or phenomena) that affect the occruence of weather and climate extreme event or extreme monsoon (monsoon, E Nino, yphoon…); ( ) Impac s on na ura and/or physica n vironm n s (drought, flood, extreme sea v …) [3.1].

Climate changing leads to changes in the frequency, intensity, spatial extent and duration of weather and climate extremes, and sometimes can result in unprecedented severe extremes. In fact, there are weather or climate events that are statistically not extreme, but they can result in extreme negative impacts when they exceed the tolerance levels of of a physical, ecological or social system. Several climate extremes (e.g. droughts and floods) can result from the combination of normal weather and climate events (become extreme when they combine together) [3.1].

Many weather and climate extremes result from natural climate fluctuations (including phenomena such as El Niño), and decadal oscillations within the context of climate change. Even if anthropogenic climate changes would not occurr; many weather and climate extremes still occur naturally [3.1].

Data used in this chapter are collected from various sources with observation data and the outputs produced by climate models. Sources of data include: monitoring data collected from the Network of Hydro meteorological Observation Stations during the 1961 – 2010 period (more than 90 stations); climate simulation and projection data from the AGCM/MRI (models of the Institute for Meteorology Japan), the PRECIS model of the UK Hadley Center and the CCAM model of the Commonwealth Scientific and Industry Research Organization, Australia (CSIRO) [3.2].

Trends in temperature extremes in the 1961-2010 period: The lowest temperatures in each region of the country showed an increasing trend, but the highest temperatures increased in northern climatological regions and reduced in Southern regions. The upward trend is consistent in the northern climatological regions, i.e. the Northeast region, the Northern Delta region, the Northwest, and the North Central Coast region. The trends in the South Central climate region, the Central Highlands, and the South are not consistent, with increases or decreases between the stations and the variables. For example, in the South Central climate region, the number of hot sunny days, the number of days on which the highest temperature exceeded the 90th percentile and days with the lowest temperature below the 10th percentile increase or decrease consistently between stations, while the highest temperature and the lowest temperatures are inconsistent. The largest increase in the number of hot days was 7.85 days / 10 years in Tuyen Hoa station, Quang Binh province; the largest increase of the highest temperature was 0.7^{o}C / 10 years in the Truong Sa meteorological station; the the largest increase of the minimum temperature was 1.56^{o}C / 10 years in M'Drak meteorological station; the largest increase of the highest temperature corresponding to the 90th percentile was

15.14% / 10 years in the Truong Sa station; the largest decline of the lowest temperature in the 10th percentile was -7.72% / 10 years in Vung Tau station [3.3.1.1; Table 3-2 - 3.8].

Projection of future temperature extremes:

- Re the lowest mean temperature: the lowest mean temperature in winter will increase by 1-1.5 ^{o}C in the middle of the 21st century, and at the end of the 21st century by 2-3 ^{o}C; in the southern regions these will rise more than in northern regions. The lowest mean temperature in summer will rise by 1- 2 ^{o}C in the middle of the 21st century; in the North, except the Northwest, this will rise more than in Central Coast, Central Highlands and Southern regions. The lowest mean temperature in summer will rise by 2-3.5 ^{o}C at the end of the 21st century: in the North, except the Northwest, this will rise more than in other regions. The annual average in the country will increase by 1-2 ^{o}C by mid-century (mostly in the South); and by 2.2-3.0 ^{o}C at the end of the century (more than average in the North, southern Central Highlands, and the Southern regions).

- Re the highest mean temperature: the higest mean temperature in winter will increase by 0-2.2 ^{o}C in the middle of the 21st century, most in Nghe An province and further north, and least in the Central and Central Highlands regions; and increase 2-3 ^{o}C by the end of the century, while in the North and in the South more than in the Centre and Central Highlands. The highest mean temperature in summer will rise by 1-2 ^{o}C in the middle of the 21st century, rising more in Northeast, South Central Coast region and the South, but less in the North West, North Central and Central Highlands regions; and increase 2-3^{o}C by the end of the century, rising more in the Northeast and Central regions than the Northwest, Central Highlands and South. The annual average rate of increase in the country will be 1-2.5^{o}C and 2-3.5^{o}C respectively, increasing more in the North and South, and less in the remaining regions[3.3.1.2; Figure 3-3].

over the seven climate zones, rainfall extremes such as a maximum one day rainfall **(Rx1day)**, maximum 5-day rainfall **(Rx5day)** and a total rainfall on days with rainfall exceeding the 95 % percentile of (**R95p)** having different trends and (increase/decrease) variability. In general, rain extreme events tended to decrease and increase in almost all of the observation stations in the North and the South respectively. The greatest decrease was measured in the North-East and Northern Delta while the highest increase observed over provinces in mid- and South Central Vietnam. The number of consecutive dry days (**CDD)** tended to increase in the North while decrease in the South. The total precipitation of intra-annual rainy days (**PRCPTOT**) tended to decrease in the North and increase in the South [3.3.2.1; Table 3-9 – 3.15].

Projection of future rain extremes: Projected results of the regional models indicate that **Rx1day** tended to increase in almost all of North-West and North-East regions in the North while decrease in Northern Delta, North and South Central Viet Nam. However, degree of variability of rainfall is relatively small and the highest is only 7% if take into account the whole region. The projected **Rx5day** increased from 10 to 20% in almost all of the territory [Fig. 3.5, 3.6].

Winds at higher speed: Wind at more than 15m/s often occur during tropical typhoons, cyclones, whirlwinds, waterspouts, monsoons, hot and dry westerly wind… In the last nearly 50 years (1961 – 2007) the annual highest wind speed (Vx) tended to decrease in almost all of the observation stations throughout the territory. According to the scenarios A1B and A2, projections show that Vx tends to slightly increase over all the climate zones by the first half of the 21st century. There is not much differential in rates of Vx increase/decrease among the climate zones. On average, the variation of Vx is in a range of ±2m/s [3.3.3.1].

Trends in changes in relatively lowest humidity (Um): the relatively lowest (Um) tends to increase evidently in the winter months, but slightly varies or decreases during the summer months [3.3.3.2].

Monsoon: in the past 15 years (1996 – 2010), summ r’s monsoon nd d o occur a r i r (about 10-15 days) compared to the past 15 years (1981 – 1995) leading to increase in early rains (May) in the South. However, the rainfall tended to decrease in June in the South due to changes in atmospheric seasonal oscillation activities. The result of monsoon projection is uncertain currently.

Tropical Cyclone: In the past 50 years (1961 – 2010), there was not clearly evident in the variability of the frequency of tropical cyclones including typhoon and depression making landfall in Viet Nam. However, the number of depression spells tended to increase; while typhoons with the medium grade tended to decrease but those with very higher intensity tended to increase. The typhoon season tends to end later and its track tends to turn southwards. Results from the projections indicate that there is a tendency for decrease in number of typhoons over the East Sea by the middle and the end of the 21st century and there are also uncertain. However, it is likely that the number of super-typhoons tend to increase.

El Niño and La Nina: According to the Pacific El Niño Southern Oscillation (ENSO) events in the past 100 years, the frequency and intensity of El Niño and La Nina indicate their increasing trends. As projected, by the 21st century, it is confidently judged that the frequency of El Niño modes of the abnormality of positive sea surface temperatures will tend to increase in central equatorial Pacific, leading to increase in the ENSO related precipitations [3.4.3].

Heat wave: According to the recent observation in Viet Nam, there was a growing trend in the number of hot day over most of the climate zones in Viet Nam, except in Central Region. According to the high GHG emission scenario RCP 8.5, the number of hot days will increase by 20 to 30 days compared to the period of 1980-1999 in the South by the middle of the 21st century; and by the end of the 21st century, this figure will increase by 60-70 days over the North-East, Northern Delta, Middle and South Central and Southern Viet Nam while in other regions where low increases are projected. The number of heat waves (three consecutive days) is projected to increase over most regions in Viet Nam, except the North-West where there will be small changes in temperature in the 21st century [3.5.1].

Drought: the severity of drought tended to grow in many regions in Viet Nam with high frequency in Winter- Spring crop season (January- Aprril) and Summer-Autumn crop seascon (May-August). As projected from the high GHG emission scenario (RCP 8.5), droughts could occur more frequently and be prolonged in most of the climate zones in Viet Nam by the 21st century [3.5.2].

Heavy Rain: According to data collected, heavy rain in extended large area have an increasing trend. The numbers of heavy rain decrease in the North, slightly increase in the South, and considerably increase in Central South and Central Highland regions. Projections indicate that by the 21st century, the number of torrential rain day tends to increase in almost all of the climate zones, except Central Vietnam where it tends to decrease [3.5.3]. It is noted that heavy rain projection is difficult, so that the current calculation results still have many uncertainties.

Floods: In Vietnam, floods are likely to occur more frequently, more severely and abnormally, causing impacts to more and more areas, even larger areas and regions of the country [3.5.4].

Hoarfrost, freeze, damaging cold: To be in line with global warming trend, the number of freeze and damaging cold days tended to decrease, especially in the recent past two decades. However, the number of cold spells has been quite complex variations and fluctuations from year to year. Especially, in recent years, there were recorded extreme damaging cold spells with very low temperature. Ice phenomenon seems to appear with more frequency in the high mountain regions. Data collected from 1981 to 2009 indicate that hoar frost tended to occur later and last shorter; the number of hoar frost day tended to decrease and reduce rapidly for the last decade [3.5.5].

Sea Level: Mean sea level has visibly risen in the East Sea and along Vietnam coast at the rate of about 2, 8 mm per year. The annual highest sea level including sea level rises by tide, typhoon and surf, tends to increase at most coastal observation stations of Vietnam. Within the context of climate change, extreme sea level is projected to exceed the spot height of sea dyke systems in some areas (such as Hai Phong) [3.5.6].

General Introduction

Climate change, specifically global warming and sealevel rise, is one of the greatest challenges to humanity in 21st century. According to the report of IPPC, climate change leads to the changes in frequency, intensity, timing and spatial scale of extreme weather and climate and sometimes create extreme severe events (IPCC, 2007).

Viet Nam is located in the tropical monsoon area, annual influenced by many weather and climate extremes such as typhoons, floods, heavy rain, heat, drought, .. The increase of the extreme climate events can be considered as the current biggest challenge for Viet Nam in responding to climate change.

Chapter 3 focuses on assessing trends and variations of climate extremes in Viet Nam based on monitoring data and calculation results from global and regional climate models. This chapter covers the following contents: Weather and climate events related disasters (Section 3.1); Data and methods for analyzing changes in extremes (Section 3.2); Change of some climate extremes (Section 3.3); Changes in phenomena related to weather and climate extremes (Section 3.4); and Impact on the natural physical environment (Section 3.5).

3.1. Weather and climate phenomena relating to disasters

In practice, there are weather or climate phenomena that are not extreme in terms of statistics but they can result in negative impacts excessive the resilience of a physical, ecological or a social systems. Several climate extremes (e.g. droughts and floods) can result from the combination of normal weather and climate events (become extreme when they combined together). A weather system such as a tropical cyclone can result in extreme impacts, depending on a specific area where and time when it makes landfall, even though it is not special compared to the others. On contrary, not all of extremes result in severe effects. Many weather and climate extremes result from natural fluctuations of the climate (including El Niño), and decadal oscillations within the context of climate change. Even if anthropogenic climate changes would not have occurred, many weather and climate extremes already occurred naturally.

3.1.1 Categories of weather and climate events discussed in this chapter

There are many definitions and ways to determine weather and climate events related to disasters (Klein Tank et al, 2009; Zhang et al, 2011; Nguyễn Văn Thắng, 0 05; Phan Văn Tân et al, 2010). This report focus on trend assessment and changes in three following extreme groups

1) Extremes of weather and climate variables (absolute highest temperature, extreme daily rainfall, value higher or lower than a climate threshold, value close to the upper (or lower) limit of a range of observed elements…);
2) Phenomena related to w a h r and c ima v n s (monsoon, E Niño, cyc on s…);
3) Impact on the natural physical environment (drough s, f oods, x r m s a v …)

According to this definition, due attention should be paid to following points:

- The selection of occurrence thresholds is often below 10, 5, or 1%, even lower than a specific reference duration (e.g. 1961-1990);
- The absolute threshold can also be used to identify extreme events (for example, a specific temperature value that significantly affects human health);
- The extreme nature of weather and climate that is depending on specific areas and/or regions. Hot days in tropical regions for example, are properly different those in the mid-latitudes;
- Some climate extremes (e.g. droughts and floods) might result from the combination of normal weather and climate phenomena. A combination of two or much more events occurred at the same time, might lead to negative impacts;
- Not all weather and climate extremes might result in negative impacts;
- The differentiation between weather and climate extremes is only relative, and a major difference is associated with the timescale. A weather extreme is closely associated with changes in the weather conformation and has a timescale of less than a day to several weeks. A climate extreme occurs within a longer timescale, and might be a combination of some weather phenomena that are extreme or not extreme (e.g. many days with below - average rainfall in a longer duration lead to a shortage of precipitation for the whole season and thus result in a significant drought).

For simplification, both weather and climate extremes shall be termed climate extremes.

3.1.2 Combined impacts of extreme events

In climate science, the extremes may be: (1) A combination of two or more extreme events occur simultaneously or consecutively, (2) A combination of extreme and resonant events, (3) A combination of the non-extreme events leading to a climate extreme (IPCC, 2012). Impacts of different phenomena can be similar or different. For example, extreme rainfall in a large area caused by typhoons and North West monsoon combing with high tide resulted in high sea level rise. The historical flood in Central region in 1999 is the combination of many different simultaneous disasters (flash flood in mountains, plain flooding, storm surges, high tide, strong sea wave..). The cause of the extreme was a combination of multiple patterns simultaneous weather as cold wind from the North, the impact of tropical depression, and high wind from the East. Some other combinations may be listed as heatwaves and drought, floods and sea level rise.

Impacts on physical environmental conditions (Section 3.5) are results of some combined phenomena. For example, flood is more likely to occur in water saturation areas. It means tha both soil moisture and rainfall intensity are important factors of flood. Similarly, drought results from lack of soil moisture, prolong rainfall shortage and large evapora ion…

3.2. Climate Extreme Data and Analytical Methods

3.2.1. Climate extreme data

<u>Station Observation Data</u>: Available data is very important to analyze changes of climate extremes. It is difficult to determine the trends of a climate extreme if it rarely occurs. To analyze the changes of climate extremes in a short time period, especially temperature, rainfall, wind,

etc., data observation should be collected in a long time period. There are about 170 surface meteorological observation stations throughout the territory of Viet Nam, but not all these stations have got daily observed data adequate for computation. Thus, the daily observed data for the period of 1961-2010 have been collected from the 90 meteorological stations were selected as major sources through the control and processing of raw data, the consideration of the length of data sets, and their quality to provide daily observed data for the period of 1961-2010 for the research of climate extremes, including the highest temperature (Tx), the lowest temperature (Tm), mean daily temperature (T), the lowest relative humidity (Rhm), daily rainfall (R), and wind maximum speed (Vx). These data were collected from the Center of Hydro-metrological and Environmental Data http://www.hymetdata.gov.vn/ .

Simulation Data of Climate Models: Nowadays, global and regional climate models are one of main tools used to make projections of future climate trends and occurrence, especially climate extremes. All the results presented in this report were made through the computation of such models as the AGCM/MRI (Japan), the PRECIS of Hadley Center – UK, and the CCAM of CSIRO.

3.2.2. Climate Extreme Indices Used for Studies in the world and Viet Nam

In the recent last decades, changes in climate extremes have been paid due attention in the research undertaken by many scientists due to their negative impacts on the environment and human beings. A series of typical climate extreme indices was set out in previous studies (Klein Tank et al., 2009; Zhang et al., 2011). In 1997, the World Meteorology Organization (WMO) established a panel of experts to study a set of climate extreme indices (ETCCDI) including experts from the IPCC Climate Panel (CCI) and the program on climate fluctuations and forecasting capacity (CLIVAR) with a view to developing a set of climate extreme indices (CEI) to be used for regions and countries. The CEI has been provided by ETCCDI with nearly 30 indices relating to temperature and rainfall factors. A list of CEIs (http://cccma.seos.uvic.ca/ETCCDI/) used in the 4th IPCC Assessment (2007) is presented in Table 3-1. By 2009, WMO continued publishing guidelines on the analysis of climate change extremes with the goal to provide information for assessing impacts of the development of response plans (Klein Tank et al., 2009).

Table 3-1. Climate Extreme Indices

No.	Sign	Indices	Indices Definition	Unit
1	FD0	Frost day	No. of days with daily temperature that drops below 0ºC (Tm) annually	Day
2	SU25	Summer day	No. of days with daily highest temperature (Tx) >25ºC annually	Day
3	ID	Frigid day	No. of days with Tm <0ºC	Day
4	TR20	Tropical night	No. of days with Tm >20ºC	Day
5	GSL	Growing season	No. of days calculated from the first period of six consecutive days with TG >5ºC and the first period of six consecutive days with TG<5ºC after 1/VII	Day
6	TXx	Max Tmax	Monthly/yearly highest temperature value Tx	ºC
7	TNx	Max Tmin	Monthly/yearly highest temperature value Tm	ºC
8	TXn	Min Tmax	Monthly/yearly lowest temperature value Tx	ºC
9	TNn	Min Tmin	Monthly/yearly lowest temperature value Tm	ºC
10	TN10p	Cold night	% of No. of days with Tm < 10% percentile	%
11	TX10p	Cold day	% of No. of days with Tx < 10% percentile	%
12	TN90p	Hot night	% of No. of days with Tm < 90% percentile	%
13	TX90p	Hot day	% of No. of days with Tx < 90% percentile	%
14	WSDI	Consecutive hot time indices	Total No. of days with heat waves (6 consecutive days with Tx > 90% percentile) annually	Day
15	CSDI	Consecutive cold time indices	Total No. of days with cold spells (6 consecutive days with Tm > 10% percentile) yearly	Day
16	DTR	Monthly temperature range	Monthly mean differential between Tx and Tm	ºC
17	RX1day	Max. one day rainfall	Max. one day rainfall per month/year	mm
18	Rx5day	Max 5-day rainfall	Max. 5-day rainfall per month/year	mm
19	SDII	Rain Intensity Indices	Total annual rainfall that divides by No. of days with rainfall >=1.0mm per year	mm/day
20	R10	Heavy rain day	No. of days with rainfall >=10mm per year	Day
21	R20	Very heavy rain day	No. of days with rainfall >=20mm per year	Day
22	Rnn	Day with rainfall exceeding nn mm threshold	No. of days with rainfall >= nn mm per year, of which nn is defined by users	Day
23	CDD	Consecutive Dry Day	Max No. of consecutive days with rainfall <1mm per year	Day
24	CWD	Consecutive Wet Day	Max No. of consecutive days with rainfall >=1mm per year	Day
25	R95p	Very Wet Day	Total precipitation of days with rainfall > 95% ppercentile	mm
26	R99p	Wettest Day	Total precipitation of days with rainfall > 99% ppercentile	mm
27	PRCPTOT	Total precipitation (rain days)	Total precipitation of days with rainfall >=1mm per year	mm

Situated within a tropical monsoon region, Vietnam is affected by almost all of climate extremes. There are many different indices used to show the nature of climate extremes in Vietnam. Basically, this information can be grouped into categories reflecting the state of climate maxima and extremes, as follows (Nguyễn Văn Thắng, 2005).

(1) Daily max values of weather and climate variables, for example:

- Highest temperature (Tx)
- Lowest temperature (Tm)
- Daily heaviest rainfall (Rx)
- Relatively lowest humidity (Um)
- Strongest wind speed (Vx)

(2) Max values and extreme events are defined by the number of days/spells with numeric value of the variables above or below threshold value or below lower thresholds. More common characteristics of these extremes include:

- No. of days with non- sunshine (= 0 non-sunshine hour/day) (nN0)
- No. of days with less sunshine (< 2 sunshine hours/day) (nN2)
- No. of days with more sunshine (> 8 sunshine hours/day) (nN8)
- No. of days with highest temperature of more than 350C (nTx35)
- No. of heat wave spells (with three consecutive days at least Tx ≥350C)
- No. of days with highest temperature of more than 300C (nTx30)
- No. of days with lowest temperature of less than 250C (nTm25)
- No. of days with lowest temperature of less than 150C (nTm15)
- No. of days with lowest temperature of less than 130C (nTm13)
- No. of damaging cold spells (at least with three consecutive days with Tm ≤130C)
- No. of days with lowest temperature of less than 100C (nTm10)
- No. of days without rain (nR0)
- No. of days with rainfall of more than 30mm (nR30)
- No. of days with rainfall of more than 50mm (nR50)
- No. of days with rainfall of more than 100mm (nR100)
- No. of days with humidity of more than 80% (nr80)
- No. of days with humidity of less than 20% (nr20)
- Windless frequency (Pl)
- Frequency of wind speed of more than or equal to 5m/s (P V5)

(3) Frequency or the number of days with occurrences
All weather categories more or less manifest their extremes monthly or yearly recorded in observation records or other documents, including:

- r qu ncy of yphoon and d pr ssi on (P XTNĐ)
- Frequency of cold front (P f)
- No. of days with frost (n Sm)
- No. of days with fog (n SM)
- No. of days with thunderstorm (n D)
- No. of days with drizzle (n Mp)
- No. of days with hailstone (n Md)

In addition to the three categories of extreme information above, there are other categories including:
(4) Highest and/or lowest numeric values corresponding to cycles;
(5) Earliest and/or latest starting and ending times of rainy season,
(6) Arid and drought indices and drought frequency.

3.2.3. Identification of Extreme Indices for Viet Nam

In this section, the identification of extreme indices has been implemented through the synthesis of application practices by the Central Hydro-meteorological Forecasting Centre (CHMFC) (http://www.nchmf.gov.vn) and the review of publications in Vietnam (Nguyễn Trọng Hiệu et al., 2002; Nguyễn Đức Ngữ et al., 2004; Nguyễn Văn Thắng a , 0 05; Phan Văn Tân a , 2010) and in the world (Klein Tank et al.,, 2009; Zhang et al., 2011; SREX, 2012). There are plenty of atmospheric variables of which the extremity might be considered and investigated. However, the effects of heat, rain, and humidity and wind variables are significantly important for the environment and human beings from application point of view.

The heat regime of the atmosphere is characterized by temperature. The ambient temperature can be high or low and the range of temperature variations can be larger or smaller depending on climate conditions of a location. To characterize the extremity of temperature, extreme temperature quantities namely highest temperature (or maximum temperature-Tx) and lowest temperature (minimum temperature-Tm) are after considered.

Rain is the most important among climate variables. Rain has diverse and typical features, namely locations where it rains, time when it occurs, the length of time it lasts, the intensity of rain, and total rainfall,...but when ones mention the extremity of rain, due attention is often paid to the intensity of rain and a total max accumulative rainfall during a period characterized by a heavy rain event. When a heavy rain is considered an extreme climate factor, a daily max rainfall variable (Rx) shall be a basis of definition.

The humidity over a region is generally regulated by the two factors, i.e. evaporated water and rainfall. In reality, the measurement of evaporated water amount is regularly implemented at meteorological observation stations and possible evaporated water amounts can be measured (with the piche pipe or cylindrical evaporimeter). The difference between rainfall (supply) and evaporated water amount (loss) can be used to assess reserves of the humidity for a region. Humidity content in the atmosphere depends on the ambient temperature and the possibility of water supply from the surface. If there is enough humidity on the surface, the difference between the real humidity and saturated humidity is small in the atmosphere that becomes more “humid”, and on con rary i b com s mor “dri r” Thus, a r a iv humidi y is usua y us d as a quantity to indicate levels of humidity in the atmosphere, and also shows the possibility of water supply from the surface. Therefore, the lowest relative humidity (Um) might be used to characterize the extremity of climate in terms of humid conditions.

Wind is also the most important among climate variables. The highest wind speed (Vx) is usually used to consider the characteristics of wind extremes.

Among extreme climate events, only those with direct or indirect effects on natural, environmental and socio-economic conditions should be considered and selected. On the basis of available observation data provided by various sources for computation, the scale and frequency of events and the extent of their impacts, following events shall be studied within the extent of this report: Tropical typhoons and depressions, torrential rains, cold atmosphere, freeze and damaging colds, heat waves and droughts.

Tropical typhoon and depression are dangerous weather events. Very often typhoon occurs with a very strong wind and heavy rain causing difficulties to human life and production activities and even loss of life and properties over locations where it made landfall.

Heavy rains are one of weather events causing deep and wide impacts on all fields of life and production. Prolonged heavy rains can cause floods and landslides leading to transport interruptions, damage to assets and even dead toll. The concept of heavy rains is also a relative one. In Vietnam, when a rain with its intensity of 25 mm/day and/or 50 mm/day is considered a medium and/or heavy rain respectively (http://www.nchmf.gov.vn). This means that a heavy rain occurs when its accumulative rainfall is ≥ 50 mm within 24 hours.

Cold atmosphere with cold front is attributed to frigid and/or damaging cold events. These events can prolong by many days, become spells and occur over larger areas. According to available parameters applied by CHMFC (http://www.nchmf.gov.vn), a frigid and/or (damaging cold) spell is considered to occur over a certain area if daily mean temperature (Ttb) measured in a half of local stations, is lower than or equals 15oC (13oC) during at least two days. A range of frigid days with one day in which it is not frigid but its Ttb is approx. 15oC (13oC) measured by a half of local stations, is still considered to be a consecutive frigid and (damaging cold) spell.

Heat wave is a weather event that occurs in the summer in almost all of climate zones in Vietnam. Similar to frigid and/or damaging cold, heat wave causes adverse impacts to human life and production activities. According to available parameters applied by CHMFC (http://www.nchmf.gov.vn), a heat wave occurs in a certain area if Tx is ≥ 35oC and a relative humidi y is ≤ 55% obs r v d by ha f of oca s a ions in a a s wo days A s ri s of ho days with one day in which it does not meet the hot day parameter but its Tx is approx. 35oC and a r a iv humidi y is ≤ 55% obs rv d by ha f of oca s a ions, is s i consid r d a cons cu iv heat wave. A heat wave that occurs over an area with Tx ≥ 37oC and a relative humidi y ≤ 45%, (or Tx ≥ 39oC) observed by a third of local stations, is considered the burning sun. It is realized that the consideration of a hot day event by using the two parameters, i.e. highest temperature (Tx) and relative humidity, is likely to be confused with a dry and hot weather event under conditions as a front event. Therefore, in this report, heat wave event is considered to occur only when Tx is ≥ 35oC (Tx ≥ 37oC) and the relative humidity is neglected. It is necessary to say that the existing regulations on temperature thresholds to define such events as frigid cold, damaging cold and heat wave are still applied for dangerous weather forecasts and warnings in Vietnam. But rationales for the definition of these thresholds have been not clear so far.

Drought is one among weather events that might occur everywhere although its characteristics vary from place to place. It is, therefore, very difficult to define precisely the concept of drought. Generally, drought means lack of rainfall in a period long enough to cause shortage of water facing a certain field of activities or the environment. It is necessary to distinguish drought from aridity. Drought is an event that occurs abnormally and temporarily while an arid event means that there is little or no rain in an area, and is an unchangeable feature of local climate.

Drought is a dangerous natural disaster. Although there is no consistent definition, drought can be attributed to lack of rainfall in a long period of one month or more. It depends on times of a year (i.e. seasonal occurrence, a later start of rainy season, the occurrence of rain in relationship with major development stages of seasonal crops) and rain effects (i.e. its intensity and frequency). Other climate factors including high temperature, strong wind and relative low humidity are usually associated with drought.

Droughts are often grouped into four categories: Meteorological, hydrological, agricultural and socio-economic droughts. In this report, drought refers to the meteorological one, which is divided into two cases.

1) Monthly drought: Based on a rainfall of a specific month to define whether drought has been occurred in that month or not. A month is considered a period of drought if rainfall has been less than 10 mm/month in winter months (Nov., Dec., Jan., and Feb), less than 30mm/month in seasonal transition months (Mar., Apr., Sept., and Oct.) or less than 50mm/month in summer months (May, Jun., July,and Aug.)
2) Seasonal drought: Based on a rainfall of some consecutive months to define whether drought has occurred in that period or not. That period is considered drought if a total rainfall of the three consecutive months in winter (Nov- Jan, or Dec-Feb.) and/or in spring (Feb-Apr or Mar-May) (dry season with little rain) has been less than 60mm or a total rainfall of two consecutive months in summer (May- Jun or June-July or July-Aug) (rainy season) has been less than 100mm.

ENSO stands for El Niño Southern Oscillation. It refers to both El Niño and La Niña events, and is associated with oscillations of atmospheric pressure between the Pacific Ocean east and west – Indian Ocean east (called the Southern Oscillation to distinguish from the oscillation of atmospheric pressure in Atlantic Ocean north). The El Niño and La Niña events have a great impact on global weather and climate at different and diverse levels. However, it is possible to identify major typical effects of each event over specific areas. El Niño and La Niña events show periodically abnormal fluctuations in the atmosphere-oceanic system with time scale of years. The ENSO event also has anomaly in its intensity.

Located within a tropical monsoon region, Vietnam suffers the impact of the two major monsoon systems: winter and summer monsoons. Activities of the summer monsoon are closely associated with rain in Vietnam, especially in the South and Central Highlands. Sometime, small fluctuations in the monsoon system could result in drought or rain and flood on a larger scale and in a prolonged time of a year. In the country, the summer monsoon usually begins from the end of April or early May and ends in September or October annually.

In summary, based on practical needs and the availability of monitoring data on monitoring, the frequency and scale of events and the extent of their impacts, following factors and events have been considered in the research of climate extremes in Vietnam:

- Highest temperature **(TXx)**
- Lowest temperature **(TNn)**
- Highest temperature exceeding the threshold of 35 ^{o}C **(SU35)**
- Highest temperature exceeding the 90th percentile **(Tx90P)**
- Lowest temperature exceeding the 10th percentile **(Tn10P)**

- Max 1 day rainfall **(Rx1day)**
- Max 5 day rainfall **(Rx5day)**
- Consecutive dry day **(CDD)**
- Total rainfall of days with torrential rain **(R95p)**
- Total rainfall of days with rain **(PRCPTOT)**
- Max wind speed **(Vx)**
- Lowest relative humidity **(Um)**
- Tropical typhoon and depression **(TC)**
- Frigid cold **(RD)**
- Heat wave **(NN)**
- Torrential rain **(ML)**
- Drought **(HH)**
- ENSO
- Summer monsoon

Within the framework of this paper, characteristics of climate extremes have been assessed in terms of their past trends based on observation data available at the stations and projections of future changes in the 1980-1999 periods by using the climate models as discussed in section 3.1.

3.2.4. Climate Extreme Assessment Methods

Study of trends and changes in the past: Climate extreme factors or events can be defined by a period of a month, season or year from daily monitoring data. The linear regression analysis of a changing trend can be conducted as follows:

$$x = a_0 + a_1 t \quad (3.1)$$

Where:

$$a_0 = \bar{x} - a_1 \bar{t} \quad (3.2)$$

$$a_1 = r\frac{s_x}{s_t} \quad (3.3)$$

With $\bar{x}, \bar{t}, s_x, s_t, r$ are an arithmetic average and a standard deviation of x and t, and a linear correlation coefficient between x and t respectively.

An increasing and/or decreasing trend in x by t is evaluated based on the consideration of the sign and magnitude of a_1 angel factor. The reliability of a trend can be evaluated by statistics checks.

Projection of changes in the future: To assess the possible changes of climate extremes in the future, the report uses the results of some global and regional computation of such models as the AGCM/MRI (Japan), the PRECIS of Hadley Center – UK, and the CCAM of CSIRO.

<u>AGCM/MRI Developed by the Meteorological Research Institute (MRI, Japan)</u>. This model with 20km and 60km resolutions is a combination between a short duration weather forecasting model and a new generation model of long duration climate simulation used by MRI. The AGCM/MRI uses data collected for the past 25 years (1979 – 2003) to simulate the past climate in order to compute a baseline period. The near future is described as a period from 2015 to

2039 (25 years) and the distant future is simulated from 2075 to 2099 (25 years). For the monthly data, the model runs on the IPCC/A1B emission scenario (MONRE, 2012).

PRECIS (*Providing Regional Climates for Impacts Studies*) is a regional climate dynamic simulation developed by the Hadley Meteorological Research Centre for the development of climate change scenarios for smaller regions. For Vietnam, the model runs with the horizontal resolution of 25 km x25 km and five options of input data. Each of the options is a different element of the global model corresponding to the A1B - medium emission scenario. The period for computation is from 1950 to 2100 (MONRE, 2012).

CCAM is a global climate model ddeveloped by CSIRO, which can provide climate projections with a high resolution (10km x 10km) for Vietnam region (MONRE, 2013).

3.2.5. Uncertainty in climate extreme analysis

As discussed above, although observed data are quite enough in Northern Viet Nam, there are lots of difficulties in extreme analysis, for example quality of monitoring data, changes of measuring equipments, changes of location of stations, spatial changes, and changes of natural surfac s of s a ions, chang s of in r ac ion b w n h oca physica siz …

The emergence of a climate extreme results from impacts of several factors in large, small and local scales. Impacts in large scale include temperature increasing due to changes in radiation, enhancing the moisture in the atmosphere, increasing the contrast land - ocean temperature and thus alter the characteristics of circulation.

The above problems have significantly affected the tendency of climate extremes and is a source of uncertainty in the calculation analysis of the trends of observed extremes.

Climate projection describes the future climate status based on assumptions of greenhouse gas concentrations in the atmosphere associated with global socioeconomic growth according to the various assumptions. Results are calculated by mathematical and physucak model simulations of the climate system with different scenario of greenhouse gas concentrations as input data. Different scenarios of greenhouse gases would result in different projection. Local and regional factors could affect the results of calculations. This means that the calculated uncertainties exist in future climate projection, especially climate extremes in any particular area.

3.3. Changes of some climate extremes

3.3.1. Temperature extrems

3.3.1.1. Past trends

Trends and levels of change in climate extremes related to temperature are evaluated on the basis of the angle factor in the linear regression equation. The negative value of the angle factor represents a decreasing trend over time, the positive value expresses and increasing trend over time.

North-West Region: Both the highest temperature (**TXx**) and lowest temperature (TNn) tended to increase in this region. However, level of increase in TNn was significantly higher than that of TXx, the level of TNn could increase by approx. 1,04^{o}C/10 y a rs a h Điện Biên station. The number of cold nights (nights with the lowest temperature below the 10th percentile (**TN10P**) tended to decrease visibly and the number of hot days (days with the highest temperature above the 90th percentile (**TX90P**) tended to increase. Of which, the number of cold nights decreased at a rate of 1 - 5 %/10 years, and they significantly decreased in Điện Biên, Sơn La, Yên Châu; the number of hot days tended to increase at the highest rate of approx. 1,6 n%/10 years in Tuần Giáo. Together with changes in these indices, the number of heat waves **(SU35)** also tended to increase slightly in all the stations, the highest rate of increase accounted for about 2,5 days/10 years (in Lai Châu). Except the Điện Biên station where the number of hot days tended to decrease slightly at a rate of about 0, 45 day/10 years (Table 3-2).

Table 3-2. Changes in temperature extreme parameters in the North-West region[*]

Station	**SU35** (day/10 yrs)	**TXx** (°C /10 yrs)	**TNn** (°C/10 yrs)	**TX90p** (%/10 yrs)	**Tn10p** (%/10 yrs)
Sìn Hồ	0.00	0.07	0.05	#	#
Lai Châu	2.46	0.25	0.46	0.61	-1.66
Tuần Gi o	1.26	0.14	0.11	1.62	-1.16
Điện Biên	-0.45	-0.05	1.04	0.82	-4.57
Sơn La	0.43	0.03	0.45	1.01	-3.16
Yên Châu	0.15	0.06	0.66	0.50	-3.00

North-East Region: Both the highest temperature (**TXx**) and lowest temperature (TNn) (TNn) tended to increase in all the regional stations, but the level of increase in TNn was significantly higher than that of TXx. The highest rate of increase in TNn could reach approx. 0,14^{o}C/10 years. Similar to the North-West region, the number of cold nights (**TN10P)** tended to decrease clearly at a rate of between 0,7 and 3 %/10 years, except the Bắc Cạn station where TN10P tended increase at a rate of approx. 1,3 %/10 years. In the mean while, the number of hot days (**TX90P**) tended to increase at a rate of between 0, 3 and 4 %/10 years. Most of the stations, the number of heat waves **(SU35)** tended to increase slightly. Except several stations such as the Cửa Ông, Hòn Gai (of Qu ng Ninh province), this figure tended to decrease slightly (Table 3-3).

Northern Delta: In this region, both the highest temperature (**TXx**) and the lowest temperature (TNn) tended to increase visibly. In general, TNx increased at a higher rate compared to that of TXx. It is quite remarkable that the number of heat waves (**SU35**) tended to obviously increase from 0, 13 to 4 days/10 years over this region. Among regional stations, Mai Châu, Sơn Tây, Ba Vì, Nam Định and Yên Định stations had faster increases. Compared to the North-West and North-East regions, the number of cold nights (**TN10P**) decreased slightly over this region; but the number of hot days (**TX90P**) has a greater increase (Table 3-4).

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[*] *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa; # data do not meet calculation conditions.*

North Central Vietnam: The highest temperature (**TXx**) tended to increase at the highest rate of 0, 38oC/10 years, while some stations around Hue City tended to decrease slightly. Similar to other regions, the regional lowest temperature **(TNn)** had a higher increase commonly from 0, 03 to 1^{o}C/10 years compared to that of the highest temperature. Similar to the Northern Delta, it is quite remarkable that the number of heat waves (**SU35**) tended to visibly increase from 1 to 8 days/10 years commonly. With the same tendency, the number of hot days (**TX90P**) also tended to increase by 0, 43 and 1 %/10 years commonly. On contrary, the number of cold nights (**TN10P)** tended to decrease by 1 to more than 2 %/10 years commonly (Table 3-5).

*Table 3-3. Changes in temperature extreme parameters in the North-East region**

Station	**SU35** (day/10 yrs)	**TXx** (^{o}C /10 yrs)	**TNn** (^{o}C/10 yrs)	**TX90p** (%/10 yrs)	**Tn10p** (%/10 yrs)
Sa Pa	0.00	0.01	0.02	0.31	-0.79
Hà Giang	0.18	0.01	0.07	1.17	-2.00
Bắc Quang	0.58	0.03	0.06	1.92	-2.54
Lào Cai	0.14	0.01	0.05	#	#
Yên Bái	0.04	0.01	0.04	0.31	-2.01
Chiêm Hóa	0.39	0.02	0.14	#	#
Tuyên Quang	0.17	0.01	0.07	1.00	-2.42
Bắc Cạn	0.08	0.01	-0.02	0.92	1.32
Định H a	0.34	0.02	0.05	#	#
Tam Đ o	0.00	0.02	0.05	0.35	-2.63
Phú Hộ	0.11	0.01	0.03	0.70	-1.85
Trùng Khánh	0.01	0.02	0.02	#	#
Cao Bằng	0.01	0.01	0.04	#	#
Thấ Khê	0.20	0.02	0.01	1.12	-1.65
Lạng Sơn	0.03	0.01	0.06	0.71	-1.19
Hữu Lũng	0.43	0.01	0.08	#	#
Tiên Yên	0.12	0.02	0.06	3.65	-1.49
Cửa Ông	-0.02	0.00	0.03	2.31	-1.98
Cô Tô	0.00	0.01	0.03	2.50	-0.90
Bạch Long Vĩ	0.13	0.39	0.28	3.57	-1.88
Hòn Gai	-0.01	0.01	0.04	-0.23	-3.38
Lục Ngạn	0.34	0.02	0.05	#	#
Việ Trì	0.24	0.00	0.04	1.31	-1.85
Thái Nguyên	0.09	0.02	0.06	1.69	-1.67
Vĩnh Yên	0.26	0.01	0.05	1.41	-2.56

* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa; # data do not meet calculation conditions.*

*Table 3-4. Changes in temperature extreme parameters in Northern Delta**

Station	SU35 (day/10 yrs)	TXx (°C /10 yrs)	TNn (°C/10 yrs)	TX90p (%/10 yrs)	Tn10p (%/10 yrs)
Hòa Bình	0.73	0.22	0.74	0.58	-2.91
Mai Châu	4.05	0.35	0.36	#	#
Phù Liễn	0.85	0.08	0.15	1.62	-1.65
Sơn Tây	3.22	0.38	0.52	#	#
Ba Vì	2.60	0.29	0.37	2.15	-1.20
Hà Đông	2.13	0.19	0.26	#	#
Hưng Yên	2.55	0.27	0.14	#	#
Chí Linh	1.11	0.20	0.38	2.40	-0.49
H i Dương	1.90	0.23	0.42	1.97	-0.83
Thái Bình	0.63	0.04	0.27	#	#
Phủ Lý	1.56	0.11	0.37	#	#
Nam Định	3.11	0.21	0.09	#	#
Văn Lý	0.24	0.14	0.16	1.25	-1.03
Nho Quan	1.41	0.17	0.47	#	#
Ninh Bình	1.72	0.11	0.26	#	#

South Central Vietnam: The highest temperature (**TXx**) tended to change unclearly. However, the regional lowest temperature **(TNn)** tended to increase evidently by 0, 23 to 1, 15oC/10 years at all the stations. It is quite remarkable that the number heat waves (**SU35**) tended to change more clearly in the region, increased faster by 3, 55 to 6 days/10 years in some stations namely Trà My, Qu ng Ngãi, Quy Nhơn and Tuy Hòa; while decreased in some stations such as Phan Rang and Đà Nẵng, by even a highest rate of 4 days/10 in Phan Rang. The number of cold nights (**TN10P**) tended to decrease evidently from 1, 5 to 3, 5 %/10 years. The number of hot days (**TX90P**) tended to increase significantly from 1 to 3 %/10 years (Table 3-6).

Central Highlands: The highest temperature (**TXx**) tended to decrease slightly from 0,17 to 0,48°C/10 years in almost all the regional stations. The regional lowest temperature **(TNn)** tended to increase evidently by 0,3 to 1,56°C/10 years . The number of cold nights (**TN10P**) and the number of hot days (**TX90P**) tended to change.. At such the stations as Mdrak, Buôn Mê Thuột, the number of heat waves (**SU35**) tended to increase evidently; while this figure decreased at some stations such as Ayunpa, Kon Tum (Table 3-7).

Southern Vietnam: The highest temperature (**TXx**) tended to decrease slightly. The lowest temperature **(TNn),** meanwhile, tended to increase in most of the stations. The number of hot days (**TX90P**) tended to significantly increase in a number of the stations namely Trường Sa, Vũng Tàu and Phú Qu c; . The number of cold nights (**TN10P**) tended to decrease clearly in the regional stations, and of which some stations of Vũng Tàu, S c Trăng and Cà Mau where the number much decreased by 8 %/10 years. The number of heat waves (**SU35)** rapidly increased

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by 4 to 7 days/10 years in Càng Long, Châu Đ cwhile in others (Tây Ninh, Cần Thơ, Cao Lãnh) where the number tended to decrease significantly by 2 to 6 days/10 years (Table 3-8).

*Table 3-5. Changes in temperature extreme parameters in the North of Central Vietnam**

Station	**SU35** (day/10 yrs)	**TXx** (°C /10 yrs)	**TNn** (°C/10 yrs)	**TX90p** (%/10 yrs)	**Tn10p** (%/10 yrs)
Hồi Xuân	2.20	0.25	0.29	0.43	-1.16
Yên Định	3.22	0.38	0.52	#	#
Thanh Hóa	1.06	0.05	0.03	#	#
Như Xuân	-0.42	0.13	-0.03	#	#
Tây Hiếu	2.47	-0.42	0.80	0.89	-2.77
Tương Dương	2.90	0.18	0.39	0.97	-2.81
Đô Lương	1.15	0.07	0.36	#	#
Vinh	3.46	0.24	0.34	1.49	-2.48
Hà Tĩnh	3.39	0.28	0.24	1.15	-2.44
Hương Khê	3.94	0.26	0.64	#	#
Kỳ Anh	1.82	0.08	0.28	0.88	-2.38
Tuyên Hóa	7.85	0.31	0.08	2.13	-1.24
Huế	0.52	-0.06	-0.03	-0.55	0.16
Nam Đông	1.94	-0.13	0.17	#	#
A Lư i	0.00	0.00	1.00	1.00	-2.00

*Table 3-6. Changes in temperature extreme parameters in the South of Central Vietnam**

Station	**SU35** (day/10 yrs)	**TXx** (°C /10 yrs)	**TNn** (°C/10 yrs)	**TX90p** (day/10 yrs)	**Tn10p** (day/10 yrs)
Đà Nẵng	-1.14	-0.25	0.30	0.89	-1.50
Trà My	5.87	0.09	0.08	2.99	0.40
Qu ng Ngãi	2.50	-0.01	0.49	#	#
Ba Tơ	-0.65	-0.10	0.50	2.07	-1.54
Quy Nhơn	3.55	0.09	0.17	1.20	-2.77
Tuy Hòa	3.94	0.17	0.19	1.40	-3.15
Nha Trang	-0.49	-0.01	0.23	#	#
Phan Rang	-4.13	-0.25	1.15	#	#
Phan Thiế	1.00	0.31	0.57	2.16	-3.50

The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa; # data do not meet calculation conditions

*Table 3-7. Changes in temperature extreme parameters in Central Highlands**

Station	SU35 (day/10 yrs)	TXx (°C /10 yrs)	TNn (°C/10 yrs)	TX90p (%/10 yrs)	Tn10p (%/10 yrs)
Ayunpa	-1.51	-0.29	0.95	2.41	-2.85
MDRAK	1.47	0.23	1.56	#	#
Kon Tum	-0.91	-0.17	1.43	2.96	-5.02
Plâycu	0.08	0.01	0.31	0.49	-5.23
B Mê Thuộ	1.71	0.07	0.38	2.13	-4.19
Đăk Nông	0.04	-0.48	1.04	2.76	-3.42
Đà Lạ	0.00	-0.32	0.34	1.23	-2.09
B o Lộc	0.02	-0.24	0.64	0.19	-2.30

*Table 3-8. Changes in temperature extreme parameters in Southern Vietnam**

Station	SU35 (day/10 yrs)	TXx (°C /10 yrs)	TNn (°C/10 yrs)	TX90p (%/10 yrs)	Tn10p (%/10 yrs)
Trường Sa	0.40	0.70	-0.12	15.14	2.41
Phú quý	0.01	-0.09	0.38	1.18	-0.63
Tây Ninh	-2.40	-0.15	0.54	0.00	0.00
Vũng Tàu	0.13	0.13	0.61	4.56	-7.72
Côn Đ o	-0.07	-0.28	0.78	3.07	-1.72
Mỹ Tho	-0.46	0.05	0.01	#	#
Càng Long	4.28	0.74	-0.13	#	#
S c Trăng	0.55	-0.09	0.41	#	#
Cần Thơ	-5.76	-0.86	0.34	-0.78	-6.66
Cao Lãnh	-3.07	-0.30	0.20	#	#
Châu Đ c	7.91	0.27	1.36	#	#
Phú Qu c	0.59	0.08	0.68	8.66	-1.34
Rạch Gi	-1.05	-0.25	0.62	-0.73	-2.86
Cà Mau	0.79	-0.11	0.87	2.13	-5.39

3.3.1.2. Future Projections

Results gained from the projection of changes in temperature extremes in the 21st century based on the medium GHG emission scenario published by MONRE in 2012, indicate a number of following points that need attention (MONRE, 2012; 2013):

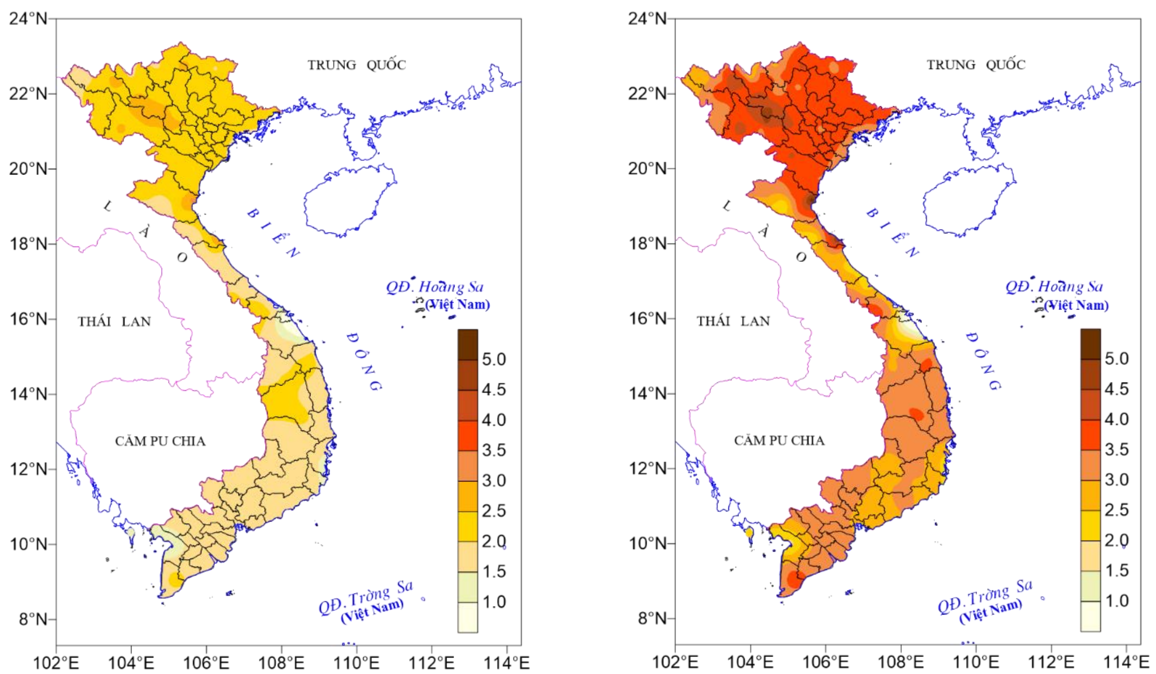
* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa; # data do not meet calculation conditions*

The lowest temperature:

Winter: According to medium emission scenario, by the mid-21st century, the mean lowest temperature can increase by approx. 1 – 1.2^{o}C compared to the average of the 1980-1999 period over almost all of northern areas (from Khánh Hòa upwards); by about 1.2 to 1.5^{o}C over the rest. By the end of the 21st century, the mean lowest temperature can increase by 2 – 2.2^{o}C over almost all of northern areas (from Khánh Hòa upwards) compared to the average of the 1980-1999 period; of which over the North-East of Northern Vietnam where the figure can increase by 2.2 – 2.5^{o}C; while the South of Central Highlands, the South of Central Vietnam and Southern Vietnam will have an increase of 2.2 to above 3^{o}C.

Summer: By the mid-21st century, the mean lowest temperature can increase by 1.7 - 2^{o}C compared to the average of the 1980-1999 period over Northern Vietnam and most of areas from areas from Thừa Thiên Huế to Ninh Thuận; and by 1.2 – 1.7^{o}C over the West of Northern Vietnam, most of areas in Central Vietnam, Central Highlands and Southern Vietnam. By the end of the 21st century, the mean lowest temperature can increase by 2.7 – 3.5^{o}C compared to the average of the 1980-1999 period, over almost all of areas in Northern and Central Vietnam; and increase by 2 – 2.7^{o}C over the North-West region and part of Central Vietnam, Central Highlands and Southern Vietnam.

Figure 3-1. Projected changes in mean annual lowest temperature by the middle (left) and the end (right) of the 21st century compared to the average of the 1980-1999 period according to medium emission scenario A1B



(Source: MONRE, 2012)

Year: By the mid-21st century, the climate change scenario with mean medium emission predicts that the mean annual lowest temperature will increase by between 1- 2^{o}C nationwide compared to the average of the 1980-1999 period, and increase very rapidly in Southern Vietnam. By the end of the 21st century, the mean annual lowest temperature can increase by

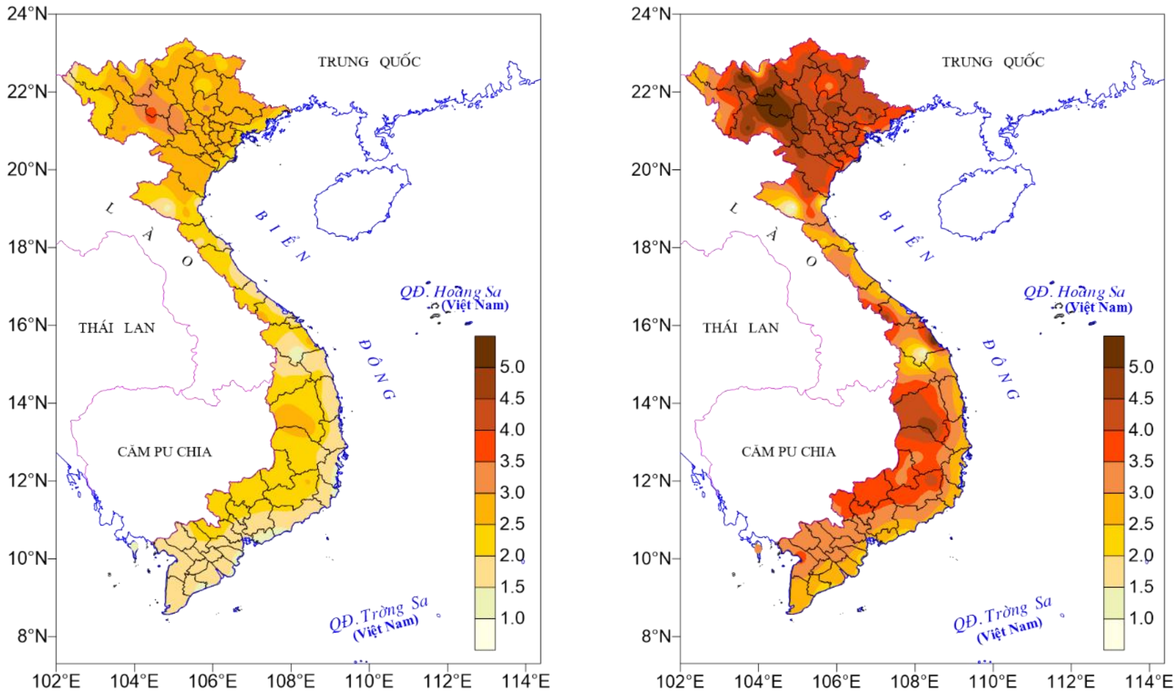
2.2 – 3.0^{o}C compared to the average of the 1980-1999 period. Over most of areas of Northern and Southern Vietnam and South of Central Highlands where an increase in temperature will be higher (from 2.7 to above 3.0^{o}C).

The highest temperature:

Winter: By the mid-21st century, the mean highest temperature will increase by approx. 1.5 – 2.2^{o}C compared to the average of the 1980-1999 period over almost all of northern areas (from Nghe An upwards); By 0 – 1.2^{o}C in most areas in Central Vietnam and Central Highlands; by 1.2 - above 1.7^{o}C in the South of Central Vietnam and Southern Vietnam. By the end of the 21st century, the mean annual highest temperature will increase by 2.2 – above 3^{o}C compared to the average of the 1980-1999 period over most areas from Nghe An upwards and Southern Vietnam; increase by 2 – 2.2^{o}C over most areas in Central Vietnam and Central Highlands.

Summer: By the mid-21st century, the mean highest temperature will mainly increase by 1.2 - 2^{o}C compared to the average of the 1980-1999 period over the North-East of Northern Vietnam and most area (from Thừa Thiên Huế downwards); increase by 1 – 1.2^{o}C over the West of Northern Vietnam, most areas of the North of Central Vietnam and Central Highlands. By the end of the 21st century, the mean highest temperature can increase by 2.2 – above 3^{o}C compared to the average of the 1980-1999 period over the East of Northern Vietnam and Central Vietnam; increase by 2 – 2.2^{o}C over the North-West, Central Highlands and Southern Vietnam.

Figure 3-2. Projected changes in mean annual highest temperature by the middle (left) and the end (right) of the 21st century compared to the average of the 1980-1999 period according to medium emission scenario A1B



(Source: MONRE, 2012)

Year: By the mid-21st century, the mean highest temperature will have similar results in terms of area and increase of between 1- 2.5°C compared to the average of the 1980-1999 period, and over the North-East, Northern Delta and Southern Vietnam where increases will be higher than other regions. By the end of the 21st century, the mean highest temperature will increase by 2 – 3.5°C compared to the average of the 1980-1999 period. Over the North of Northern Vietnam and most Southern Vietnam where an increase in temperature will be the highest (from 2.7 to 3.5°C).

3.3.2. Rain extremes

3.3.2.1. Past trends

In this section, we concentrate on the assessment of various rain extreme characteristics directly affecting the natural environment and society, such as daily max rainfall (Rx1day), five-day max rainfall (Rx5day), a total rainfall of days with rainfall exceeding the 95% percentile threshold (R95p), intra-annual rainfall total (PRCPTOT) and the consecutive dry days (CDD). The analytical results can be summarized as follows:

The North-West Region: In the past 50 years, Rx1day tended to increase in most regional stations, except the Tuần Giáo station where there was a slightly decreasing trend. The highest rate of increase in Rx1day measured at the Mộc Châu station (approx. 6 mm/10 years on average). Changes in Rx5day were inconsistent. While half of the regional stations had an increasing trend, the rest had a decreasing tendency. It is quite remarkable that Rx5day increased by 8 mm/10 year in the Lai Châu station and decreased nearly 6 mm/10 years in the Sơn La station. The number of CDD tended to increase slightly in the North-West region (less than 2 days/10 years on average), except the Yên Châu station where it tended to decrease. Results of calculation according to monitoring data indicate that R95p and PRCPTOT varied significantly, but with different trends depending on specific locations in the region. Both R95p and PRCPTOT tended to increase in the stations of Lai Châu and Điện Biên while decrease in the stations of Mộc Châu, Sơn La and Tuần Gi o (Table 3-9).

*Table 3-9. Changes in rainfall extreme parameters in the North-West region**

Station	RX1day	RX5day	CDD	R95p	PRCPTOT
	(mm/10 yrs)	(mm/10 yrs)	(day/10 yrs)	(mm/10 yrs)	(mm/10 yrs)
Sìn Hồ	-2.3	-1.2	-0.6	-3.2	-23.7
Lai Châu	4.4	7.5	1.1	32	11.3
Tuần Gi o	-0.5	0.8	1.1	-16.5	-36.5
Điện Biên	1.1	-0.8	1.4	33.8	22.4
Sơn La	0.2	-5.9	1.9	-1.2	-12.1
Yên Châu	0.1	-1.2	-0.9	-4.2	12.5

* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;*

*Table 3-10. Changes in rainfall extreme parameters in the North-East region**

Trạm	RX1day	RX5day	CDD	R95p	PRCPTOT
	(mm/ hập kỷ)	(mm/ hập kỷ)	(ngày/ hập kỷ)	(mm/ hập kỷ)	(mm/ hập kỷ)
Sa Pa	-5,3	-11,3	-0,1	-53,7	-60
Hà Giang	1,2	2,5	0,7	30	-19,9
Bắc Quang	6,6	-0,2	0,9	-7,9	-89
Lào Cai	1,7	4,7	3,5	-3,2	-18,9
Yên Bái	3,3	4,6	0,8	10,3	-30,6
Chiêm Hóa	-99,4	-104,7	3,3	-114,9	-130,3
Tuyên Quang	5,7	5,5	0,6	-14,1	-47,2
Bắc Kạn	-10,7	-16,6	6,1	-15,6	-44,6
Định H a	3,1	3,5	1,4	7,3	-27,3
Tam Đ o	-3,4	-18,5	1,9	-66,4	-131
Phú Hộ	-19,5	-23	1,6	-81,9	-125,1
Trùng Khánh	-10,7	-15,7	0,0	8,0	-21,8
Cao Bằng	-15,7	-26,8	6,6	-222,1	-335,6
Thấ Khê	0,6	-1,3	0,8	-26,6	-27,5
Lạng Sơn	2,2	3,3	1,2	-6,6	-21,3
Hữu Lũng	-15,9	-20,1	2,9	-4,4	-5,2
Tiên Yên	8,1	-14,5	1,3	-39,9	-52,9
Cửa Ông	-10,6	-22	-0,9	-108,4	-102,8
Cô Tô	1,3	5,5	0,5	-11	10,8
Bạch Long Vĩ	2,9	-1,1	-1,2	-8,3	19,5
Hòn Gai	1,9	-3,0	2,0	-31,3	-55,1
Lục Ngạn	-2,5	-8,2	2,1	-4,5	-12,7
Việ Trì	-10,2	-10,6	0,5	-47,1	-80,1
Thái Nguyên	-2,3	-1,0	1,9	-16,2	-65,9
Vĩnh Yên	6,9	-3,2	0,3	-1,5	-37,7

The North-East Region: Rx1day tended to increase and/or decrease differently depending on the position of the regional stations: decreased by 10-20 mm/10 years, and even up to 99 mm/10 years measured at the Chiêm Hóa station; increased between more or less than 3 mm/10 years, and even up to 6.6 mm/10 years in Bắc Quang. Generally, a trend in Rx5day was similar to that of Rx1day. Decreasing trends were much more observed than increasing trends, within a range of 2-4 mm as the highest rate in Cô Tô, Lào Cai, Yên Bái. CDD tended to increase in most the regional stations with the most significant increase (of about 6 days) measured at the Bắc Cạn and Cao Bằng stations. R95p tended to decrease in most the stations in the North-East region, except such the sta ions as Yên B i , Trùng Kh nh and Định Hóa where there was a growing trend with an increase of about 7-10 mm/10 years. Decrease in

The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;

R95p was relatively significant, which can increase to 222 mm/10 years in the Cao Bằng station, and then the Cửa Ông and Chiêm Hóa stations (108 mm and 115 mm/10 years respectively). Th s a ions inc uding Vĩnh Yên, Hữu Lũng and Lục Ngạn where decreases were insignificant while an increase was less than 5 mm/10 years. Results gained from the calculation of PRCPTOT indicate that the total rainfall decreased in the whole North-East region except Co To, in the last 50 years. Decreases among the regional stations significantly fluctuated from 5 mm to 335.6 mm/ 10 years (Table 3-10).

Northern Delta: Rx1day tended to decrease in most the regional stations in the Northern Delta with less than 10 mm/10 years, while it was more than 10mm/10 years observed at nearly quarter of the regional stations (5/19 stations), especially at the Ba Vi station (approx. 25mm/10 years). Rx5day also tended to decrease in a majority of the regional stations, especially at the s a ions such as Sơn Tây, Ba Vì, Hưng Yên, H i Dương wh r a high y significan d cr a s was 37mm/10 years. The number of consecutive dry days (**CDD)** tended to increase slightly by between 0 and 3.3 days/10 years in most the regional stations. **R95p** and **PRCPTOT** tended to decrease strongly, oscillating in a range of 50-100mm/10 years in most the regional stations (Table 3-11).

*Table 3-11. Changes in rainfall extreme parameters in the North-West of the Northern Vietnam**

Station	RX1day (mm/10 yrs)	RX5day (mm/10 yrs)	CDD (day/10 yrs)	R95p (mm/10 yrs)	PRCPTOT (mm/10 yrs)
Mộc Châu	6.1	5.1	1.3	-20	-21.4
Hòa Bình	-8.5	2.2	1.3	-9.7	-21.3
Mai Châu	1.9	12	3.3	4.9	-15.4
Bắc Giang	1.4	0.2	2.4	4.4	3.8
Phù Liễn	-2.2	-0.9	1.6	-46.6	-71.5
Sơn Tây	-7.5	-6.9	0.9	-40.8	-78.9
Ba Vì	-26.4	-37.1	0.1	-115.8	-152.3
Hà Đông	6.7	12.9	3.1	-0.9	19.5
Hưng Yên	-12.8	-15.5	1.9	-59.2	-90.7
Chí Linh	-1.7	7.3	0.2	-7.4	-5
H i Dương	-9.7	-14.3	0.6	-67.3	-52
Thái Bình	-8.7	-11.9	2.2	-77.7	-107.5
Phủ Lý	-0.2	0.1	1	-7.3	-32.3
Nam Định	-7.2	-12.1	0.9	-41.7	-72.9
Văn Lý	-1	0.3	0.6	-19.8	-86.4
Nho Quan	4.2	7.7	1.6	14.7	5.8
Ninh Bình	-4.7	-7.5	0	-28.9	-66.7

* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;*

North Central Vietnam: Both Rx1day and Rx5day tended to increase significantly at most the regional stations. Of which, increases in Rx1day were commonly from 9.8 to nearly 31mm/10 years; and increases in Rx5day were in a range of 4 to 63mm/10 years. Except some stations in Thanh Hóa and Nghệ an areas where Rx1day tended to decrease slightly; and Rx5day tended to decrease at several stations of Thanh Hóa and the Tương Dương station. Meanwhile, the number of CDD tended to change insignificantly in a range of -3.5 to 1.6 days/10 years over the region. The R95p threshold tended to increase significantly in a rather wider range of 4 to more than 200mm/10 years in the past years, of which the faster rate of increase was observed at the southern stations and the slower rate of increase measured at the northern stations. Thus, a total rainfall also tended to increase from 100 to approx. 388mm/10 years at most the regional stations, especially at those in the south of the region (Table 3-12).

*Table 3-12. Changes in rainfall extreme parameters in the North of Central Vietnam**

Station	RX1day (mm/10 yrs)	RX5day (mm/10 yrs)	CDD (day/10 yrs)	R95p (mm/10 yrs)	PRCPTOT (mm/10 yrs)
Hồi Xuân	-10.6	-6.5	0.5	-63.1	-57.3
Yên Định	2-7.5	-6.9	0.9	-40.8	-78.9
Thanh Hóa	5.8	-5.6	0.6	-18.9	-21.5
Như Xuân	-25.5	-42.0	-4.3	-154.5	-63.4
Tĩnh Gia	-13.9	-29.6	-5.9	-19.5	-30.6
Tây Hiếu	6.5	7.3	-1.4	5.8	-6.0
Tương Dương	-0.4	-3.9	1.6	-16.4	-20.1
Đô Lương	-3.7	4.4	-0.2	12.6	4.2
Vinh	-1.4	8.4	-1.0	4.1	-2.7
Hà Tĩnh	18.1	7.6	0.7	8.4	-42.2
Hương Khê	9.8	36.7	0.1	47.6	14.9
Kỳ Anh	26.1	6.4	0.4	66.2	-26.4
Tuyên Hóa	13.6	25.6	-3.5	37.3	18.1
Huế	19.9	38.4	-0.6	106.8	141.0
Nam Đông	30.9	51.8	-2.6	266.2	355.7
A Lư i	30.0	63.0	-3.0	202.0	388.0

South Central Vietnam: Both Rx1day and Rx5day tended to increase significantly over south central Vietnam. Noticably, heavy rain increased by 31 to more than 180mm/10 years. R95p and PRCPTOT tended to increase significantly in Qu ng Nam, Đà Nẵng, Qu ng Ngãi and Quy Nhơn with approx. 50 to more than 250mm/10 years. CDD tended to decrease in most the

* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;*

regional stations, especially at the Pham Rang station where decrease in heavy rain was about 17 days/10 years (Table 3-13).

Central Highlands: Both **Rx1day** and **Rx5day** tended to increase at a significant levels observed at most the regional stations, of which increase in Rx1day was in a range of 0.8 to 12.8mm/10 years and increase in Rx5day was from 6.5 to 55mm/10 years. R95p and PRCPTOT tended to increase significantly at most the stations, especially at the stations of Mdrak, Đắk Nông and B o Lộc. CDD also decreased from 2 to 8 days /10 year (Table 3-14).

Table 3-13. Changes in rainfall extreme parameters in the South of Central Vietnam[*]

Station	RX1day	RX5day	CDD	R95p	PRCPTOT
	(mm/10 yrs)	(mm/10 yrs)	(day/10 yrs)	(mm/10 yrs)	(mm/10 yrs)
Đà Nẵng	-2.2	-1.0	-3.8	93.4	151.0
Trà My	34.3	59.7	-4.8	101.4	187.5
Qu ng Ngãi	31.6	38.3	-2.1	164.3	282.0
Ba Tơ	-1.9	28.7	-3.4	180.5	358.4
Quy Nhơn	11.4	10.0	-1.4	110.5	144.4
Tuy Hòa	27.5	44.5	1.2	182.5	224.2
Nha Trang	6.0	17.7	1.7	56.6	77.6
Phan Rang	26.5	48.2	-17.3	79.6	134.3
Phan Thiế	1.2	2.3	-0.1	31.6	50.7

*Table 3-14. Changes in rainfall extreme parameters in Central Highlands**

Station	RX1day	RX5day	CDD	R95p	PRCPTOT
	(mm/10 yrs)	(mm/10 yrs)	(day/10 yrs)	(mm/10 yrs)	(mm/10 yrs)
Ayunpa	-17.2	-9.9	2.0	-39.4	-72.7
MDRAK	6.4	54.9	-2.3	77.5	294.8
Kon Tum	8.0	18.5	-7.9	52.8	87.0
Plâycu	0.8	6.5	-2.4	1.6	-18.2
B Mê Thuộ	12.8	16.5	1.5	34.6	74.1
Đăk Nông	-8.2	-4.0	-1.9	66.4	93.8
Đà Lạ	-1.4	6.0	-6.2	-8.6	68.3
B o Lộc	7.2	24.2	0.3	43.8	126.3

Southern Vietnam: Rx1day and Rx5day tended to increase slightly in most the regional stations at a common rate of less than 30mm/10 years. It is noticeable that the number of CDD tended to decrease significantly if compared to the other regions, at a rate of less than 16 days/10 years. PRCPTOT also tended to increase at most the regional stations, especially at

[*] *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;*

s v ra s a ions as h Trường Sa (179,6 mm/10 years), Cao Lãnh (115 mm/10 years) and Phú Qúy (86,1 mm/10 years). PRCPTOT decreased a ra of 9 mm/ 0 y a rs a h Vũng Tàu station (Table 3-15).

*Table 3-15. Changes in rainfall extreme parameters in Southern Vietnam**

Station	RX1day (mm/10 yrs)	RX5day (mm/10 yrs)	CDD (day/10 yrs)	R95p (mm/10 yrs)	PRCPTOT (mm/10 yrs)
Trường Sa	29.6	61.5	3.4	167.6	179.6
Phú quý	10.1	23.7	-15.1	45.2	86.2
Tây Ninh	3.9	4.8	-3.7	17.7	19.8
Vũng Tàu	-10.3	-10.7	-15.8	-14.6	-91.0
Côn Đ o	-6.8	-9.1	-4.1	-19.2	-30.2
Mỹ Tho	10.1	11.2	-10.3	35.6	70.1
Càng Long	10.6	25.2	-4.1	60.0	79.9
S c Trăng	-5.6	-7.7	-4.2	-12.4	35.6
Cần Thơ	10.3	7.9	-10.9	11.3	15.6
Cao Lãnh	-5.3	6.5	-12.9	16.9	115.2
Châu Đ c	-2.6	-2.3	-0.9	17.9	44.2
Phú Qu c	3.5	-2.7	-0.5	28.0	-38.3
Rạch Gi	-7.4	-6.0	-11.5	-39.7	-4.4
Cà Mau	0.0	-5.7	1.3	-17.3	-4.5

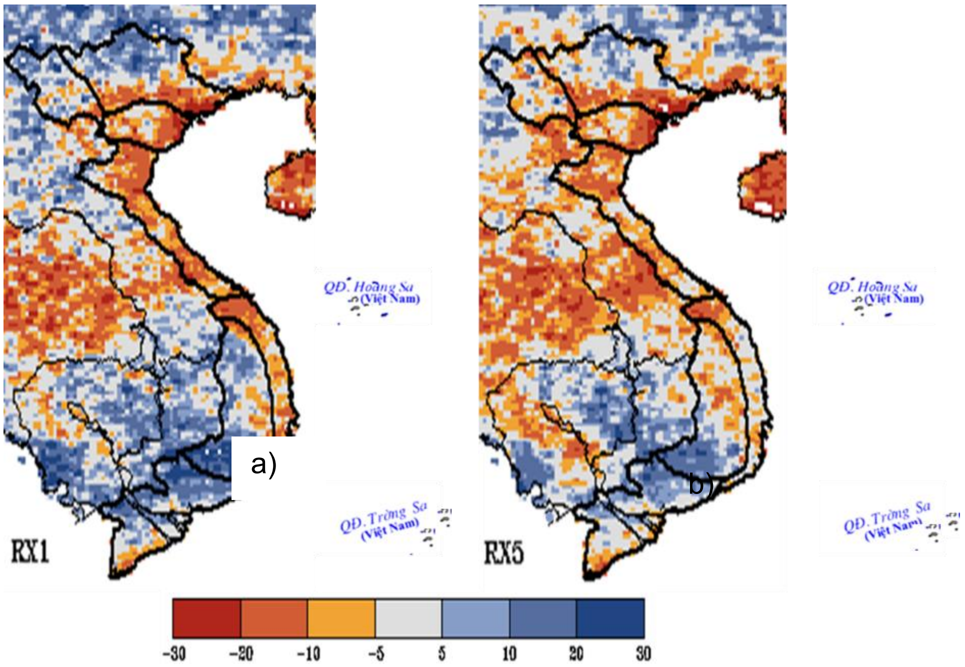
3.3.2.2. Future Projections

Future projection of rain extremes is very difficult, depending on many different factors and processes, because of many uncertainties in future projections.

Th mos r c n s udy r su s produc d by Proj c on “High R so u ion Proj c ion of u ur Climate for Vi na m” (MONRE, 0) indica ha fu ur rain x r m s vary in diff r n ar a s Accordingly, it is projected that Rx1day increases in most areas in the North-West, the eastern part of the North and decreases in the Northern Delta, North and South Central Vietnam. However, mean statistics for all areas as a whole shows that the variability is rather low, the highest being only 7%. Annual fluctuation of the number of days with max. Rainfall is projected to increase except the South Central Vietnam with standard deviation of up to -10%, and 17% and 13% in the North-East and the Central Highlands respectively. The number of wet days (>1mm) and that of dry days (without rain) in future vary but not clearly, with the greatest ranges from -4 to -7 days in the South and the Central Highlands respectively, while the variability in other regions are insignificant. The Rx5day is projected to increase by 10% to 20% in almost all of the territories. (Fig. 3.3)

* *The more darker pink describes th more significantly increasing rates and vice versa; the more darker green depicts the more significantly decreasing ratss and vice versa;*

Figure 3-3. Projected changes in Rx1day (a), Rx5day (b) in the end of the 21st century according to high emission scenario RCP 8.5 (%)



(MONRE, 2013)

3.3.3. Other extremes

3.3.3.1. Wind

According to the analyses of wind observation data of the 1954-1990 period, Tran Viet Lien (1990, 1994) holds that storm is the main factor that brings about the greatest wind speed in our country with the greatest speed of possibly up to 40m/s. This speed prevails in most coastal provinces from Quang Ninh to Phu Yen. Besides, this numeric value is also recorded in many land-locked provinces. Most remarkable is that wind speed greater than 50 m/s is also recorded in some places like Phu Lien, Ky Anh and Quy Nhon… wi h migh y s orms wh r v ry arg areas of up to 500 – 600 km suffer wind of greater than Beaufort number 10 (Tran Viet Lien, 1990, 1994). When the storm goes ashore, the affected area shrinks to 150 – 250 km with wind of Beaufort number 12 and greater, and most affected is the coastal area of 50 – 150 km. However, whether the strong wind can rage deep into the land depends on the coastal topography. In the coastal plain, wind number 10 can rage into area of 100 – 150 km from the coast while in coastal areas of Quang Ninh province and those Central provinces, the storm only reaches 20 – 50 km from the coast. Besides, wind speed is higher in larger areas north of the eye of the storm. As such, strong storms in Thanh Hoa province can also bring about wind number 10 in the Northern Plain. Stormy wind may rage for 20 -25 hours (wind greater than number 8 when inland), 10 -15 hours (wind number 7 and above) and 2 – 3 to 10 hours in coastal areas. Whirlwinds and cyclones are direct causes of high-speed wind in all parts of the territory especially in the mountainous and plain areas in the South. Even in the storm-affected coastal areas in the North, whirlwinds and cyclones contribute considerably to the extreme of wind speed (Tran Viet Lien 1990, 1994). It is also mentioned by Tran Viet Lien that storms and tropical atmospheric depressions, when inland, cause wind speed of 20m/s or higher. The greatest speeds of wind recorded were those in the Becky storm that took place on 29 August 1990, which were 54m/s in Ky Anh and 40 m/s in Huong Khe; wind speed of 46 m/s was recorded in Ky Anh in the tropical atmospheric depression on 20 September 1992 (Tran Viet Lien, 1990).

In a study conducted by Phan Van Tan *et al.* (2010), it is mentioned that the greatest wind speed in year Vx tends to become lower in most stations throughout the territory, except in some stations such as those in Da Nang, Da Lat and Rach Gia where the wind speed tends to become higher, the most remarkable one is in Rach Gia station with the recorded coefficient a1=0.32.. Projections based on scenarios A1B and A2 for the first half of the 20th Century show that Vx tends to increase slightly in all climate regions. The Vx increase/decrease variations in climatic zones are insignificant. On an average, Vx oscillation amplitude is within ± 2m/s (Phan Van Tan, 2010).

3.3.3.2. Humidity

Situated in the tropical monsoon region, relative humidity in Vietnam is comparatively high. Annual average relative humidity is between 80 and 85%. In mountainous areas and where there is much rain, the average relative humidity may be up to 87%. In the coastal areas in the South, it is comparatively lower and is about 77 – 78%. The highest value of relative humidity in all areas of Vietnam is up to 100% while the lowest is 20% or may be even 50% lower than the average. Annual variation of the relative humidity is profoundly influenced by the precipitation regime. In North-East and the Northern Plain, the relative humidity is low in early and mid winter, higher in late winter, then lower again, and then becomes drastically higher in summer months. In the coastal areas of Central Vietnam, the relative humidity is low in summer months and high in winter months, the cause being the blowing of dry and hot west wind in these areas. In the North-West, the Central Highlands and the South, the relative humidity is rather low in mid- and- late winter; and rather high in all summer months (Nguyen Duc Ngu and Nguyen Trong Hieu, 2004).

There is a comparatively small distribution of the annual lowest relative humidity (Um) in the mountainous areas in the North and in the high mountainous areas in the Central Highlands region. In these two regions, the RHm value is only between 10 and 20%; and particularly only 8% and 0 % in Y n Chau and Da La r sp c iv y Th “r co rd” ow va u s ar 7% in Nor h-West and 9% in the Central Highlands. In the coastal plains, as RHm becomes higher and higher in the north-south direction, the RHm is the highest in the country. The RHm variation is the greatest in the North-West and the Central Highlands (about 6-7%) while it is the smallest in the South (about 3-4%). The lowest HRm tends to increase sharply in winter months and vary slightly or decrease in summer months (Phan Van Tan, 2010).

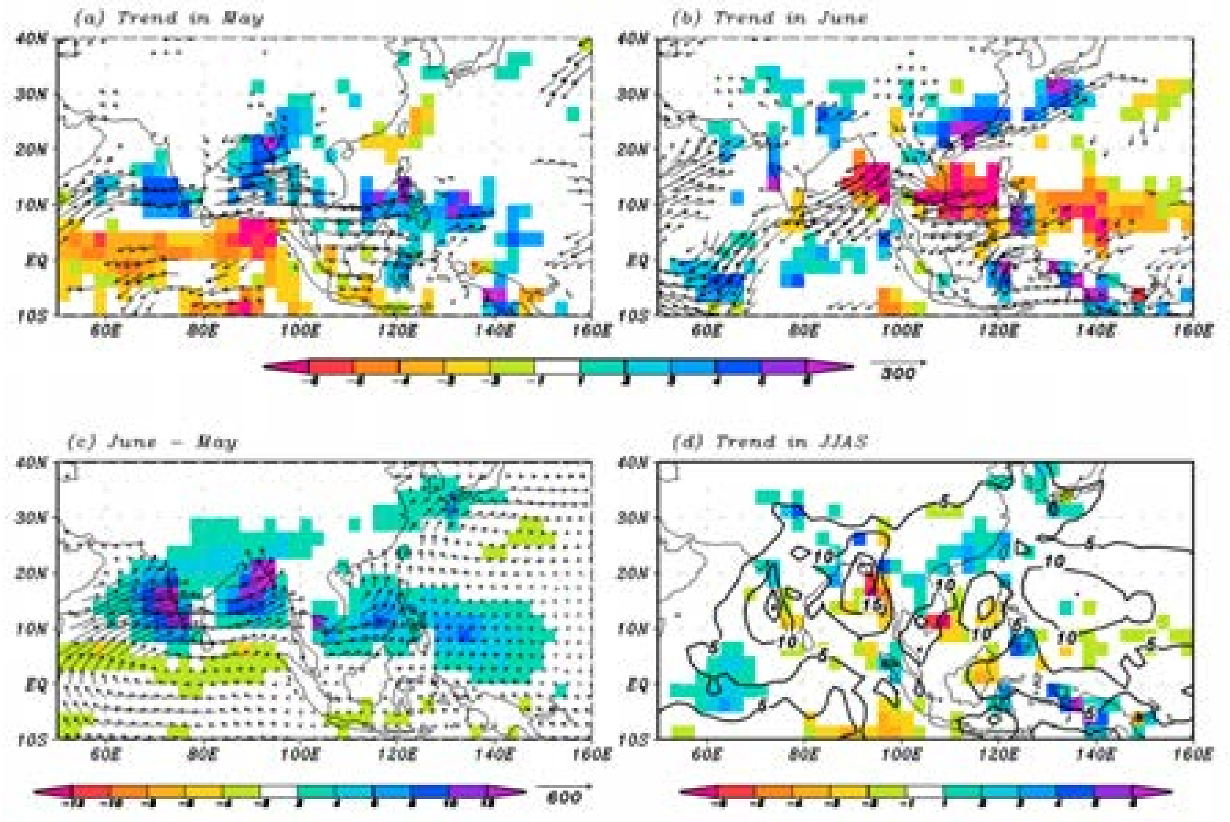
Phan Van Tan (2010) projects the variation of the lowest RHm in the first half of the 21st Century based on scenarios A1B and A2 against the average of the 1971-2000 reference period. The results show the slight decrease or the stability of Um in all climate regions. The levels of increase/decrease of Um in all climate regions are not much different. On an average, Um oscillation amplitude is within ±10% (Phan Van Tan, 2010).

3.4. Variations of circulations that affect climate extremes in Vietnam

3.4.1. Monsoon

Monsoon is a large-scale circulation system characterized by the reversal of the main wind direction in the period between winter and summer due to the contrast between oceanic and mainland temperatures as a result of the change of solar radiation during the year (Ramage, 1971). As Vietnam is situated in the tropical zone, the climate in Vietnam is impacted by two main monsoon systems namely South Asian monsoon system and East Asian monsoon system. Monsoons cause strong impacts on climate extremes in Vietnam. As such, winter monsoons bring about severe and hazardous cold spells, extreme rainfall and strong winds in the North while summer monsoons bring about big rains in the South and in Central Highlands with floods and landslides. Of particular impact is the co-occurrence of and interaction between monsoons and storms and tropical atmospheric depressions, which cause record big rains. In climate regions that are strongly influenced by circulations of Southwestern monsoons such as the South, the Central Highlands and the North-East, the beginning of the rainy season coincides with that of the summer monsoon season. The comparatively multiple-yearly average late beginning of the summer monsoon season may cause some drought.

Figure 3-4. Changing trends in rainfalls from CMAP data (colour,mm/day) and total atmospheric moisture load vector from NCEP re-analyzed data (kg m^{-1} s^{-1})

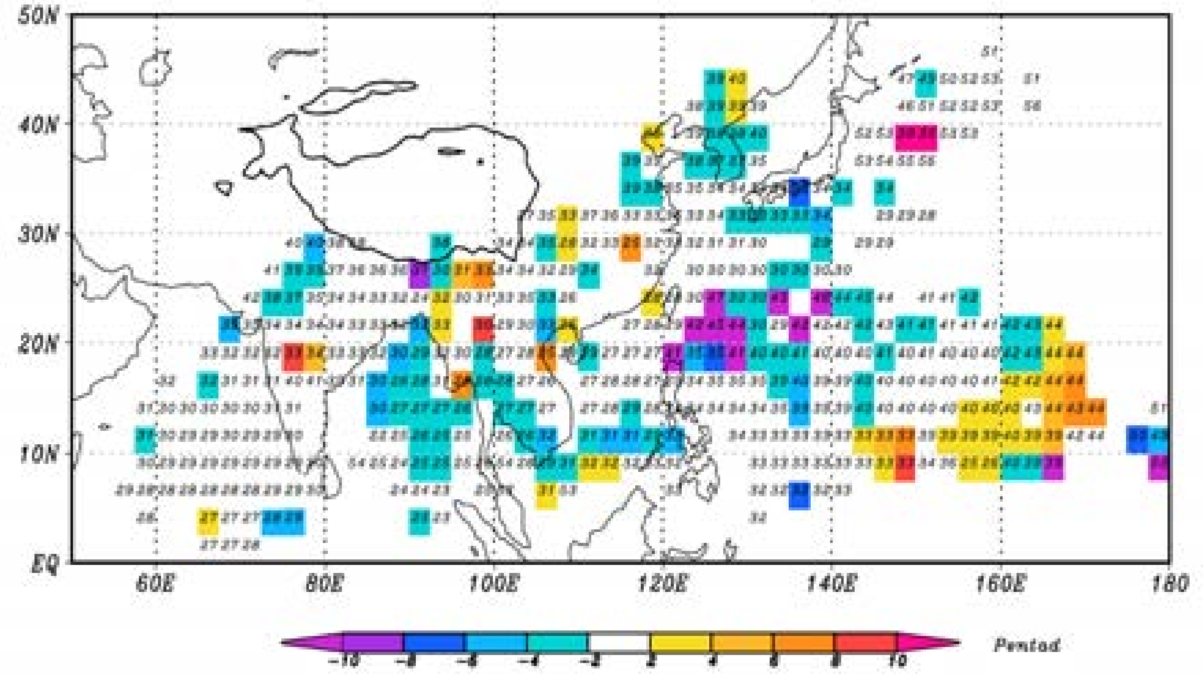


(Source:Yoshiyuki et al, 2012)

Study by Yoshiyuki et al (2012) shows that over recent three decades, there has been a remarkable change in the behavior of the Asian monsoons, especially that of summer monsoons. Analyses of the trend of the rain in the period of the Asian monsoon in 1979-2010 show that precipitation in May in the South increased by 4-6mm/day in the last 30 years (50% of the average of many years) (Fig. 3-5). According to the above author, this change was due to the earlier beginning of summer monsoons (10-15 days earlier) in the region (Fig. 3-5). The tendency of fluctuation of rainfall was almost opposite in June with the decrease of rainfall in the South. This may have been due to a slow northward movement of the intra-seasonal oscillations (Goswami et al, 2010). In the North, rainfall tended to decrease in June (Figure 3-4) while rainfall fluctuation during July and August did not present a clear trend.

Figure 3.4a presents the changing trend in rainfall CMAP data (colour, mm/day and total atmospheric moisture load vector from NCEP re-analyzed data (kg m^{-1} s^{-1}) for the month of May. These values are multiplied by 30 (number of years from 1979 to 2010). The Figure only indicates threshold values of 95% as given out by Mann-Kendall test. Figure 3.4b is similar to Figure 3.4a but for the month of June. Figure 2.4c presents the difference between the rain with the total atmospheric moisture load in June and those in May. Figure 2.4d presents the tendency of average rainfall fluctuation in summer (June to September), with identical lines indicating the value of the average rainfall in summer climate (mm/day) (Yoshiyuki et al, 2012)

Figure 3-5. Date when summer monsoons began (after) the 1979-1993 period. Background color presents the difference between the 1994-2010 period and the 1979-1993 period



(Source: Yoshiyuki et al, 2012)

Based on the generalization of the results from 20 atmosphere-ocean global climate models in IPCC's a s s of CMIP5 da a agains ow m d ium missi on sc n arios RCP4 5, L and Wang (2012) hold that by late 21st Century, summer monsoons in Asia will tend to start earlier and end later than they do at present; and their wind will also be stronger. The area of performance of monsoons will extend by turning eastwards about 10% (Lee and Wang, 2012). This type of fluctuations is closely linked with ENSO fluctuations. On a regional scale, most r c n s udi s by Vi nam s and Aus ra ian r s arch rs show ha according o IPCC's high s

GHG concentration scenario (RCP 8.5), there is no considerable change in the starting date of the summer monsoon in South Central Vietnam and in Central Highlands (MONRE, 2013).

3.4.2. Typhoon and Tropical Depression

Typhoon and tropical depression, generally referred to as tropical cyclone, is a hazardous weather phenomenon accompanied by heavy rainfall, high waves and sea water level. Tropical cyclone often causes great damages in terms of human lives and material losses, and serious negative consequences to socio-economic activities.

Vietnam, with a 3260 km long coastline, is situated in a region that is strongly affected by the basket of typhoons in northwest Pacific Ocean. Tropical cyclones that affect Vietnam can emerge right in the East Sea, in the sea east of the Philippines or in the middle of the Pacific Ocean. In our study and assessment of the operation of tropical cyclones in northwest Pacific Ocean and the East Sea, we make use of tropical cyclone survey data recorded in 50 years (1961-2000) by various agencies and institutions such as Scientific Research Institute of Hydro-meteorology and Environment, Central Hydrological Meteorology Forecast Centre, Japanese Meteorology Agency, US Navy Storm Warning Center (MONRE, 2012).

The typhoons that rage in the East Sea are normally at their final phase of those in northwest Pacific Ocean, or else emerge and grow right in the East Sea. Typhoons affect Viet Nam mostly from June to November. In the first half of the typhoon season, typhoons move in the North-West, North and North-East direction and landfall in South Easten China and Japan. Typhoons move to the West direction to Viet Namin the second half of the typhoon season. In average, typhoons are less likely to affect to Viet Nam. In June-August, typhoons are more likely to affect to the North. In September-November, typhoons are more likely to affect to the South Central and Sou h rn r gions In h firs ha f s a son, yphoons’ dir c io n is ss comp x , and vice versa, typhoons usually move in the second half of the season complicated.

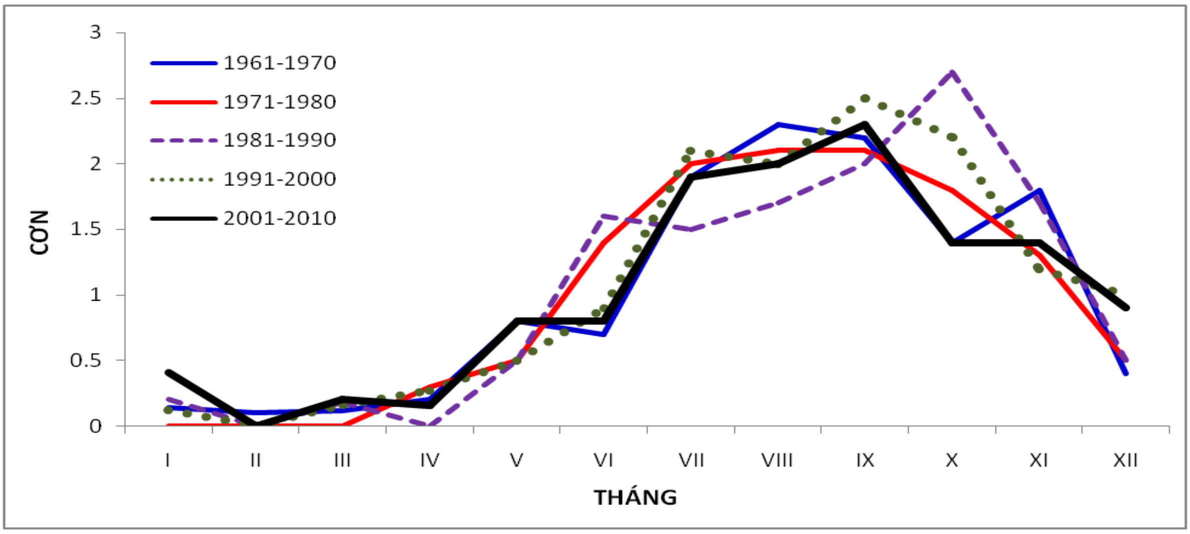
Table 3-16. Average number, in period terms, of tropical cyclones in storm seasons (May to December) in the East Sea

Thời kỳ	5	6	7	8	9	10	11	12	Năm
1961-2010	**0.62**	**1.08**	**1.88**	**2.02**	**2.22**	**1.90**	**1.48**	**0.66**	**12.34**
1961-1970	0.80	0.70	1.90	2.30	2.20	1.40	1.80	0.40	12.00
1971-1980	0.50	1.40	2.00	2.10	2.10	1.80	1.30	0.50	12.00
1981-1990	0.50	1.60	1.50	1.70	2.00	2.70	1.70	0.50	12.60
1991-2000	0.50	0.90	2.10	2.00	2.50	2.20	1.20	1.00	12.90
2001-2010	0.80	0.80	1.90	2.00	2.30	1.40	1.40	0.90	12.20

(Source: Nguyen Van Thang et al, 2010)

In average, there are about 12 typhoons per year (Table 3-16). The year of 1964 was with the highest number of typhoons, which was 19; and 1969 – the lowest, with 4 typhoons. Distribution of tropical cyclones in the East Sea in terms of month on a decadal basis shows that there is less than 0.2 cyclone each month from January to April (Figure 3-6); from June to November the number is 1 to 2 each month and this is the period of violent storms in the East Sea. In the period of 1961-2010, the highest typhoon frequency happened in August and September, except the period of 1981-1990 decade with highest typhoon frequency in October. Historic months with plenty of typhoons include November 1964 and that of 1985 when there were up to 6 tropical cyclones each in the East Sea; and November 1970, October 1983 and July 1994 when there were 5 each. February 1965 was the month with the least number, just 1 cyclone (Nguyen Van Thang et al, 2010).

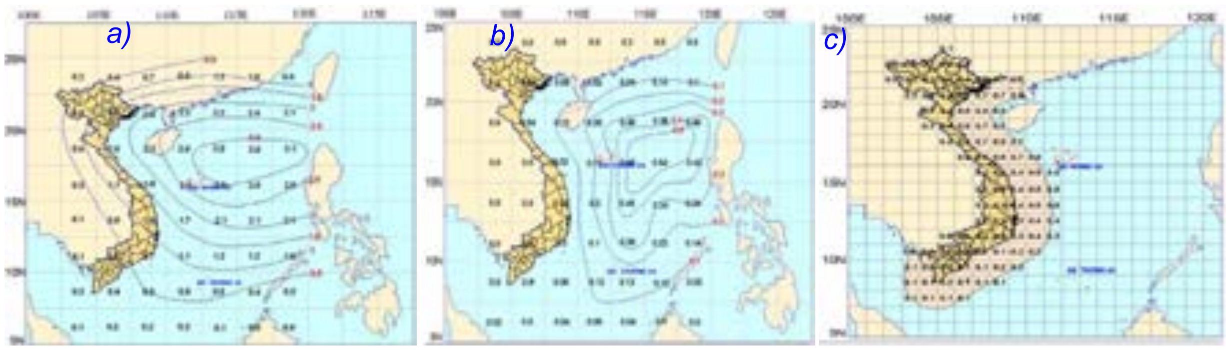
Figure 3-6. Average number, in monthly terms for each decade, of tropical cyclones in the East Sea



(Source: Nguyen Van Thang et al, 2010)

Special distribution of tropical cyclones in the East Sea in 1961-2000 period in Figure 3-7a shows that the greatest frequency is in the middle section of the northern part of the East Sea. On average, there are 3 cyclones traversing longitude-latitude grid 2.5x2.5^{0} . About 47% of the cyclones emerged right in the East Sea and 53% coming from the Pacific Ocean where they emerged. The northeastern section of the middle part of the East Sea is where tropical cyclones emerged with greatest frequency (Figure 3-7b) (MONRE, 2012).

Figure 3-7. Chart showing multi-annual average number of tropical cyclones. a) Occurrence frequency; b) emerging in the East Sea; c) affecting Vietnam mainland



(MONRE, 2012)

Though not making landfall in the mainland, many storms raging in coastal areas still cause no less great damages to the mainland than those making landfall into it. Tropical cyclones normally cause strong impacts on area with a radius of about 2 degrees longitude-latitude (about 220 km) from their eyes. Therefore, this report deals with those tropical cyclones that dir c y impac Vi nam main and, h dis anc from whos y s o Vi n am’s coas in is ss than or equals 2 degrees longitude-latitude. As such, in the 1961-2010 period, there were 381 storms and tropical atmospheric depressions that directly hit Vietnam, thus, averaging 7.62 storms per year (Table 3-17). 1989 and 1995 are those years with the highest number of tropical cyclones that affect Vietnam with 14 storms in each. And 1969 and 1976 witnessed the least number, just 2 in each (Nguyen Van Thang et al, 2010).

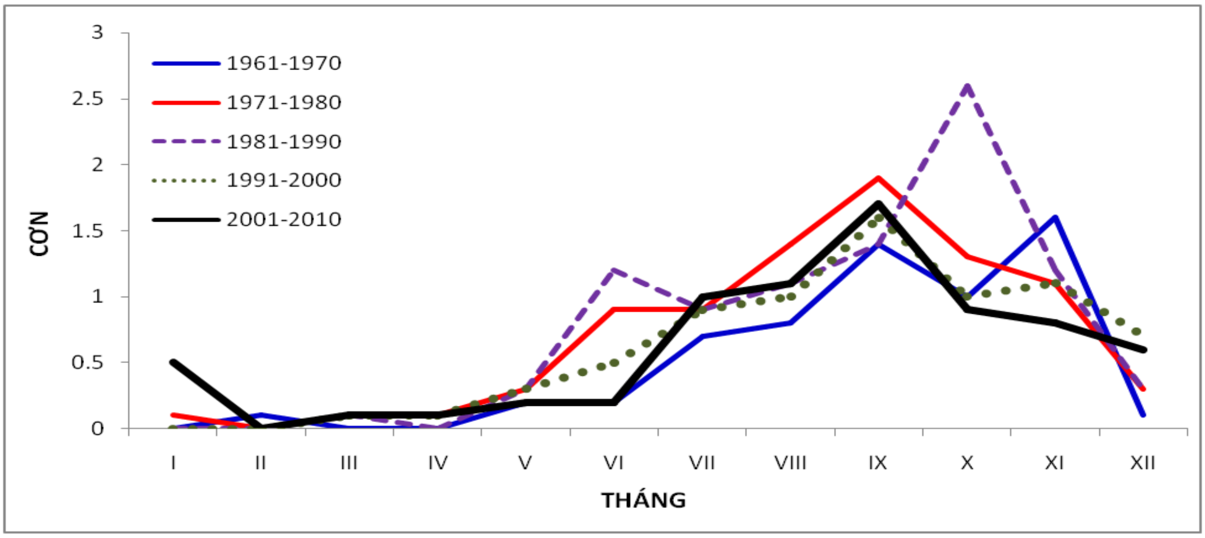
In recent 5 decades, the 70s and the 80s witnessed comparatively many typhoons that hit Vietnam, whose number is 10-15% greater than the average of many years (Figure 3-8, Table 3-17). Most of the above decades witnessed the extreme numbers of tropical cyclones in Septembers that hit Vietnam except the 1981-1990 decade that had the extreme in Octobers. In 1961-1970 decade, the extremes were in Septembers and Novembers (Figure 3-8, Table 3-17) *(Nguyen Van Thang et al, 2010).*

Table 3-17. Average number, in period terms, of tropical cyclones that hit Vietnam

Period	1	2	3	4	5	6	7	8	9	10	11	12	Year
1961-2010	0.12	0.02	0.08	0.06	0.26	0.60	0.88	1.08	1.60	1.36	1.16	0.40	7.62
1961-1970	0.00	0.10	0.00	0.00	0.20	0.20	0.70	0.80	1.40	1.00	1.60	0.10	6.10
1971-1980	0.10	0.00	0.10	0.10	0.30	0.90	0.90	1.40	1.90	1.30	1.10	0.30	8.40
1981-1990	0.00	0.00	0.10	0.00	0.30	1.20	0.90	1.10	1.40	2.60	1.20	0.30	9.10
1991-2000	0.00	0.00	0.10	0.10	0.30	0.50	0.90	1.00	1.60	1.00	1.10	0.70	7.30
2001-2010	0.50	0.00	0.10	0.10	0.20	0.20	1.00	1.10	1.70	0.90	0.80	0.60	7.20

(Source: Nguyen Van Thang et al, 2010)

Figure 3-8. Average number, in monthly terms for each decade, of tropical cyclones that hit Vietnam



(Source: Nguyen Van Thang et al, 2010)

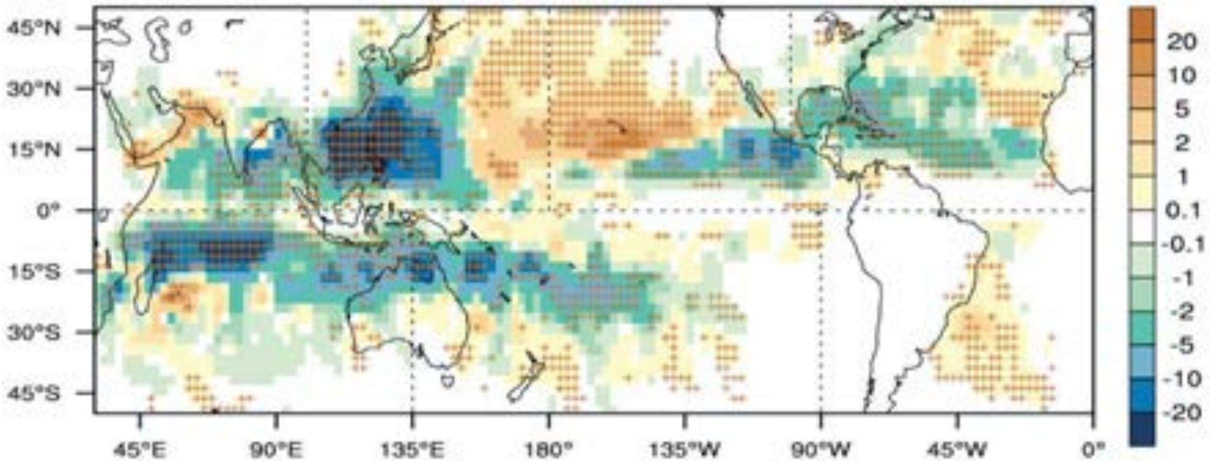
As far as special distribution of tropical cyclones along the entire coastline of Vietnam is concerned, the coastal areas from 16^o to 18^oN in Central Vietnam and the coastal areas from 20^0N upward in the North witnessed the highest frequency with 1 occurrence in every 2 years, which enters the region 1 of coastline longitude (Figure 3-7c) while the coastal areas of the South witnessed the lowest frequency of tropical atmospheric depressions that hit Vietnam.

Over the past 50 years, the number of tropical cyclones in the northwest of the Pacific Ocean and the East Sea does not indicate a clear trend. The number of typhoons in the northwest of the Pacific Ocean, storms in the East Sea, and tropical cyclones that affected Vietnam and the number of tropical cyclones that hit Vietnam tend to be unchanged or to decrease slightly. The most recent decade (2001-2010) witnessed the average number of tropical cyclones that affected Vietnam at 7.2 storms per year, which is 0.4 storm less than the multi-annual average (MONRE, 2012).

Statistics of the occurrences of tropical cyclones that affected certain areas of Vietnam for certain decades (Nguyen Van Thang et al, 2010) shows that the occurrences in mainland and coastal areas from 20^0N upwards tend to decrease; in mainland and coastal areas from 15 to 20^0N- inconsiderable change; and in mainland and coastal areas from 15^0N downwards in Central and South Vietnam- increase. As such, occurrences tend to turn southward.

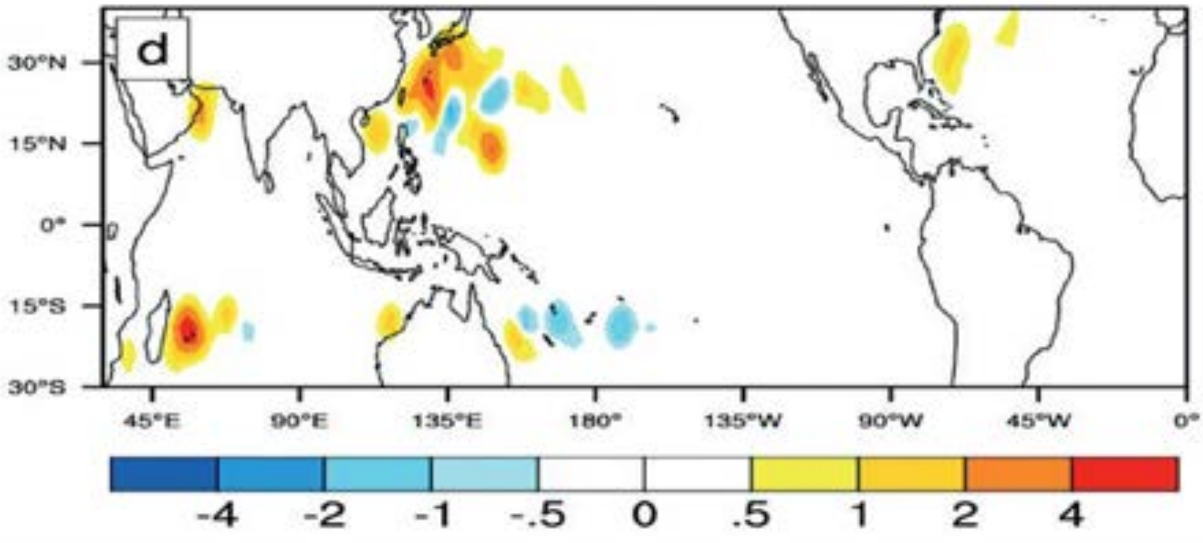
According to surveys of the performance of tropical cyclones in the past 5 decades, they can be classified into 3 levels of intensity: Tropical depression (maximum wind speed Vmax <17,5 m s^{-1}); Ordinary storm (Vmax from 17.6 to 32,4 m s^{-1}); Strong storm (Vmax ≥ ,4 m s^{-1}); and Very strong storm (Vmax ≥ 40, m s^{-1}). The results of these surveys also show that the number of tropical depressions tends to increase, that of ordinary- decrease, that of strong storms – slightly increase, and that of very strong storms – increase. Of those tropical cyclones that hit Vietnam, the number of tropical atmospheric depressions tends to increase, that of ordinary- decrease, that of strong storms – decrease, but that of very strong storms – increase (Nguyen Van Thang et al, 2010).

Figure 3-9. Trend of change in storm frequency in the 21st century (occurrences/25 years)



(IPCC, 2012)

Figure 3-10. Trend of change in strong storm frequency (Vmax>70 m s-1) in the 21st century (occurrences/25 years)



(IPCC, 2012)

As for the behavior tendency of tropical cyclones in the 21st century, IPCC assessments indicate that there has not been a confirmation of the trend to increase/decrease the frequency of storms on a global scale (including the northwestern part of the Pacific Ocean) (IPCC, Section 10.6.1, page 51; Section 14.6.1.2, page 30). On the intensity, there is a reliable observation that due to the impact of climate change, the storm intensity will increase by 2 to 11%, and rainfall within the radius of 100 km from the eye of the storm will probably increase by 20% in the 21st Century (IPCC, 2013, Section 14.4.1.2, page 30).

Report from the Japanese Innovative Program of Climate Change Projection for the 21st Century (IPCC, 2012) indicates that the number of storms in the East Sea tends to shrink (Figure 3-9), while the number of very strong storms (Vmax > 70 m s-1) tends to increase (Figure 3-10)

MONRE's c ima proj c io n ou pu s for h Eas S a show ha in h fu ur h r wi b a lower frequency but higher intensity of storms in the northern part of the East Sea. There are signs of higher frequency of tropical depressions in the southern part of the East Sea (MONRE, 2012, page 8).

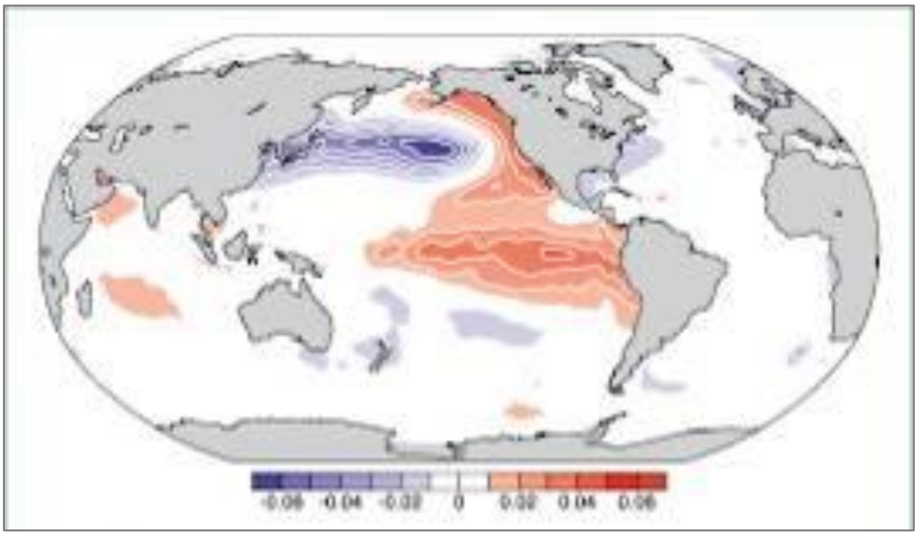
3.4.3. El Nino and Southern Oscillation

Southern Oscillation is a large-scale multi-annual oscillation in the eastern and western parts of equatorial Pacific Ocean discovered by Walker (1924) in the late 1920s of last century. The combination of this oscillation with the sea surface temperature (SST) in the eastern part of the Pacific Ocean is associated with El Nino and La Nina. The changes in atmospheric and oceanic conditions are referred to as El Nino South Oscillation (ENSO). El Nino is the warm phase of ENSO with the anomalous warming of SST in the central area and the eastern part of equatorial Pacific Ocean, while La Nina is the cold phase of the anomalous coldness of SST in this area. These two phases of ENSO are associated with the climate and weather extremes such as draughts and floods in Vietnam and in many other parts of the world. El Nino often makes draughts more severe in Southeast Asia. When La Nina occurs, how climate and weather anomalies evolve is the opposite of how they do when El Nino occurs.

El Nino and La Nina markedly influence the effects of tropical cyclones in Vietnam. The storm statistics of the past 45 years indicates in El Nino conditions, the number of storms that affect Vietnam is 27% less than the multi-annual average number (5-6 storms). By contrast, in La Nina conditions, the number of storms that affect Vietnam is 38% more than the multi-annual average number. Besides, in El Nino conditions, tropical cyclones usually concentrate in mid- storm season (July, August and September), while in La Nina conditions, there are more tropical cyclones in the second half of the storm season (September, October and November) (Nguyen Duc Ngu, 2007).
With regard to the effects of ENSO on rainfall, most El Nino spells cause losses of rainfall in most areas of Vietnam, while most of La Nina spells cause heavier rainfall than the multi-annual average in the coastal provinces in Central Vietnam and western part of South Vietnam, but they cause losses of rainfall in the North, in the Central Highlands and Southeast Vietnam. Some spells of El Nino and La Nina have brought about record heavy rainfall in 24 consecutive hours and in consecutive months in some areas. As such, ENSO heightens the rainfall variability in Vietnam (Nguyen Duc Ngu, 2007).

With El Nino, monsoons in Vietnam weaken but with La Nina they become stronger (Nguyen Duc Ngu, 2002). In El Nino winters, cold front frequency lessens especially during later months of the season. The performance of cold air in Vietnam ends earlier than usual. However, cold front often penetrates deeper into lower latitudes and even reaches Central Vietnam (Nguyen Duc Ngu, 2002).

Figure 3-11. Tendency of SST temperature change in recent years as indicated in IPCC (2007) 4th assessment report (AR4)



According to a report of IPCC(2007), the increase in the past decades of SST in the central and eastern parts of equatorial Pacific Ocean brings about the increase of frequency and intensity of El Nino (Figure 3.11). ENSO intensity became stronger and ENSO spells became longer especially in late 19th century and early 20th century (IPCC, 2007). During the last 100 year period, El Nino in later decades tended to be stronger and longer than it was in earlier decades (Vecchi and Wittenberg, 2010). This increase tendency might be associated with global climate change and global warming (IPCC, 2013).

Available assessments on the effects of the increase of the GHG concentrations on ENSO performance in the last 50-100 years still have a high degree of uncertainty (IPCC, 2007) . Power and Smith (2007) hold that the dominance of El Nino in the past several decades was due to the change in the baseline status of the South Oscillation Index (difference in standard deviation of surface pressure between Tahiti and Darwin). Zhang et al (2008) hold that the increase of El Nino performance may be due to the increase of Co2 concentration in the atmosphere. Nevertheless, Power and Smith (2007) argue that these ENSO changes are within natural changes. Therefore, it cannot be concluded that these changes are due to the increase of CO2 concentration in the atmosphere.

With regard to the tendency of ENSO performance change in future, IPCC reports (2007;2013) firmly hold that the various models do not produce consistent results of ENSO changes in the 21st Century as assessments on ENSO in future have a high degree of uncertainty. Although there has not been a general assessment on the change of ENSO performance, it can be fairly firmly concluded that, as the projection outputs of the global models indicate, there is a tendency to increase the frequency of El Nino performance in anomalous condition of plus SST in the central part of equatorial Pacific Ocean (El Nino Mokodi). Besides, as moisture increases in the atmosphere when temperature rises, it is almost certain that ENSO-linked rain will tend to be more intensive in future (IPCC, 2007; 2013).

3.5. Effects of Changes in Some Climate Extremes on Natural Physical Environment

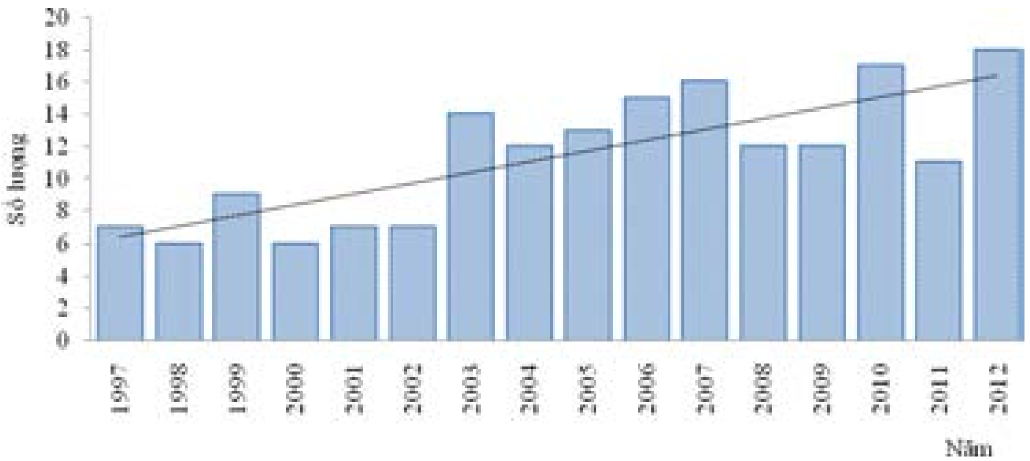
Impacts on natural environmental conditions result from the combination of different phenomena. For example, flood is more likely to occur in water saturation areas. It means tha both soil moisture and rainfall intensity are important factors of flood. Similarly, drought results from lack of soil moisture, prolong rainfall shortage and large evaporation. This section analyzes changes of some phenomena such as h a wav s, drough , h avy rain… having s rong impac s on natural environment.

3.5.1. Heat waves

Impacts of heat waves are effects of high heat (T_x is ≥ 5 ºC), dry heat (Tx is ≥ 35oC and a relative humidity R_H is ≤ 55%). Recently, observed data show the increasing trends of the number of days and thenumber of heat waves in the whole country, especially in the Central region (Phan Văn Tân et al, 2010). Some region have extreme high recorded temperature.

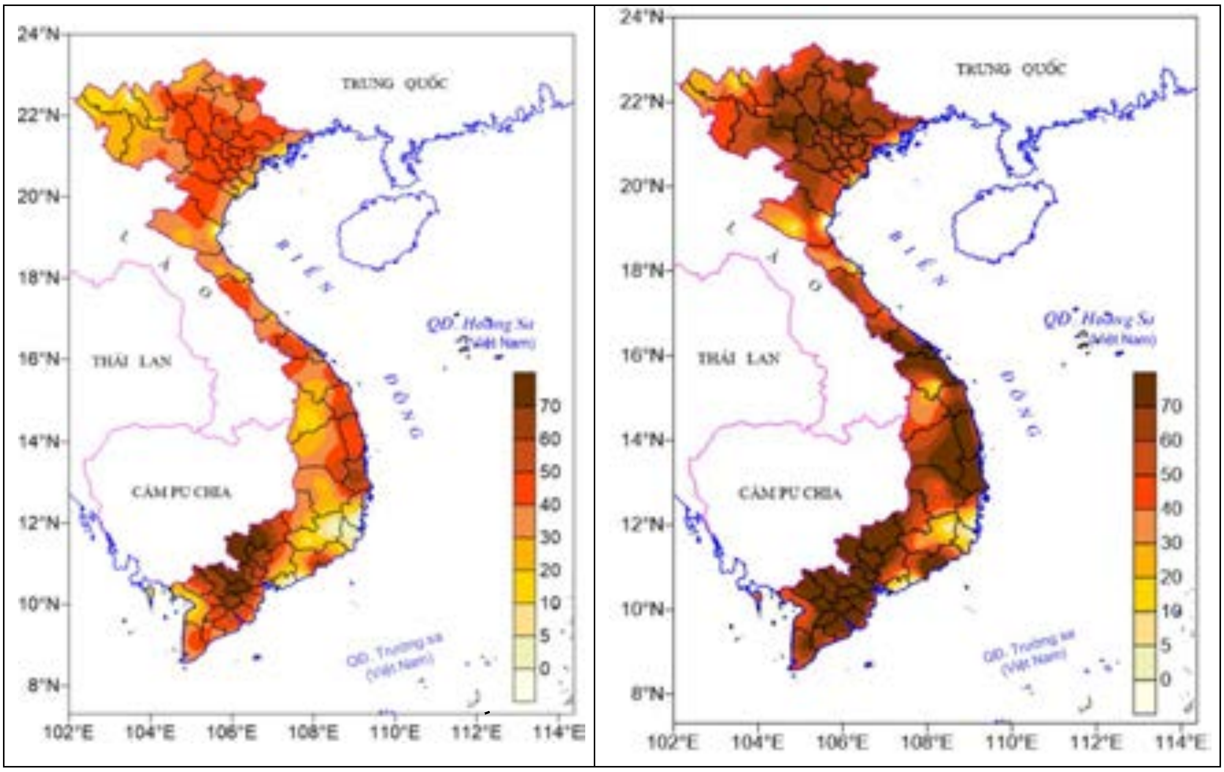
According to the statistics of the National Hydro-meterological Service, in the last 16 years, the recorded number of heat waves increased sharply (Fig. 3-12). In 2012, there were 18 heat waves – highest in this period. The lowest number was 6 heat waves in 1998; however, the number of hot days wass highest, up to 132 days per 6 heat waves. In some special strong heat waves, temperature reached above 40^{0}C. For example, the temperature reached 40.9^{0}C in the heatwave of 12-16/6/1998 in Tinh Gia (Thanh Hoa Province) and 41.2^{0}C in Cua Rao (Nghe An Province) (NHS, 2009). Heat waves in large areas (two-thirds of monitoring stations in the region have hot conditions) develop from the north to the south and from the west to the east. In North-East region, hot season comes lastest. Central Highlands and Southern region have less severe hot season. Provincies along the Central Coast have greatest frequency and intensity of hot season (Phan Văn Tân et al, 2010).

Figure 3-12.



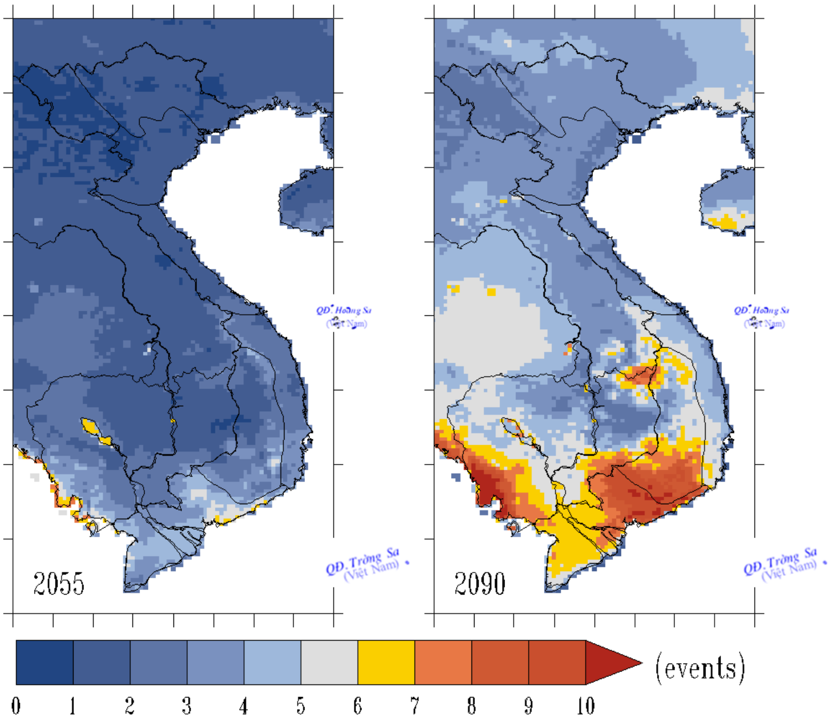
(Source: NCHMF, 1998-2013)

Figure 3-13. Projected changes in the number of heat waves in mid-21st century (left) and late 21st century (right) against the average of the 1980-1999 period, based on the medium emission scenario



(Source: MONRE, 2013)

Figure 3-14. Changes in the number of heat waves in mid- and late 21st century based on high emission scenario RCP8.5. Results of the calculation based on CCAM model



(MONRE, 2013)

Figure 3.13 shows the result of projected changes in the number of heat waves in mid and late 21st century against the average AB1 of the 1980-1999 period from PRECIS model. The analysis shows that the number of heat waves tends to increase in a large scale throughout the country in the 21st century, with a sharp increase in the Northern Delta, South Central Vietnam and the South. In mid-21st century, the number of heat waves will increase by 20-30 days against the 1980-1999 period in the South. And in late 21st Century, this figure will mostly increase by 60-70 days against the 1980-1999 period in the North-East, the Northern Delta, Mid- South Central Vietnam and the South. The remaining areas will have a lower level of increase (Fig 3-13).

The number of heat wave spells (3 consecutive days) is projected to increase in most areas of Vietnam, except the North-West where slight change is projected in the 21st century. By the end of the 21st century, the number of heat wave spells is projected to increase in the South and in South Central Highlands, especially in Southern Vietnam and South Central Highland Vietnam there will be an increase of 6 to 10 spells); while in the others, there will be from 2 to 6 spells (Fig 3-14).

3.5.2. Drought

Drought is a common natural disaster which evolves gradually but causes great environmental, socio- co nomic and po i ica impac s as w impac s on p op ' s h a h Draugh is c assifi d as a commonly occurring disaster in Vietnam after flood and storm. Recent studies indicate the possibility of higher frequency of occurrence of serious draughts in many parts of Vietnam (Nguyen Van Thang et al 2010, 2013a, 2013b). Drought is one of the main causes of the shrinkage of the cultivation land area, the lowering of crop productivity and output, the reduction of the produc rs' incom ; and h soaring of h production costs and of the food prices. Hydrological power stations will meet with difficulties in their operation for lack of water caused by draught.

The world has not reached a unanimous definition of draught and criteria for the identification of drought because it occurs in different parts of the world with different characteristics and causing different impacts. Documents of the World Meteorological Organization (WMO) mention 60 different definitions of aridity which are based on the relations between meteorological and hydrological conditions. Since 1980, there have been 150 different concepts of drought. Nevertheless, all definitions, in general, are made by referring to the lack or absence of rain for a comparatively long period of time.

According to WMO, drought is classified into 4 categories:

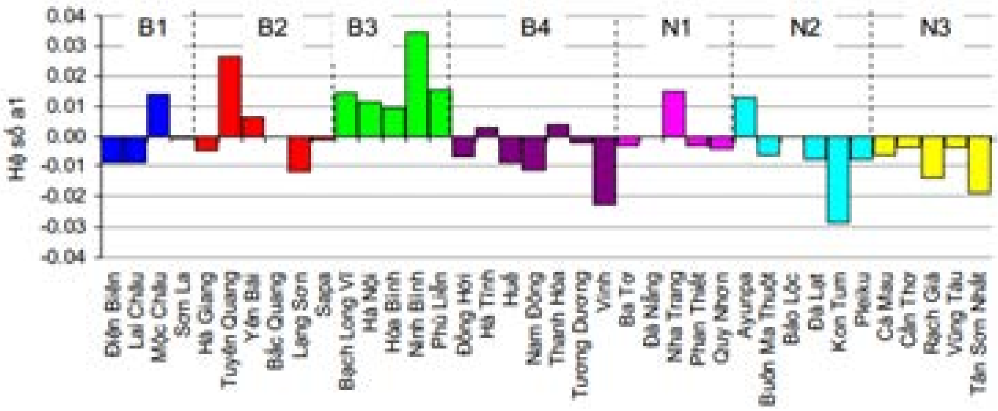
- Meteorological drought: Deficit of rain in the precipitation-evaporation balance;
- Hydrological drought: Obvious reduction of river/stream flow, low water level in underground water layers;
- Agricultural drought: Lack of rain water that results in imbalance between available water and wanted water for cultivation;
- Socio-economic drought: Lack of water to be supplied for socio-economic activities.

The characteristics and properties of draught (intensity, frequency of occurrences, and evolution) can be evaluated through such indices as K, SPI and EDI (Nguyen Trong Hieu and Pham Thi Thanh Huong, 2002). With these draught indices, information about the details of the draught can be easily transmitted and easily understood. The availability of the draught indices would provide important cues for developing draught warnings and draught forecasts. According to WMO, draught indices are those that give descriptions of accumulated lack of humidity for a long and unusual period of time. In other words, draught indices constitute a function of one or more than one climate elements such as precipitation, evaporation, humidity, temperature, flow, c…Each ind x has i s own pros and cons and is sui ab o som par icu ar localities.

Analyses of drought on a global scale (Dai et al, 2004; Wanders et al, 2010) and those on a regional and local scale (Benjamin Lloyd-Hughes et al, 2002; Hayes, 1999) by using draught indices calculated from survey data on temperature, humidity and precipitation reveal that the number of draught spells, their duration and their level of severity in certain parts of the world have considerably increased. According to IPCC (2007), global warming has caused the incr as of h wor d' av rag mp rature, especially since after 1950. There exists a close association between arid days and high temperature in summer in tropical regions. Draught tends to intensify in some areas, especially in those areas in low and medium latitudes (Christensen et al, 2007) with high frequency of and long lasting spells (IPCC, 2007). According o IPCC's *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX), it is projected that drought will occur with higher severity and with longer spells in some regions such as South Europe and West Africa; and by contrast, less in North America and Northwest Australia. Also in this report, IPCC holds that human activities would contribute considerably to the evolution of draught in the 20th Century. With regard to Southeast Asia which includes Vietnam, projection in a report by SEREX indicates that the number of arid days will tend to increase in the 21st century especially in its later half (IPCC, 2012)

Some studies conducted by Vietnamese researchers indicate that severe draught spells occur more and more frequently in many parts of Vietnam, particularly during winter-spring period (January through to April) and during summer-autumn period (May through to August) (MONRE, 2012). Winter drought spells mainly occur in the North, the South and the Central Highlands while summer draught spells occur in the Northern and Southern Central Vietnam. Winter draught spells have higher frequency than summer ones. The former may be up to 100% in some areas in the Central Highlands and in the South (Nguyen Trong Hieu, Pham Thi Thanh Huong, 2002; Nguyen Duc Ngu and Nguyen Trong Hieu, 2004). Nguyen Trong Hieu and Pham Thi Thanh Huong mention that draught spells only occur in winter, spring and summer months, but not in autumn months. In reality, draught spells occur in both winter and spring in the North-West; in winter in the North-East; in winter in the Northern Plain; in the latter half of winter in Northern Central Vietnam; from late winter through to mid-summer in Southern Central Vietnam; severe draught spells occur in both winter and spring in the southernmost part of Central Vietnam, the Central Highlands and the South (Nguyen Trong Hieu and Pham Thi Thanh Huong, 2002). Phan Van Tan et al (2010) indicate that draught spells in the southern climate regions have much higher frequency of occurrence than those in the northern ones but those in the northern ones have higher extremity. Frequency fluctuation is strong in Northern and Southern Central Vietnam while the frequency fluctuation is minor in the North-West. As far as frequency in the month and that in the season are concerned, there is not much difference in all regions, which means that monthly occurrence of drought usually prolongs and meet the parameter of seasonal drought occurrence. During the 2000-2007 period, there was a strong fluctuation, which indicated the increasing tendency of this phenomenon throughout the country. Considering the entire long period from the past until 2007, the increase/decrease tendency does not present itself clearly (Fig 3.15) (Phan Van Tan et al, 2010)

Figure 3-15. Coefficient a1 developed from a series of arid months in the 1961-2007 period in some typical stations



(Source: Phan Van Tan, 2010, page 181)

Nguyen Van Thang et al (2010) point out that drought will intensify throughout the 21st Century at a high rate in more arid regions such as South Central Vietnam and the Central Highlands; and at a comparatively low rate in other regions (Nguyen Van Thang et al, 2010). Vu Thanh Hang et al (2011), in a study on draught in Central Vietnam for the 2011-2050 period, hold that in future, draught will probably occur more frequently with a higher degree of severity. (Vu Thanh Hang et al, 2011).

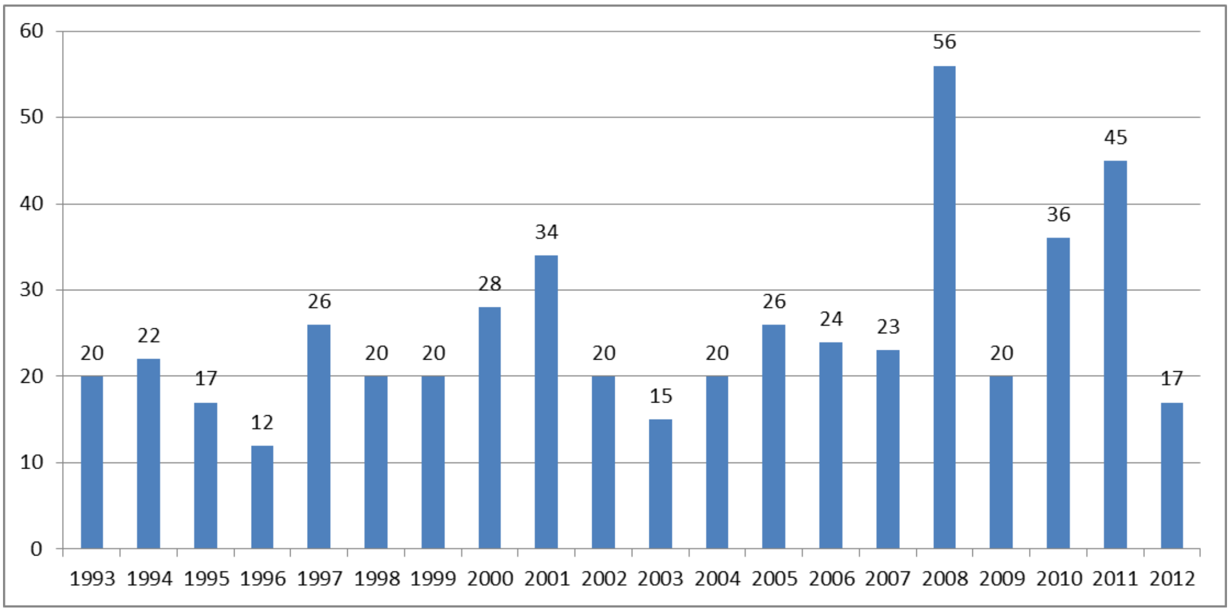
Results of the most recent studies show that it is likely that draught will occur more frequently and last longer in most climate regions of Vietnam, except in the South and the Central Highlands where the number of draught spells might not increase but they may last longer once they emerge (MONRE, 2013)

3.5.3. Extreme rainfall

In Vietnam, extreme rainfall is usually a consequence of some types and forms of weather such as storm and tropical depression, tropical convergence trip, cold front, interrupted line, etc. especially when these phenomena combine to bring about prolonged extreme rainfalls in extended large areas (Nguyen Ngoc Thuc and Luong Tan Minh, 1990; Nguyen Ngoc Thuc, 1990). According to regulations by the Central Hydro-Meteorological Forecast Centre (http://nchmf.gov.vn/), a day of extreme rainfall is determined by the precipitation measured in 24 hours and is classified into the following categories: Moderate Rainfall (16-50 mm/24h), Extreme Rainfall (51-100 m/24h), and Very Extreme Rainfall (>100 mm/24h). Extreme rainfall in extended large area is a heavy rainfall occurring in one area or in adjacent forecasted areas. A surge of extreme rainfalls in extended large area is a period of continually occurring heavy rains, which includes at least one day with extreme rainfall in extended large area.

In Vietnam, there are, on an average, about 25 surges of extreme rainfall in extended large area, with their concentration in April through to December, earlier in the North and gradually later in the South. The North-East witnesses the greatest number of surges, then comes Northern Central Vietnam, and less in the remaining regions, and least in the coastal areas in Middle and Southern Central Vietnam (Nguyen Duy Chinh, 2004).

Figure 3-16. Numbers of extreme rainfall in extended large area in Viet Nam in the period of 1993-2012

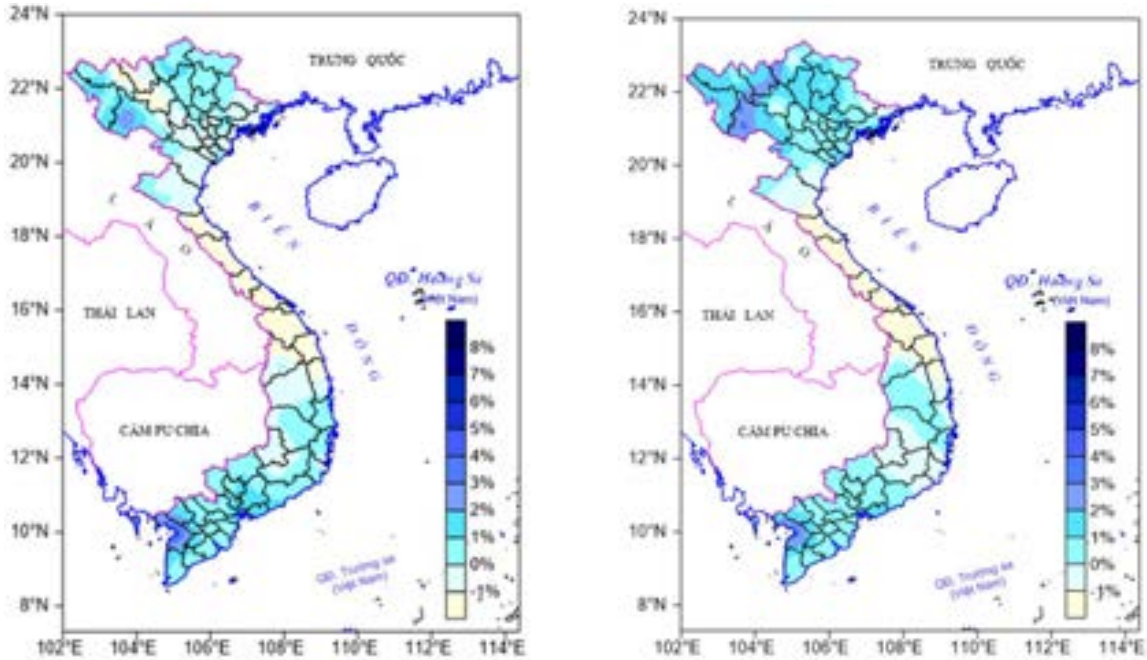


(Source: CHMFC 1994-2013)

Surveys of the behavior of rain in the past show that as time went by the duration and the number of extreme rainfall surges increased considerably. In the 1950-2000 period, the number of extreme rainfall surges increased in the South and decreased in the North (Endo et al, 2009). Phan Van Tan et al (2010) observe that the number of days of extreme rainfall in the North tends to decrease while it tends to slightly increase in the South and rather strongly increase in the South and in the Central Highlands. These concerned authors are of the opinion that there is a rather obvious correlation between global warming with SST increase in equatorial East Pacific Ocean and the tendency of fluctuation of the number of extreme rainfall days in the climate zones of the South. Annual reports of the Central Hydro-Meteorological Forecast Centre show the increasing trends in extreme rainfall because of tropical depression, the intertropical convergence zone (ICTZ), cold wind, West South monsson and the combination of these. In the last 20 years (1993-2012), the number of extreme rainfall in extended large area is highest in 2008 (58 surges) and lowest in 1996 (12 surges).

According to medium emission scenarios (A1B), the number of extreme rainfall days tends to increase slightly in North-West, slightly decrease in North and South Central Vietnam and in the South in the first half of the 21st century (Phan Van Tan et al, 2010). Results of the projection from the outputs of PRECIS model based on scenario A1B at the Scientific Research Institute of Hydro-meteorology and Environment show that the number of days with > 50mm rainfall in the 21st Century will increase in the North and the South while it tends to decrease slightly in Central Vietnam (Fig 3-17).

Figure 3-17. Projected change in the number of days with >50mm rainfall in Mid- (a) and Late (b) 21 century



a) b)

3.5.4. Flood

Flood is a natural phenomenon which occurs nearly every year. Flood is caused by the rise of river water level in rainy season. The rise of the water level in a river to the extent that causes flood may occur one or more times in a year. When the river water level rises (due to much/extreme rainfall and rising tide), the water overflows the river banks, spreads to lowland areas and causes widespread flood that lasts for a certain period of time. This phenomenon is called flood. Flood is considered big or especially big when it causes great damages in terms of human and material losses for a long period of time (Le Anh Tuan, 2004).

Impacts of climate change in recent years have caused more and more big, violent and severe floods in many river basins especially in the downstream areas of these basins.

In the North and in North Central Vietnam: Analyses of survey data recorded in 24 hydrological stations in the rivers in the North and in North Central Vietnam in the past 3 decades show that there was a general tendency of continual increase of the number of occurrences of flood crest in the year, except some stations in Hanoi and Pha Lai in the downstream of the Red River and Thai Binh River, where the number decreases due to the fact that some water reservoirs on the Red River are operated to control the flood; and some stations in the downstream of Ma River and Ca River where only few changes are recorded. Calculation for the average year in 3 consecutive decades (1980-1989, 1990-1999 and 2000-2990) shows that flood heights tended to increase gradually in all rivers, except in Thai Binh River downstream where a slow decrease is recorded due mainly to flood control work done over the past 2 decades in Son Tay and Hanoi, Thuong Cat by means of water reservoirs on the Red River. If the flood control work by means of water reservoirs on the Red River is not taken into account, it can be seen that there is a higher increase of flood heights in the upstream area than there is in the downstream area of the river basin. Therefore, the threat of the increase of flood occurrences due to climate change and partly due to human activities has become evident in the North and in Northern Central Vietnam. The tendency for the flood heights to decrease in the downstream areas of the Red River and Thai Binh River while they strongly increase in the upstream areas has proved the fact that the building of water reservoirs can contribute actively to the moderation of harms that might be caused by floods and other natural disasters to the downstream areas (MARD, 2010)

In Central Vietnam: Analyses of survey data recorded in 18 hydrological stations in the rivers in Central Vietnam in the past 3 decades show that there is a general tendency of increasing the number of flood peaks in the year, except the downstream of Ba River (probably due to the operation of the water reservoir on Hinh River that controls and reduces the level of flood in the centre of the largest rainfall area in the basin). The rivers in the area of the provinces of Thua Thien-Hue, Quang Ngai and Khanh Hoa witnessed the increase of the greatest heights of the flood of the year; while the rivers in Binh Dinh province witnessed only a slight increase; and those in the provinces of Quang Binh, Quang Tri and Phu Yen witnessed a slight decrease. Considering the annual average number of highest water mark of flood for 3 consecutive decades (1980-1989, 1990-1999, 2000-2009), most rivers from Thua Thien-Hue province to Quang Ngai province have a tendency to increase, while other rivers have a tendency to decrease insignificantly (MARD, 2010)

In the Central Highlands and the eastern part of the South: Analyses of survey data recorded in 14 hydrological stations in the upstream of Dong Nai river in Central Vietnam and in the eastern part of the South in the past 3 decades show that there is an obvious tendency of considerable increase of the number of flood peak in the year in the tributaries of La Nga River, B Riv r, Sai Gon Riv r…, causing s rong impac s on h wa r f ow r g im This is du o many on-going changes in infrastructure in the Dong Nai River basin such as socio-economic development, construction of hydro-power stations, water-control systems, roads, etc, which causes the shrinkage of forest flora and micro climate change. In the downstream area of Dong Nai River, things happen in more or less the same way after the construction of water reservoirs for water control work and hydro- power generation. A typical change that took place was the considerable increase of water level to the highest mark (15-20 cm) in Bien Hoa and Phu An downstream areas caused by the stable operation (1990) of Tri An hydro-power establishment. The combined impacts caused by flood tide and the operation of the establishment have brought about the increase of annual flood heights (by about 15-30 cm) and the decrease of the lowest water level by 20-35 cm. Over the past 10 years, the volume of the flow of flood heights has gradually increased except that in the Phuoc Hoa section of the Be River. Data of the average annual flow volume available in the stations in the basin and other related happenings show a tendency of gradual increase of water level (MARD, 2010).

In the Mekong Delta: The variation of water level in the Mekong Delta in the past 30 years and its decadal average calculation at 11 main hydrological stations show that the general picture is the marked increase of flood heights in most downstream areas while the increase in the upstream areas is not significant (Tan Chau, Tan Doc). According to the International Mekong Commission, the flood heights in mid-stream Mekong in Laos evidently increase due to impacts of climate change. Therefore, it can be projected that the tendency to increase the flood in recent years will continue into the future in the Mekong Delta (MARD, 2010)

Some recent studies indicate that climate change would increase the severity of the danger posed by flood in the future, which has already become evident in the increase of the flow of flood heights and the total flood volume. According to Tran Thanh Xuan et al (2011), the projected variation of the greatest volume of flow, on an annual basis, of flood heights corresponds 1% and 5% frequencies of the medium scenario (B2) and the high scenario (A2) respectively at some hydrological stations on some rivers. The results show that the value of the flow of the greatest flood heights of the year (Q_{max}) that corresponds the frequencies of most rivers has a tendency to increase. The increase is higher when it corresponds the lower frequencies, except in some tributaries of Dong Nai River where Q_{max} tends to decrease. With scenario B2 for the 2040-2059 period, the value of Q_{max} that corresponds 1% frequency ($Q_{max\ 1\%}$) on most rivers is projected to increase by 1.0 -5.0% against the reference 1908-1999 period, and would increase drastically in some tributaries of the Red River system (about 10.0% on the Yen Bai section of Thao River and the Vu Quang section of Lo River), but would tend to decrease on La Nga River (-0.29% at Ta Pao) and on the upstream of Be River (-1.0% at Phuoc Long). For the 2080-2099 period, the increase of $Q_{max\ 1\%}$ on most rivers is projected at 0 – 15.0%, higher increase on the downstream of Ba River (18.5% at Cung Son), Thao River (21.7% at Yen Bai), Lo River (19.9% at Ghenh Ga). On La Nga River and the upstream of Be River, the value $Q_{max\ 1\%}$ of most rivers in the 2080-2099 period is projected to decreased by 0.5 – 2.5%. With scenario A2, the value Q_{max} that corresponds the frequency of most rivers is projected to increase against the reference 1980-1999 period, but would decrease on La Nga River and on the upstream of Be River; the variation of Q_{max} in this scenario is greater than that of scenario B2. Frequency 1% is greater than frequency 5%. It follows that the variation of small floods is lower than that of big floods especially very big floods (Tran Thanh Xuan et al, 2011). On the Mekong, the mean flow on a day with greatest flood heights ($Q_{max,ng}$) at Kratie in each decade from 2010 to 2050 is, according to climate change scenarios, projected to increase. However, only after 2030 will the increase become obvious and distinction be seen between scenario A2 and scenario B2. In mid-21st Century, $Q_{max,ng}$ will probably increase by 60-70% against the flood heights in the year 2000 (Thanh Xuan et al, 2011).

Impacted by climate change, the flow of most rivers during the flood season would also have a tendency to increase, with the exception of Dong Nai River where the flow would be lower than what it was like in the 1980-1999 period (Thanh Xuan et al, 2011). With scenario B2, it is projected that in the 2040-2059 period the mean flow during the flood season will increase by 2.0 – 4.0% in the system of the Red River-Thai Binh River and that of Ca River, but only 0.9 – 1.5% in the two systems of Thu Bon River and Ba River; in the 2080-2099 period, the increase would be 5.0 – 10.0% on the Red River and Ca River, and 2.0 – 4.0% in the two systems of Thu Bon River and Ba River; but the increase would be rather high on the Yen Bai section of Thao River and is projected at 8.7%. Meanwhile, the flow in the Dong Nai River system is projected to decrease by 3.5 – 6.7%, the lowest decrease being on Be River at Phuoc Hoa station. As a whole, the mean flow in flood season in the entire Mekong basin is projected to increase. Thus, the increase of the flow in flood season, in the 2010-2050 period against the reference 1985-2000 period, on the Mekong at Kratie and Tan Chau is projected at 5% and 2.0% respectively according to scenario B2; and 11.0% and 5.8% respectively according to scenario A2 (Thanh Xuan et al, 2011)

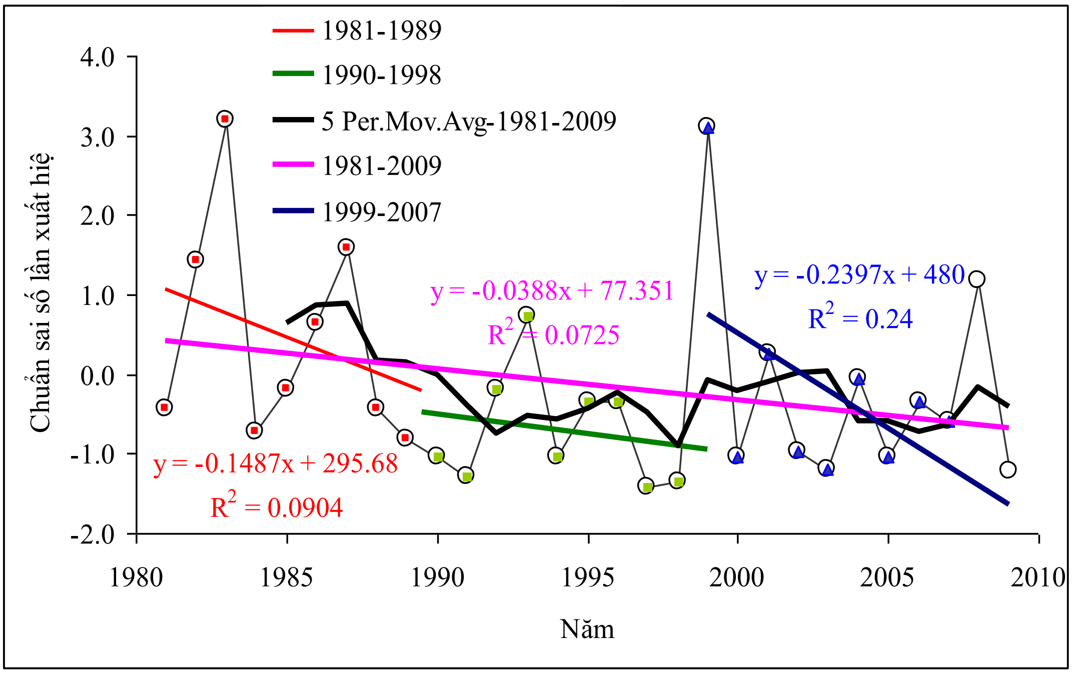
3.5.5. Hoarfrost, Frigid Cold and Damaging Cold

While the South has a tropical monsoon climate with warm and hot temperature all year round, the North has a cold winter as a result of the strong influence of the frigid air mass in the northern hemisphere (Phan Tat Dac, 1961; Pham Ngoc Toan, Phan Tat Dac, 1975). In winter and early spring in the North, there are long and repeated extreme cold spells (Average temperatarure T2m ≤ 5 ºC) and damaging cold (T m ≤ ºC). Consequently, frozen frost and hoarfrost in some areas badly affected the vegetation and domestic animals and thus causing great losses and damages in economic terms.

There are, on a yearly average, 20 to 50 frigid days in the North-West and North-East respectively, 15 to 25 days in the Northern Plain and 4 to 20 days in Northern Central Vietnam. In many mountainous areas, the number of frigid days may be as many as 100. Extreme cold usually begins in November and ends in April the following year, mainly in winter months and in areas of high terrain elevation. The average number of frigid days on a seasonal basis, as recorded in some typical stations, tends to reduce in one decade after another especially in the last two decades, which conforms to the global warming pattern. So does the number of frigid days on a monthly basis, especially in winter months (December, January and February) (Phan Van Tan, 2010). Whereas, the number of frigid days has been in a downward trend, the number of cold spells has been quite complex variations and fluctuations from year to year. Ice phenomenon seems to appear with more frequency in the high mountain regions such as Sa Pa, Mau Son…

Hoarfrost is a weather phenomenon that occurs when the surface temperature drops to such a very low level that water is frozen into an ice-like formation. Hoarfrost is normally formed during the night or dawn when the sky is cloudless and the wind is calm and the air temperature is so low that the surface temperature of everything including that of the grass reaches the frost point that makes vapor become condensed when the air humidity is at a suitable level for such a condensation. When there is hoarfrost, the earth surface temperature is usually below 5^0C and the air temperature is below 7^0C. This temperature is very dangerous for the vegetation and domestic animals, especially for the vegetation because when the water in the capillaries inside the trunk becomes ice, it will break the micro-balance of humidity in the tree, causing the anabolism to stop and the tree perishes if this continues for a long time. In Vietnam, the North-West is where hoarfrost occurs most frequently. The tendency of fluctuation of the number of days with hoarfrost in this region is the same as what happened in the 1981-2009 period (Fig 3.18) (Duong Van Kham et al, 2012).

Figure 3-18. Changing trend in the average number of days with hoarfrost in the North-West region



(Source: Duong Van Kham et al, 2012)

3.5.6. Extreme sealevel

According to survey data from the Vietnamese coastal oceanographic stations, the sea water level recorded in most stations show a tendency to rise. Assessment by Phan Van Huan and Nguyen Tai Hoi in 2007 indicates that due to global warming and other effects, the sea water v c os o Vi nam 's coas in ris s by -3mm/year (Pham Van Huan and Nguyen Tai Hoi, 0 07) R c n s udi s a so show ha h av ra g s a wa r v a ong Vi n am's coas in tends to rise by approximately 2.8 mm/year (MONRE, 2012). Satellite-assisted studies also indicate that the average sea water level in the vicinity of Vietnam rose by 4.7 mm/year in the 1993-2010 period. The sea water level along the coastline of the Mid-Central Vietnam and that of the western part of South Vietnam rises at a faster rate than that in the coastline of other regions. On an average, sea water level along the entire coastline of Vietnam rises approximately 2.9 mm/year (Nguyen Xuan Hien et al, 2010).

Based on high emission scenario A1F1, it is projected that in late 21^{st} Century the sea water level for Vietnam in general will, on an average, rise by 78cm to 95 cm. The coastline from Ca Mau to Kien Giang will be subject to the highest rise (85 cm to 100 cm), and that of Mong Cai –

the lowest (66cm -85 cm). This can be attributed to climate change effects. (MONRE, 2012; Tran Thuc et al, 2012).

Studies on the rise of water caused by storms show that the highest rise recorded is 3.6 m in the DAN storm in 1989 (Phạm Văn Ninh, 0 0) A historic record storm with the rise of water that caused great damages is the storm that raged Hai Phong in 1881 claiming about 300,000 lives (James P. Terry et al, 2012). Water rise caused by storm is especially dangerous when it coincides with flood tide, making the rise even higher. An example of this is the Damrey storm in 2005 with big water waves that caused collapse of some dikes in Nam Dinh and Thanh Hoa (Lê Trọng Đào, 0 09)

Studies on extreme water levels are mainly based on data from observation stations located in the coastal areas and on the islands (Hoang Trung Thanh et al, 2008; Nguyen Ngoc Thuy, 1993; Nguyen Xuan Hien, 2011; Dinh Van Uu, 2011; and Dinh Van Manh, 2010). Recent studies show that the highest sea water levels tend to fluctuate at a higher rate in most stations, the highest rate being at stations in Cua Ong, Hon Dau and Con Dao, which is about 5mm/year; some stations such as Phu Quy witnesses a lower rate (Hoang Trung Thanh et al, 2008; Nguyen Xuan Hien, 2011). No tendency of fluctuation of the annual lowest sea water levels has been concluded from the data available in the oceanographic stations along the coastline of Vietnam (Nguyen Xuan Hien et al, 2011)

Some recent studies are interested in the extreme water levels that affect the coastal areas including the co-occurrence of the rise of water due to storm and the flood tide. Given the climate change, the extremity of the sea water level may be on the same par or higher than the highest dike surface. Take Hai Phong for example, the cycle of the extremity of the sea water level at 550 cm above the highest dike surface is 100 years, and at 600 cm in the cycle of 1000 years (Nguyen Xuan Hien et al, 2012)

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Chapter 4
Changes in Impacts of Climate Extremes: Human Systems and Ecosystems

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Summary

Chapter 4 analyses the hazard exposure and vulnerability based on the economic damage (economic vulnerability, Gupta et al., 2010), the number of deaths and missing (social vulnerability, Gupta et al., 2010), according to population criteria, property, livelihoods, energy and industrial activities, settlement and transportation in some provinces and districts (ADB, 2011), and it assesses the vulnerability and risks of areas (Lê Đăng Trung, 2012).

The exposure to hazards and vulnerability of socio-natural systems in Viet Nam changes in both space and time. It also depends on the danger level of climate extremes, density, value and adaptive capacity of the objects that are exposed to hazards, as well as natural factors such as geology, geomorphology, topography, and hydrology. Climate extremes associated with adverse natural conditions increase the exposure level and vulnerability of human systems and natural ecosystems. Coastal ecosystems, especially mangrove ecosystems and coral are most vulnerable to storm, storm surges and sea level rise, and changes in salinity; terrestrial forest ecosystems are most vulnerable to drought, forest fires, flash floods, mud and rock floods. Vulnerable natural ecosystems can increase the exposure to hazards and reduce the adaptive capacity of human systems.

Climate extremes interacting with each other can mutually strengthen and increase the exposure level and the vulnerability of socio-natural systems. Heavy rains and storm surges cause floods, destroy infrastructure and residential coastal areas, erode sea dikes and mangrove forests, and cause land loss and saltwater intrusion. All of these cause increasingly serious damage to the coastal and lowland areas of Viet Nam, and increases the level of exposure and vulnerability of natural ecosystems and human systems. Human systems can increase exposure (unsuitable water resource use; deforestation; moving to the vulnerable areas; urbanization; construction of industrial parks in areas, which suffer many climate extremes; living and producing when climate extremes appear frequently; poverty, etc.), or reduce exposure to hazards (enhancing the adaptive capacity of natural-social system; mitigating the negative effects of extreme climates with construction or non-construction solutions such as land use and natural resources planning, which mitigate climate extremes; applying early warning systems; evacuating people out of the affected areas; adjusting production and human activities at the time when climate extremes occur less frequently; living wisely with climate extremes, etc.), the vulnerability situation, risks and impacts of climate extremes in both natural ecosystems and human systems, and socio-natural systems in general.

Disasters related to weather and climate, and depending on topography can cause significant impact on different areas, sectors and livelihoods, including water resources, agriculture, forestry, fisheries, food systems and food security; natural ecosystems; residential areas, infrastructure and tourism; human health, social protection and social welfare. Over the past 30 years in Viet Nam, the annual average number of people killed or missing due to disasters was about 500, and thousands of people were injured; and economic losses were about 1.5% of GDP, which is 1% higher than that of GDP loss in middle–income countries and about 0.3% higher than losses in low-income countries. From 1989 until now, the number of deaths (social vulnerability), and the total economic losses (economic vulnerability) caused by disasters in Viet Nam is complicated, but overall it tends to increase with GDP growth. Agriculture, including crop farming, livestock, aquaculture and fisheries are vulnerable to climate change. The damages (in

cash) of agriculture, irrigation, transport and fisheries caused by natural disasters in Viet Nam between 1989 and 2009 tended to decrease, but the number of damaged schools, hospitals, etc., tended to increase.

The risk of extreme climate extremes differs between the North and the South of Viet Nam, the East and the West, seasonally, and it is increasing due to the change in climatic extremes. Hazard exposure and vulnerability of socio-natural systems will increase in the months and the years in which more climate extremes occur, and will reduce at the time when there are fewer of those events. If the sea level rises by 1 meter, 6.3% of Viet Nam’s land area, approximately 39% of the Mekong River Delta, 10% area of the Red River Delta and Quang Ninh Province, more than 2.5% of the central coastal provinces and more than 20% of Ho Chi Minh City are at risk of flooding (MONRE, 2012).

Exposure and vulnerability often have a complex interaction; and their interaction is complicated at different scales and at different times. The increased level of exposure to hazards of human systems (humans and property, economy, technical and social infrastructure, etc.) and inappropriate human activities are major causes of increased climate risks.

4.1. Introduction

Chapter 4 analyses the impact, exposure to hazards and vulnerability (see Figure 1-1) in systems (human, natural, ecosystems), sectors (water, food and food security, tourism), residential areas, infrastructure, human health, welfare, etc., in Viet Nam due to the impacts of climate extremes. Two types of impact of climate extremes on human and ecosystems are reviewed and discussed, namely: (1) impacts of extreme weather and climate events; (2) extreme impacts triggered by less-than-extreme weather or climate events (in combination with non-climatic factors, including high exposure and/or vulnerability).

Losses, exposure to hazards, and vulnerability due to climate extremes were researched at many different levels; however, there were several limitations and challenges. (1) The first difficulty was the lack of reliable information and data: (i) Lack of data about vulnerability, exposure to hazards, losses, etc.; (ii) short and discontinuous time series data, (iii) procedures of collecting and processing data of vulnerability, losses, sensitivity, especially the process of loss data adjustment at different times. (2) Secondly, documention of losses is limited to the number of deaths, missing, injured, and property (buildings, social and technical infrastructure, crops and livestock, etc.); estimates of economic losses are based on asset losses and are usually lower than the actual loss value. The reason for that is that many effects such as human losses, and losses to cultural heritage and ecosystem services, indirect effects, etc., are hard to quantify. Thus, many non-material losses are not fully reflected in damage assessments, and long-term effects are not taken into account. The indirect impacts on the economy may have important implications for some sectors and some industries, but generally these are not included in damage assessment reports. (3) Thirdly, the comprehensive vulnerability to disasters (related or not related to weather and climate, so also e.g. earthquakes, volcanoes, landslides, pollution of water and marine sediments) and inappropriate human activities are only assessed for the coastal region of Viet Nam; a part of the vulnerability related to weather and climate disasters like floods and storms were evaluated only for some small areas. (4) The fourth challenge is that because of lack of data, some authors consider that damage can be converted into economic damage, including assets and social damage such as the number of deaths due to all types of disasters are related and not related to weather and climate. (5) The last issue is that official documents (reports by sector ministries and departments at the central level or local level, international organizations), provide limited evidence about the status of vulnerability, loss, exposure to hazards, etc.

Within such limitations of data and documents, chapter 4 analyses hazard exposure and vulnerability based on the economic damage (economic vulnerability, Gupta et al., 2010) and the number of deaths and missing (social vulnerability, Gupta et al., 2010) as well as according to indicators of population, property, livelihoods, energy and industrial activities, settlement and transportation in some provinces and districts (ADB, 2011), and it assesses the vulnerability, and risks of areas (Lê Đăng Trung, 2012).

4.2. Integrations between climate extreme events, exposure, and vulnerability of socio-economic systems in Viet Nam

4.2.1. The nature of interactions between climate extreme events, exposure, and vulnerability of socio-economic systems in Viet Nam

Chapter 3 and many other studies have shown that climate change results in higher intensity and frequency of climate extremes (typhoons and tropical storms, heat waves, cold spells, frost, hail, floods and other hazards such as landslides, erosion and accretion (Carew-Reid, 2008; Đỗ Minh Đức et al., 2012), floods, drought, salinity intrusion (Dasgupta et al., 2009; Trần Quốc Đạt et al., 2011; Birkmann et al., 2012; Wen-Cheng and Hong-Ming, 2014), forest fires, desertification, epidemic diseases (Hoàng Xuân Huy and Lê Văn Chinh, 2007; WMO, 2007; Running, 2008; Trần Công Thành et al., 2013). Typically, climate extremes result in negative impacts to socio-natural systems. Disaster risks depend on the extent of exposure and vulnerability (IPCC, 2012). All three factors including climate extremes, exposure and vulnerability of socio-natural systems change over space and time (see chapter 2). The change of one component of a system will also increase or decrease the impact level of climatic extremes to its system or other systems.

Depending on the original source and the interaction among climate extremes, adaptive capacity and resilience of the systems, climate extremes cause extreme impacts, and extreme impacts can occur even when there are no climatic extremes (IPCC, 2012).

Land and rock slide due to heavy rains involving a large amount of material carried by the flow, can give rise to mud flows of which 60% is landslide and rock and soil mixture, 25% is related to erosion, 10% is deep sliding and 5% is rock slide and rolling stones (Doãn Minh Tâm, 2008, 2009; Nguyễn Đức Lý and Đoàn Thế Tưởng, 2011). Sea level rise and storms cause erosion along most of our country's coast line, from a few to tens of meters per year (Nguyen Ngoc Cat et al., 2010). In the river systems, river bank erosion occurs in many parts during the flood season, most seriously in the downstream parts of the Red river basin, Mekong river, Tra Khuc river, Ba river, etc. (Mai Hạnh Nguyên, 2008).

Located in the Asia-Pacific area with a long coastline, Viet Nam is strongly affected by tropical cyclones. In the period of 1961-2010, there were 381 tropical cyclones affecting Viet Nam; the average number of typhoons per year is 7.62, especially in 1989 and in 1995 there were 14 typhoons formed each year, while there were only 2 typhoons appearing per year in 1969 and in 1976 (Nguyễn Văn Thắng et al., 2010) (see Chapter 3). Tropical cyclones accompanied with storm surges can cause flooding in coastal areas. Statistics show that approximately 50%, 30% and 11% of tropical cyclones causes storm surges over 1 m, 1.5 m and 2.5 m, respectively (NHMS, 1999). The maximum height of storm surges caused by some storms can reach over 4m. The exposure to storm surges in the Northern and the North-Central regions is higher than in other coastal areas (Table 4-1) (Viện Khoa học Khí tượng Thủy văn và Môi trường, 2014). Whereas in southern regions, such as in the Mekong River Delta, storms rarely strike and flooding is the main result of monsoon (Pilarczyk và Nguyen Si Nuoi, 2005). The southwest monsoon and the northeast monsoon in the Mekong river delta cause the sea level surges, if combined with the tide, it can surge by 0.8-0.9 m. The strong southwest monsoon in the dry season can create 2-meter waves reaching the shore in Ca Mau province.

Storm surges are especially dangerous when coinciding with high tide, and the dramatic rise in water level combined with high waves can overtop dykes and flood fields, and cause severe losses and damages to people and property. Mangrove deforestation has exacerbated the negative effect of storm surges in these areas. Tropical Storm Linda in 1997 landed at high tide and made the sea level rise over 3m. The provinces such as Ca Mau and Kien Giang can have the water level reaching over 2m combined with waves of 4-5 m. Tropical Storm Linda caused serious damages in the Mekong river delta (See chapter 9).

Table 4-1. Storm surge risks and storm-related total water levels along Viet Nam's coast

Coastal Region	Highest storm surges occurred (m)	Maximum potential storm surges (m)	Largest tidal amplitude (m)	Potential total water level (m)
Region I: Quang Ninh - Thanh Hoa	3.5	4.0	1.7 - 2.0	5.7 - 6.0
Regional: Quảng Ninh - Thanh Hóa				
area II - 1: Nghệ An - Hà Tĩnh	4.0	4.5	1.2 - 1.7	5.7 - 6.2
area II - 2: Quảng Bình - Thừa Thiên Huế	3.0	3.5	0.5 - 1.2	4.0 - 4.7
Region III: Đà Nẵng - Bình Định	1.5	2.0	1.0 - 1.2	3.0 - 3.2
Region IV: Phú Yên - Khánh Hòa	1.5	2.0	1.2 - 1.4	3.2 - 3.4
Region V: Ninh Thuận - Cà Mau				
Area V - 1: Ninh Thuận - Bình Thuận	1.5	2.0	1.4 - 1.8	3.4 - 3.8
Area V - 2: Bà Rịa Vũng Tàu - Cà Mau	2.0	2.5	1.8 - 2.0	4.3 - 5.0

(Source: MONRE, 2014)

Thus, large waves during storms, heavy rains, and storm surges cause floods and the destruction of infrastructure, residential coastal areas, erosion of sea dykes, mangrove forest, land loss and saltwater intrusion. All of these lead to increasing vulnerability of the coastal and lowland areas of Viet Nam, increasing the level of exposure and vulnerability of natural ecosystems and human systems.

Heat waves and droughts are extreme weather events that normally occur in the summer months, starting at the end of March and ending in late September. The number of annual heat waves is increasing sharply (MONRE, 2012) (see chapter 3). The exposure and the vulnerability to heat also show the spatial differentiation. In the Northeast, the hot season comes later when compared with other regions, and in the Central Highlands and the South the hot season is less severe than in the others. The heat events' frequency and severity is largest in Central coastal provinces, especially the North Central region of Viet Nam (Phan Văn Tân, 2010). The phenomenon of prolonged heat events combined with absence of rain can result in droughts (in Ninh Thuan, Binh Thuan, Tay Nguyen, etc.), or forest fires (Tay Bac, Tay Nguyen, Tay Nam Bo, etc.) which cause major damage to many social-economic sectors, particularly to agriculture, and thus these areas are vulnerable to heat events combined with forest fires. Heat events accompanied with increasing temperature can be harmful in terms of bad influence on human health, cattle, poultry and the aquaculture industry.

Freezing and damaging cold spells commonly appear in Viet Nam in the winter months (December to February) with a frequency of 91-97%, and concentrated in January and February (72-80%). These events usually last about 3-5 days with a frequency of 46-79%.

Climatic risks to human systems and ecosystems, water resources, food, infrastructure, tourism, services, etc., depend very much on changes in the characteristics of not only climate-related variables relevant to a given sector, but also on sector-relevant non-climatic factors and adaptive capacities (Kundzewicz, 2003), the social-economic structure, regional characteristics, current status of land use, management capacity (including organisational and institutional aspects), awareness, and response capacity of communities (Adger, 2006; Mai Trọng Nhuận et al., 2011a; 2011b; Mai Trọng Nhuận et al., 2014). The change of adaptive capacity, resilience and natural factors can change vulnerability of a system or a region.

Migration from the mountainous areas to the lowlands, from the rural areas to urban areas has contributed to an increase in exposure and vulnerability of our country's socio-natural systems under the impact of climate change. Migration in the Mekong River Delta is considered a typical consequence of climate change, mainly due to floods. It is estimated that 5 million people could be displaced later this century from the Mekong River Delta due to climate change (McElwee et al., 2010 p.23).

Land use changes cause changes in land cover and rainfall-runoff patterns, which can impact on flood intensity and frequency (Kundzewicz and Schellnhuber, 2004). Deforestation, urbanization, reduction of wetlands, and river engineering (e.g. channel straightening) alter the flow and reduce water storage capacity (Douglas et al., 2008; Few, 2003). The proportion of impervious areas (e.g. roofs, concrete roads, pavements and parking) and the value of the runoff-coefficient increase, so the river flow velocity increases and the hydrograph shows a higher peak and a shorter time-to-peak (Cheng and Wang, 2002; Douglas et al., 2008; Few, 2003).

Human activities can increase climatic extremes, and therefore increase the vulnerability of social–natural systems. Flooding caused by climate change combined with non-natural causes (deforestation, inappropriate land use, river works, etc.) is gradually increasing. The issue of reservoir safety and the increased risks of natural hazards and environmental disasters in the downstream river stretches resulting from inappropriate operation of hydropower and irrigation works is a problem in regions, causing increased vulnerability of downstream social-natural systems.

Climate change is changing climatic extremes. With an average emissions scenario (the B2 scenario), the highest flood level in the Red River in Ha Noi may go beyond the third warning level (11.5m) by approximately 0.5m in case there is a flood like the 1996 flood. Similarly, in the Ca River, in case there is a flood like the one in 1988, the water level in Nam Dan would be 1.8 m higher than the third warning level. In the Thu Bon, Ba, Dong Nai and Cuu Long river basins, the increase of flood runoff accompanied with sea level rise will make flooding in the downstream delta become increasingly serious (Nguyễn Lập Dân et al., 2007). In the Mekong river delta, large floods will occur in the mid-21st century, and combined with sea level rise of about 30cm this would increase the flooded areas by 25% in comparison with that of the historical flood in 2000. The flood would cover almost 90% of the Mekong river delta (Trần Thanh Xuân et al., 2011).

Salinity intrusion is an increasing risk in the future, but it is also unpredictable because of water resources exploitation in upstream countries of Mekong river delta. In fact, the Mekong delta is under a “double” threat because it is affected by climate change as well as upstream development including dams. In the future, saline water intrusion in the Mekong Delta will be exacerbated as the upstream countries increase their water use in the dry season whilst sea level rise also occurs (Trần Quốc Đạt et al., 2011; DMC, 2011). Thus, the exposure to saltwater intrusion risk in the Mekong Delta is increasing in the coming time due to climate change and water resources exploitation and management in the upstream parts of the Mekong River.

Under the impact of rising sea levels and changes in water resources due to climate change upstream, in the downstream of the Red River - Thai Binh, Dong Nai and Mekong River systems, saltwater intrusion will penetrate deeper inland. At the end of the 21st century, the inland penetration with 1‰ salinity may increase to over 20 km on the Dong Nai, Tien and Hau rivers and approximately 10 km into the Thai Binh River.

The above analysis shows that there are complex interactions between the climatic risk factors hazards, exposure and vulnerability, and impacts are complex at different scales (IPCC, 2012). Human systems can increase exposure (inappropriate water resources use; deforestation; moving to vulnerable areas, etc.), or reduce exposure to hazards (by evacuating people out of the affected areas; improving their adaptive capacity; limiting the negative impact of climate extremes with infrastructure and non-construction solutions.

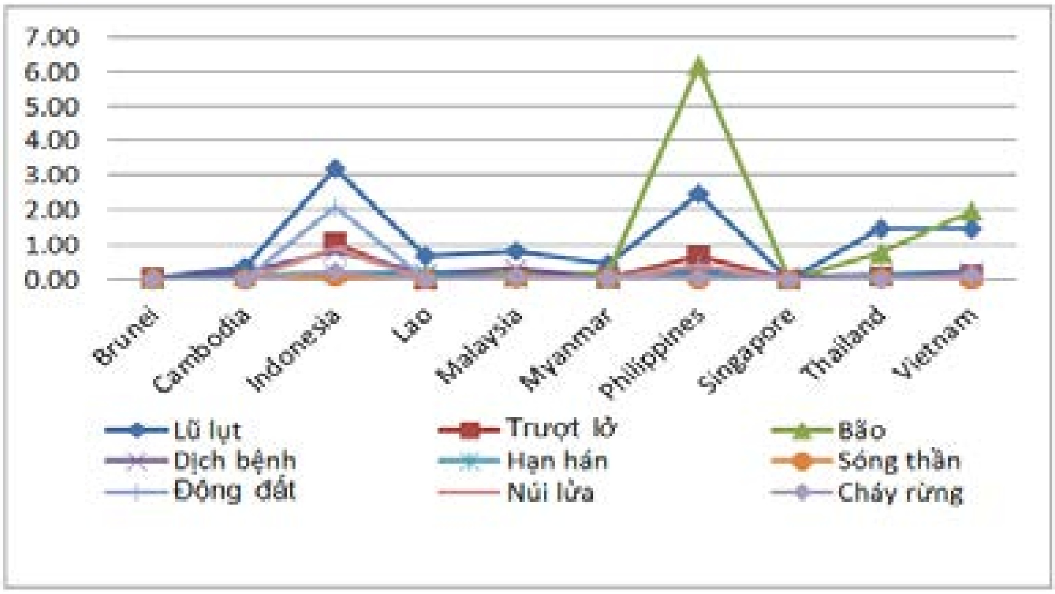
4.2.2. Exposure, impact of extreme climate events, disasters, and vulnerability of socio-economic systems in Viet Nam

In Southeast Asia, floods, storms, epidemics, droughts, earthquakes, volcanoes, and forest fires cause the most damage to society and economy. In the period 1970-2009 in Southeast Asia, the number of deaths due to storms was biggest (184,063 people), followed by earthquakes (105,735 people), tsunamis (92,021 people) and floods (17,801 people) (Gupta et al., 2010). Compared with other Southeast Asian countries, the number of disasters (floods, storms, landslides, droughts, epidemics, forest fires, tsunamis, earthquakes, volcanoes) (Figure 4-1) and the number of deaths per one million inhabitants in Viet Nam are average (Gupta et al., 2010).

Climatic extremes (Chapter 3 and section 4.2.1) are different in terms of intensity and spatial distribution across Viet Nam (Figure 2-1), so the role, impact and danger level of each hazard, and the exposure to extreme risks are varying and depend on the nature of affected areas (Table 4-2 and Figure 4-2). The interaction (reducing or increasing the negative impact) between extreme events and impact depends on their scale and frequency (Buzna et al., 2006).

Due to the impact of climate change, in recent years, climate anomalies have gone beyond current human understanding, as they happen more frequently, are more complicated, and cause unpredictable consequences (MONRE, 2011). Figure 4-3 and Figure 4-4 show the percentage of areas and population affected by each type of disaster.

Figure 4-1. Number of Disasters per Year in Southeast Asia (1970-2009)



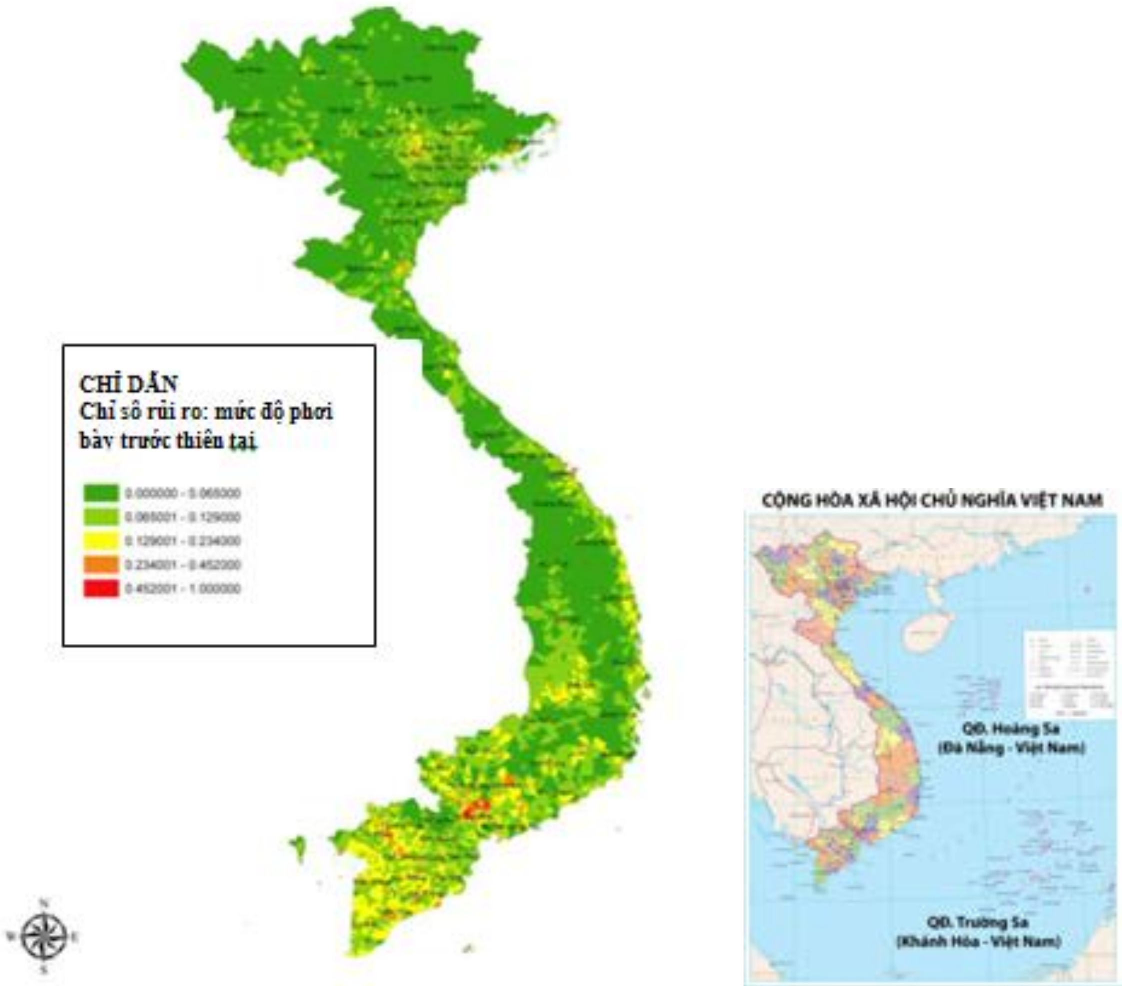
(Source: Gupta et al., 2010)

Table 4-2. Danger Levels of Disaster Across Regions and Economic Areas in Viet Nam

Disaster	Northeast and North West	Red River Delta	Costal North Central	The Coastal South Central	South East	Central Highlands	Mekong delta	Other coastal economic region
Storms	+++	++++	++++	++++	+++	++	+++	++++
Floods	-	++++	++++	+++	+++	+++	++++	++++
Flash floods	+++	-	+++	+++	+++	+++	+	+++
Typhoons	++	++	++	++	++	+	++	++
Drought	+++	+	++	+++	+++	++	+	+++
Desertification	-	-	+	++	++	++	+	++
Saline Intrusion	-	+	++	++	++	+	+++	++
Inundation	-	+++	++	++	++	-	+++	+++
Landslides	++	++	++	++	++	+	+++	++
Storm surges	-	++	++	++	++	++	+++	++
Forest fires	++	+	++	+++	+++	-	+++	+++
Environmental and industrial disasters	-	++	++	++	+++	+++	++	+++

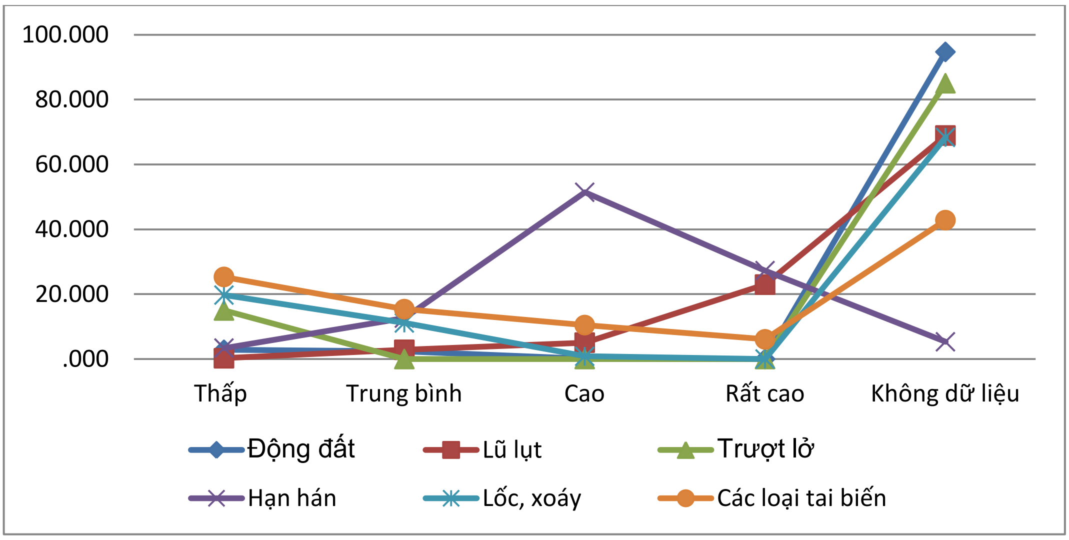
Note: ++++: extreme danger; +++: danger; ++: moderate danger; +: less danger; -: safety. (Source: UNISDR, 2004*).*

Figure 4-2. Risk Index: Exposure to Hazards



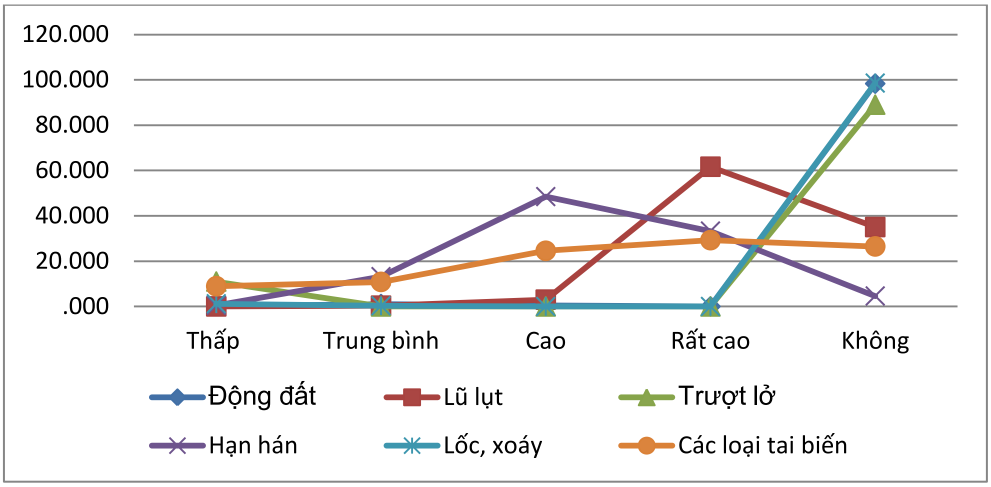
(Source: Lê Đăng Trung, 2012)

Figure 4-3. Percentage of Areas Affected by Disasters in Viet Nam



(Source: Gupta et al., 2010)

Figure 4-4. Percentage of Population Affected by Disasters in Viet Nam



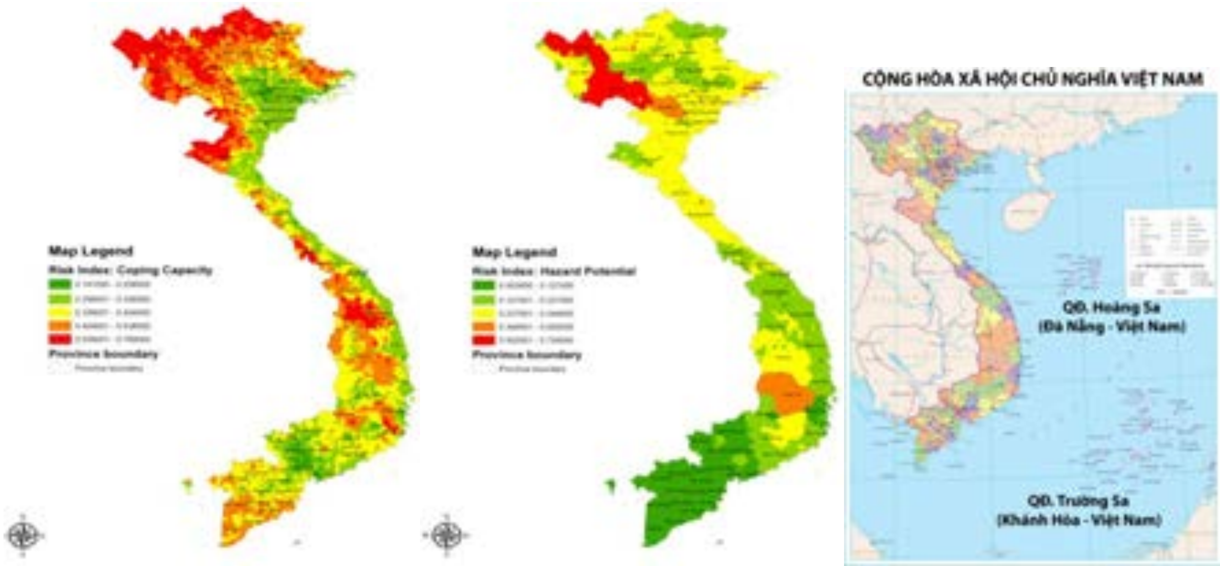
(Source: Gupta et al., 2010)

Table 4-3. Regional Vulnerabilities Caused by Disasters in Viet Nam

Region	North West	North East	Red River Delta	North Central	South Central	Central Highlands	South East	Mekong river delta
EXPOSURE								
Storms	1	3	4	4	4	2	2	3
Floods	1	1	4	4	4	2	2	4
Saline Intrusion	0	0	1	2	2	0	1	4
Sea Level Rise	0	0	2	2	2	0	3	4
Landslide	3	3	1	3	3	2	1	1
Drought	2	2	1	4	4	4	2	2
Average	1.2	1.5	2.2	3.2	3.2	1.7	1.8	3.0
VULNERABILITY								
Property	4	3	2	4	2	4	1	2
Economic diversity	4	4	2	4	3	4	2	2
Education	4	3	1	2	2	2	1	3
Health and Hygiene	4	1	2	1	1	1	1	3
Ethnic Minorities	4	3	0	1	1	4	1	2
Women and children	4	3	1	2	3	3	1	2
Migrants	0	0	2	2	1	4	4	1
Urban households	0	0	2	1	1	0	4	3
Average	3.0	2.1	1.5	2.1	1.8	2.8	1.9	2.3
Total	4.2	3.6	3.7	5.3	5.0	4.5	3.7	5.3

(Source: McElwee et al., 2010)

Figure 4-5. Risk Index of Viet Nam: (a) Disaster Response Coping Capacity, and (b) Hazard Potential



a) b)

(Source: Lê Đăng Trung, 2012)

The population, technical and social infrastructure are concentrated in urban areas such as Ha Noi, Ha Long, Vinh, Da Nang, Ho Chi Minh City and towns in the Southwest region, and the exposure to hazards of these areas is greater than that in the northern mountainous regions and the Central Highlands, with low population density and less infrastructure (Table 4-3). The regions of Viet Nam could be sorted in order of decreasing exposure to hazards, as follows: the North Central Coast and the South Central Coast (3.2), the Mekong River Delta (3.0), the Red River Delta (2.2), the South East (1.8), the Central Highlands (1.7), North East (1.5), North West (1.2). In order of decreasing vulnerability, these areas are classified as follows: North West, Central Highland, the Mekong Delta, North East and Central North Coast (2.1), Central South Coast and South East (1.8-1.9), and the Red River Delta. Sorted by the decreasing exposure and vulnerability, the regions are put in the following order: the Mekong River Delta and North Central Coast, South Central Coast (5-5.3); North West, Central Highlands (4.3-4.6); Red River Delta, and South East and North East (3.6-3.7).

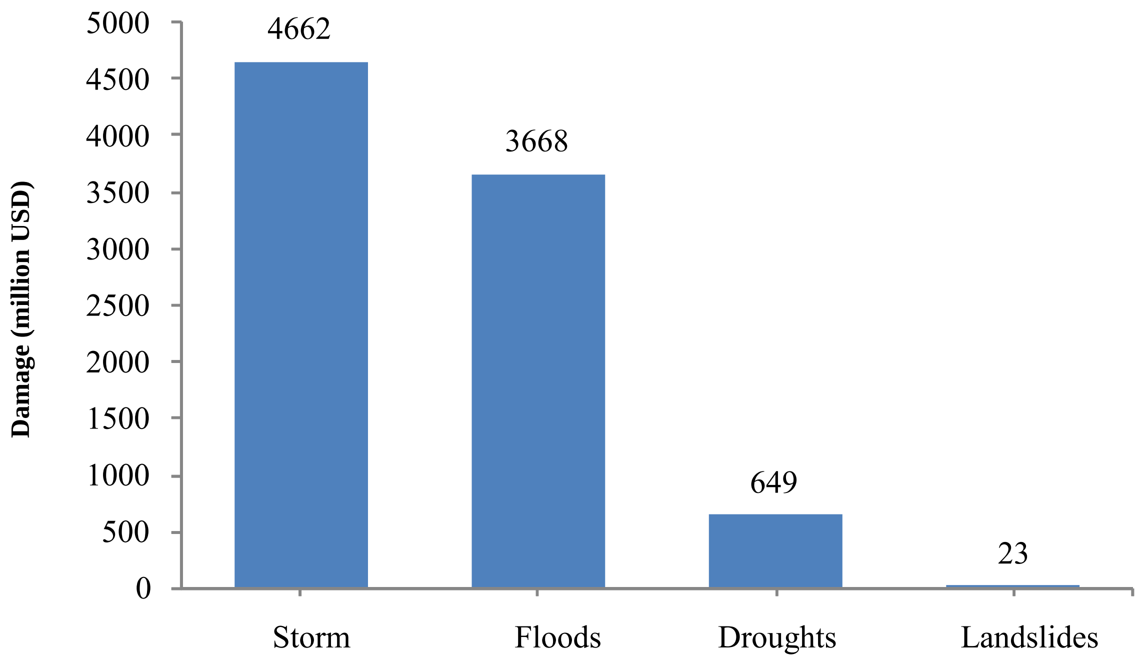
In each region, the poor, ethnic minorities, people whose income depends on climate, older people, women, children, and sick people are most vulnerable to climate change (McElwee et al., 2010). As shown in the Figure 4-5a, the disaster response capacity in the North West, North East, Central Highlands, and South West is quite similar and higher, and their potential disaster risk level is higher than that in other regions (Figure 4-5b).

The vulnerability of social and natural systems in Viet Nam depends very much on the intensity of extreme events, value and adaptive capacity of exposed objects to the hazard and natural factors such as geology, geomorphology, topography, and hydrology (Mai Trọng Nhuận et al., 2011a; Mai Trọng Nhuận et al., 2014).

In general, from 1989 until now, the number of deaths (social damage) and the total loss to the economy (economic losses) (Gupta et al., 2010) due to natural disasters in Viet Nam are complicated, but on the whole, they are increasing along with the growth of GDP (Figure 4-6 and Figure 4-7).

Among several types of disasters, Viet Nam suffered most losses from tropical cyclones and floods, followed by drought and landslides (UNISDR, 2014). Over the period 1990-2012, nearly 4.7 billion USD and 3.7 billion USD were lost due to tropical cyclones and floods, and droughts and landslides caused damages of 649 and 2.3 million USD (Figure 4-6). These data did not include all losses of floods, which were partly caused by heavy rains during and after storms, whilst the total precipitation during storms can reach 25% of annual total precipitation in some coastal stations in Central Viet Nam (Nguyễn Thị Hoàng Anh et al., 2012). The number of people affected by tropical cyclones was very high and reached more than 8 million during the typhoon in September 1980, which particularly affected Thanh Hoa and Nghe Tinh provinces (the latter is Thanh Hoa and Ha Tinh today) (ADRC, 2002). Although the economic losses increased sharply in recent typhoons, the number of deaths due to typhoons fortunately has been not be proportional to these damages (Figure 4-7, Table 4-4 and Figure 4-10). There were 15 tropical cyclones causing high levels of damage and human losses in Viet Nam in the period of 1901 - 2012.

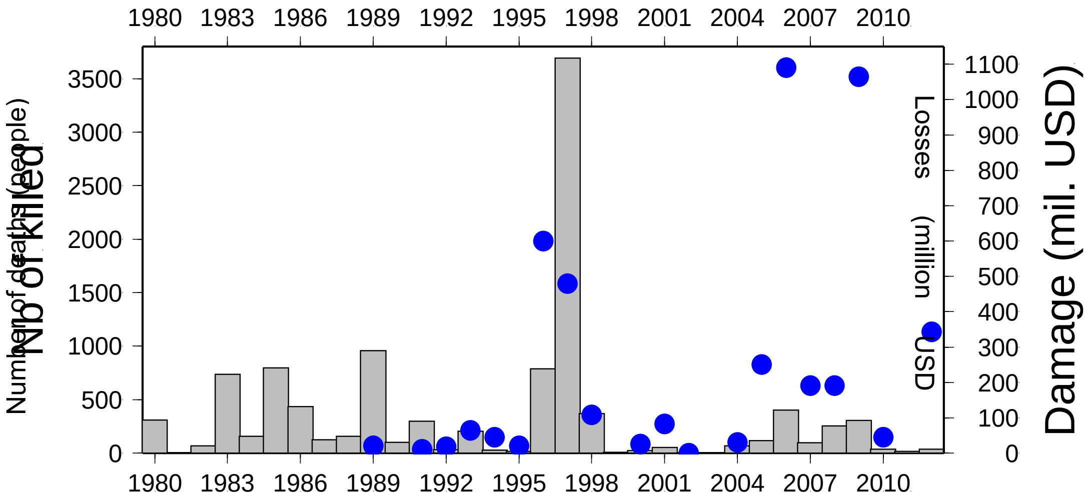
Figure 4-6. Economic Losses (1990-2012) Caused by Disasters in Viet Nam



(Source: EM-DAT: The OFDA/CRED International Disaster Database - www.emdat.be - Université Catholique de Louvain - Brussels - Belgium)

According to statistical data, the number of deaths due to landslides is on average 30 people/year (Nguyễn Đức Lý, 2011). Besides floods, landslides are a frequently occurring natural hazard, causing high human and property losses, especially in the North West mountainous region of Viet Nam (Đỗ Minh Đức, 2009; Lee and Nguyen Tu Dan, 2005). In the past 15 years, flash floods and stony mud floods have killed more than 1,000 people, injured more than 700 people and caused economic losses up to VND 2,000 billion.

Figure 4-7. Number of Deaths (the grey column) and Total Losses (blue dot) Caused by Tropical cyclones from 1980 to 2012

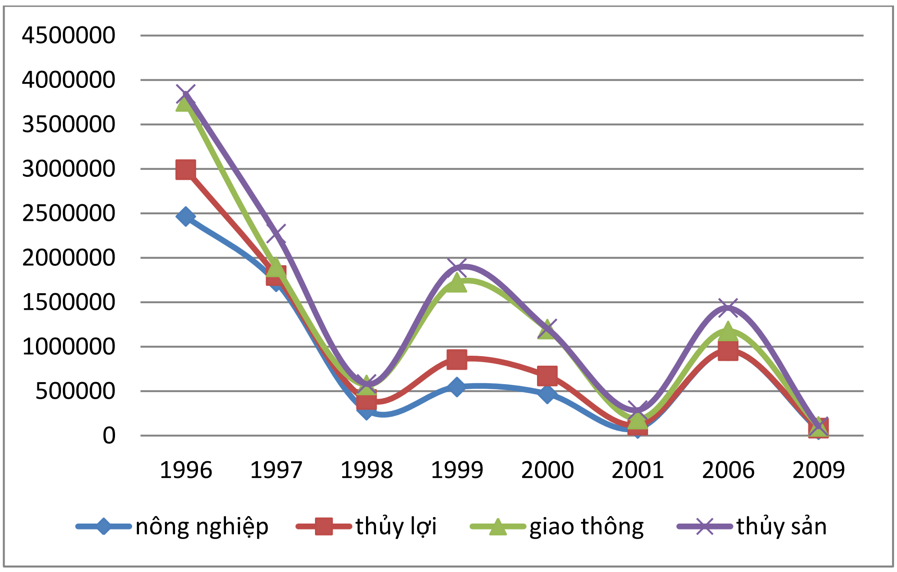


(Sources: EM-DAT: The OFDA/CRED International Disaster Database - www.emdat.be - Université Catholique de Louvain - Brussels - Belgium.)

Note: Due to the lack of data, there are a number of years without damage

The damage from extreme climate events on different economic sectors socio-economic system is given in Table 4-4 (Nguyễn Văn Thắng et al., 2010; MONRE, 2012). Impacts of climate change (expressed in % of GDP losses) ranked from high to low for each sector (for the years 2010 / 2030) are estimated as follows: labour productivity 4.4% / 8.6%, fisheries 0.5% / 1.6%, agriculture 0.2% / 0.4%, biodiversity 0.1% / 0.1%. Climate extreme damages (in 2010 / 2030) are estimated as follows: sea level rise 1.5% / 2.7%, heating and cooling 0.1% / 0.3%; floods and landslides 0.1% / 0.1% (DARA, 2012 p.221).

Figure 4-8. Losses (million VND) of Agriculture, Irrigation, Transportation and Aquaculture Caused by Disasters in Viet Nam from 1989 to 2009



(according to ccfsc.gov.vn)

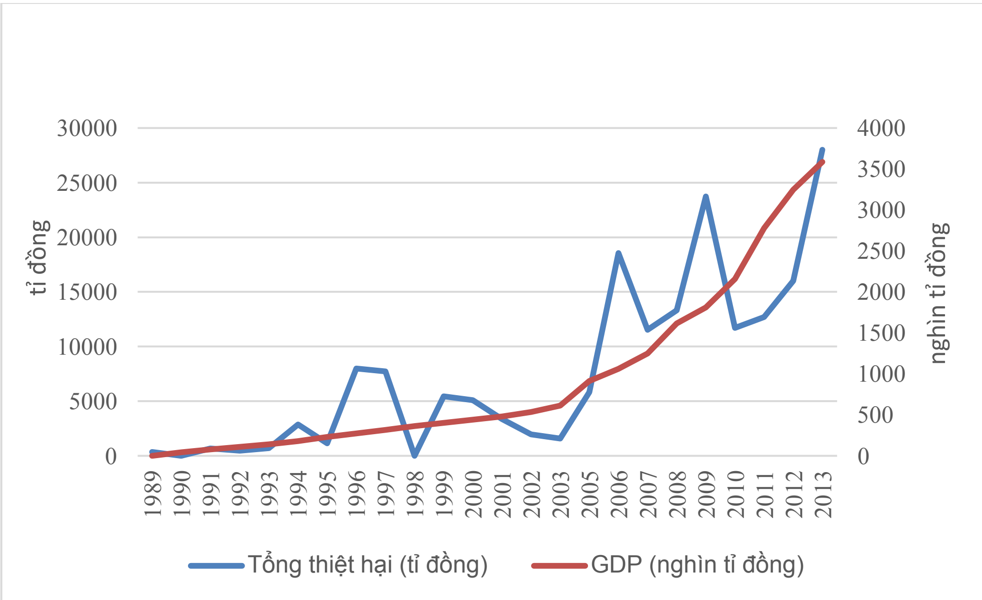
Table 4-4. Damage Caused by Disasters in Viet Nam from 1989 to 2013

Year	Deaths	Damaged Houses	Schools	Hospitals	Agriculture		Irrigation		Transportation		Aquaculture		Total losses
					Flooded & damaged rice area	The total losses	Irrigation Losses / Landslides	Total losses	Transportation/ Landslides	The total losses	Ponds, lakes swamps	Total losses	
	Nr of people	number	Nr of rooms	number	ha	Million dong	m³	Million VN dong	m³	Million VN dong	ha	Million dong	Million VN dong
1989	412	235,729	10,400	1,760	765,375		8,495,526		1,819,861		479		350,177
1990	342	14,521	1,931	423	237,800		5,930,817		2,047,067		684		-
1991	464	15,063	383	53	211,377		920,480		401,790		936		680,407
1992	332	8,211	313	45	366,572		4,460,705		2,016,335		29,130		468,818
1993	347	29,470	1,462	29	171,560	1,050	3,216,396	900	858,914	1,000	7,664,4		697,505
1994	507	7,302	9,840	23	658,676		21,195,929		914,753		6,440		2,850,080
1995	351	11,043	1,161	26	198,439	58,369	7,637,489	9,231	3,271,918	10,358	4,410		1,129,434
1996	1.128	96,927	5,297	200	927,506	2,463,861	59,668,186	526,667.4	6,879,992	767,629	70,991	84,339	7,998,410
1997	941	111,037	1,714	86	641,393	1,729,283	4,684,519	70,658	1,795,052	9,863	138,331	373,563	7,730,470
1998	485	13,495	563	5	195,661	285,216	5,460,263	121,476	3,562,284	163,021	7,616	11,782	-
1999	825	52,585	726	95	131,267	546,119	14,795,275	308,396	111,704,16	870,256	42,903	161,278	5,427,139
2000	762	12,253	140	47	655,403	468,239	29,249,495	202,034	1,219,387	528,042	21,250	6,604	5,098,371
2001	604	10,503	151	28	132,755	79,485	1,195,524	38,380	970,149	68,361	16,615	100,650	3,370,220
2002	355	9,802	77	2	46,490		115,332		947,601		5,828		1,958,378
2003	180	4,487	49	1	209,764		2,200,097		2,752,120		14,490		1,589,728
2005	377	7,586	258	198	504,098		2,987,876		3,417,238		55,691		5,809,334
2006	339	74,783	268	25	139,231	954,690	1,053,377	258,150	1,636,560	222035	9,819	258,500	18,565,661
2007	462	9,908	1,304	52	173,830	432,615	4,834,057	42,294	7,126,064	104180	19,765		11,513,916
2008	474	5,180	138	6	146,945		2,743,835		4,728,829		57,199		13,301,000
2009	435	13,354	1,364	7	237,799	66,000	3,033,202	18,000	10,321,193	19100	9,424	2,000	23,745,000
2010	355	2,600			30,000								11,700,000
2011	257	1,200			330,000								12,703,000
2012	269	2,600			272,000								16,000,000
2013	313	6,401			122,000								28,000,000

(Source: http://www.ccfsc.gov.vn)

Figure 4-9. Number of Human Deaths and total Losses Caused by Disasters per Year in Viet Nam

Figure 4-10. Total Economic Losses Caused by Disasters and Annual GDP of Viet Nam between 1989 and 2013



(Source: General Statistics Office, 2013)

In the past 30 years, the number of deaths and missing as a result of disasters in Viet Nam per year was about 500. People injured by disasters ran into the thousands of people per year, and disasters caused economic losses of about 1.5% GDP/year (Trần Thọ Đạt and Vũ Thị Hoài Thu, 2012). In the years 2002 – 2006, disasters killed about 1,700 people, and property losses were estimated at VND 75,000 billion (Table 4-4). The total damage due to disasters in 2013 was estimated at nearly VND 30,000 billion (which is double the losses in 2012), 313 deaths, and 1,150 injured (GSO, 2013). Agriculture, including farming, livestock, and fisheries are vulnerable to all climate change factors. The total damage caused by disasters is primarily in the sectors that depend strongly on weather, climate, topography and soil, such as agriculture, fisheries, irrigation, and transportation (Table 4-4). Damage (in million VND) to agriculture, irrigation, transportation and fisheries due to disasters in Viet Nam in the period 1989-2009 shows a decreasing trend (Figure 4-8), but the number of deaths and total damage increased (Figure 4-9 and Figure 4-10). If mean sea level would rise by one meter and there would be no response, then most of the Mekong River Delta would be inundated for a prolonged period of the year, and the estimated losses may be 17 billion USD.

Due to climate change, by the end of the 21st century mean sea level may rise one meter, which puts approximately 6.3% of the land area of Viet Nam, 39% of the Mekong River Delta, over 10% of the Red River Delta and Quang Ninh province, over 2.5% of the Central Coast region and over 20% of Ho Chi Minh City at risk of flooding (MONRE, 2012).

With a one-meter sea level rise, agriculture and aquaculture land will be primarily threatened with inundation (10,962 km^2), or 76% of the total agriculture and aquaculture land area; following are wetlands (1,895 km^2; 13%); forest and natural vegetation (1,159 km^2; 8%); and residential areas (302 km^2; 2 %). Coastal industrial zones of the Mekong River Delta, the Red River Delta and the Central North coastal region are most vulnerable due to sea level rise of one meter, which will directly affect 16% of the national population, nearly 55% of the population in the Mekong Delta; over 9% population of the Red River Delta and Quang Ninh province; nearly 9% population of the Central Coast provinces and about 7% of the population of Ho Chi Minh City. Simultaneously, over 4% of rail systems of Viet Nam, over 9% of the national highway systems and approximately 12% of the provincial highway systems will be affected. The highest social vulnerability (the number of affected people) due to sea level rise of one meter is in the Mekong River Delta and the Red River Delta. According to UNU-WIDER (2012), Viet Nam is one of the most affected developing countries by sea level rise. The result of an assessment of potential impacts of sea level rise on 84 coastal developing countries by 6 indicators of land, population, GDP, urban extent, agriculture extent and wetlands showed that Viet Nam is one of 5 countries potentially most affected if mean sea level rises by one meter (Dasgupta et al., 2009). Moreover, the World Bank ranked Viet Nam as one of 12 countries most affected by sea level rise due to climate change (Gebretsadik et al., 2012).

The impact of extremes on communities is also reflected through a reduction of livelihoods. The income of nearly half a million Vietnamese is primarily from fisheries, and the income of another 2 million Vietnamese is related to this. Their livelihoods depend on climatic factors and natural resources, their lives and livelihoods are subject to the risks of hazards as well as the disadvantages of climatic factors, especially storms, floods, and droughts. Provinces in the Mekong River Delta and the Central Coast regions are economically vulnerable because the main income of many local people is related to fisheries. However, by knowing how to adapt and take advantage of the opportunities brought by climatic extremes, their exposure and vulnerability can be reduced. Floods in the Mekong River Delta are an annual phenomenon that bring many benefits such as aquatic resources and alluvial deposits for the delta that result in high agriculture crop productivity, washes away toxic substances that accumulate in low-lying areas, and that lessen vulnerability caused by floods in the area. People adjust their cultivation patterns and techniques as well as daily activities to live with floods by shifting towards adaptation and taking advantage of opportunities brought by floods, thereby reducing exposure to the hazard and reducing their vulnerability to the river floods.

4.3. Impact of climate change and climate extremes on socio-economic systems

The current and future impact of climate change and disasters on socio-economic systems have been studied (Nguyễn Đức Ngữ, 2002; Trần Thục, 2008; Mai Trọng Nhuận et al., 2009; 2011; 2014; Phan Văn Tân, 2010; Nguyễn Văn Thắng et al., 2010). Projections of impacts based on different climate change scenarios published by the Ministry of Natural Resources and Environment (MONRE, 2009, 2012) have also been considered.

4.3.1. Impact on water resources

Past and future changes in exposure and vulnerability to climate extremes in the water sector are driven by both changes in the volume, timing, and quality of available water; and changes in the population, equipment and systems for water resource use that are exposed to water-related hazards (Aggarwal and Singh, 2010). Vulnerability increases as more demands are placed on the water resource (due to increased population and water consumption, for example, or increased discharge of waste water) and it reduces as measures are implemented to improve water resource management, appropriate planning, and resilience of water resources is enhanced (IPCC, 2012). On the other hand, the vulnerability of water resources also depends on the change in intensity and frequency of extreme hazards, which have been calculated by numerical models that contain high uncertainty. This part focuses on assessing the impact of climate change to quality and quantity of water and water consumption based on historical and current data as well as the results of future climate projections.

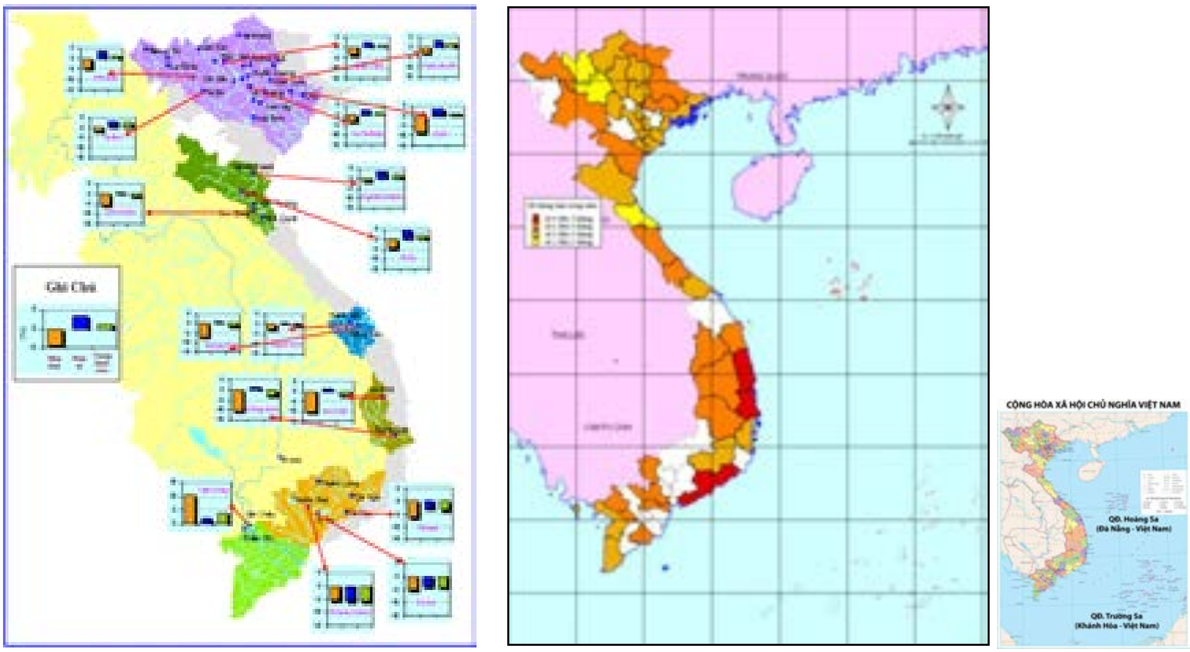
According to hydrological studies, the flow of river and stream systems in Viet Nam has in recent years been deficient. In some places the flow was lower than the average flow by 60-90%, and the water level in many river systems reached its lowest level in the recorded history such as Hong - Thai Binh river, Ma river, Ca river, La river, Tra Khuc river, and Ba river, which caused water shortages for agriculture production and saline water intrusion into estuaries (Figure 4-11) (Nguyễn Văn Thắng, 2010; Trần Thanh Xuân et al., 2011). As a result of climate change, the flow in most river systems in Viet Nam has decreased by 3% to 10%, but the flow reduction varies significantly between rivers, and between the upper, middle and downstream parts of one river system. It is estimated that in the period 2040-2059, the dry season mean flow will reduce by 1.5% (in the Da, Gam and Hieu rivers) and more than 10% (in the Ba river); other river flows will reduce between 3.0 and 10.0% (Trần Thanh Xuân et al., 2011); and in the La, Ba, Thu Bon and Dong Nai rivers the flow reduces between 1% and 10%. In the Red -Thai Binh river, the annual flowswill increase by less than 5%. The average flow of the Mekong River (in the delta) will increase by 4 to 12% over the period 2010-2050. Peak flow in the Red - Thai Binh, Ca, Ba and Thu Bon rivers will increase by 2% to 9%, but in the Dong Nai river system, it decreases by 4% - 7%. The peak flow in the Mekong river (in Kratie) will increase in the period 2010-2050 by 5% - 11% in comparison with the period 1985-2000, and the average dry season flow (Tan Chau station) in the period 2010-2050 will increase by about 10% (Trần Thục and Hoàng Minh Tuyền, 2011). Based on these data and the climate change scenarios for Viet Nam, it could be concluded that droughts will increase due to future water shortages in all river basins in Viet Nam (Figure 4-11) (Nguyễn Văn Thắng, 2010). Results of drought assessment in the two key areas including the Red River delta (representing the North) and the coastal areas in the South Central region (Nguyễn Lập Dân, 2010) showed that in 2020 and in the middle of 21st century, hydrological drought indicators ($K_{drought}$) of the North increase by 0.3 – 0.6, which is a signal of drought and mild drought intensity; and in the South Central by 0.6 – 0.9 for the dry period of one month, 3 months, and season corresponding to mild drought. The droughts would become more severe by mid-century.

According to Viet Nam's Second National Communication to the UNFCCC, climate change may cause significant reduction of the groundwater level, especially in the post 2020 period due to groundwater extraction activities for production and the declining water recharge in the dry season. In the Southern delta, if dry-season flow decreases by 15% to 20%, the ground water level will be 11m lower than the current level. In the dry season, the ground water level decline is caused by a decrease in water recharge from precipitation and sea level rise results in saline water intrusion into the groundwater in coastal areas and deltas, reducing the amount of fresh water which can be exploited and used (Trần Thanh Xuân et al., 2011).

4.3.2. Impact on natural ecosystems

Ecosystems in Viet Nam include: (1) Terrestrial ecosystems with characteristics such as forests, grassland, savannah, dry land, urban areas, agriculture, and limestone; (2) Wetland ecosystems with specific areas such as lakes, reservoirs, ponds, swamps, rice paddies, and water conduits (rivers, streams, canals); (3) The coastal and marine ecosystems (estuaries, alluvial grounds, mangroves, sea grass beds, and coral reefs) (MONRE, 2011). The marine ecological region in Viet Nam is very diverse and abundant, which is divided into 7 basic ecosystems: mangrove ecosystems, sea grass ecosystems, coral reef ecosystems, intertidal ecosystems, cave ecosystems, saltwater lake and saline water ecosystem (Đỗ Công Thung and Massimo, 2004).

Figure 4-11. Water Resources Depletion and Drought Distribution in Viet Nam



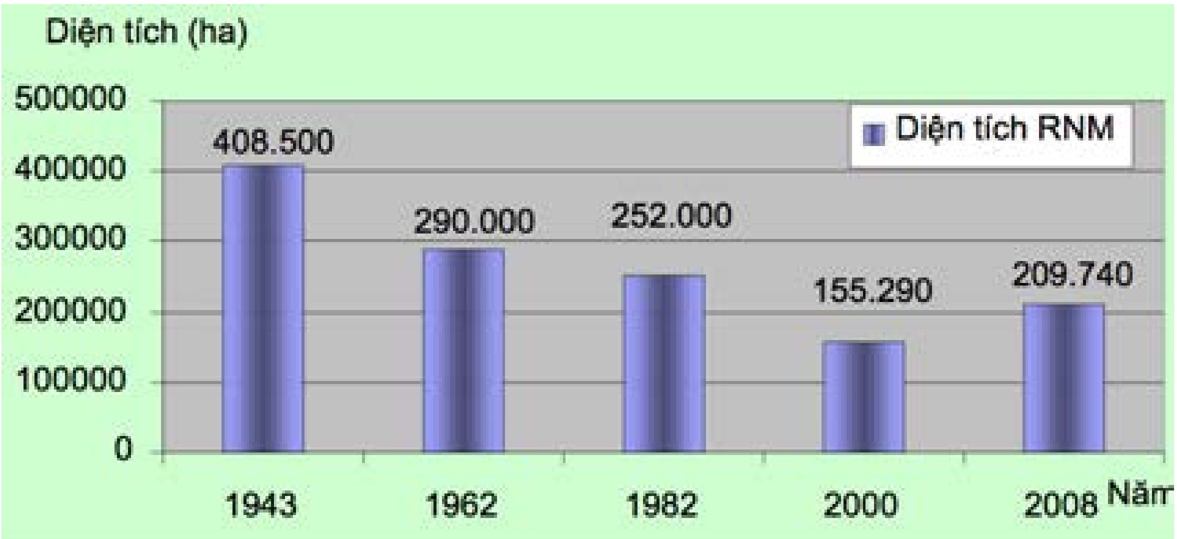
(a) (b)

a) Depletion of water resources in main river basins (Source: Trần Thanh Xuân et al., 2011); b) Mean annual number of dry months map in Viet Nam (Source: Nguyễn Văn Thắng, 2010).

Nearly 200 coral reefs in Viet Nam's coastal areas have recently been surveyed, which shows that the coral reefs are not in a good condition. The cover of live coral reef in the North of Viet Nam has decreased by 25 - 50%; only about 1% of coral reefs studied in southern Viet Nam are in an excellent condition. According to the World Resources Institute, since 2002 approximately 80% of coral reefs in Viet Nam's territorial waters are at risk, of which 50% is at a very high risk. Without proactive and effective actions by 2030, Viet Nam's sea territories might become "marine deserts" without any reefs and aquatic resources remaining. Before the period 1996-1997, 39 submerged sea grass beds covered an area of 10,768 ha, and in 2003 only nearly 4,000 ha remained, which is equivalent to a loss of 60%. Approximately 100 aquatic species are at various levels of risk and more than 100 species have been included in Viet Nam's Red List of endangered species.

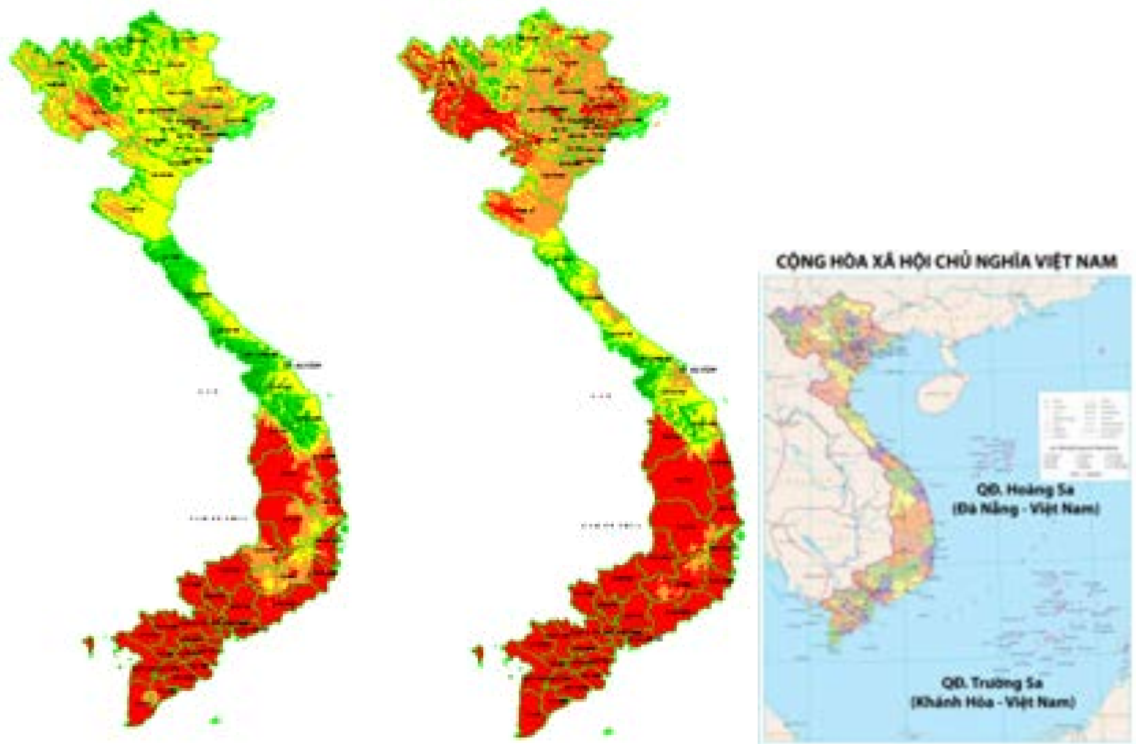
The potential impact of climate change on mangroves in Viet Nam may include: increased temperature would make mangroves shift toward the North; increased precipitation would result in better mangroves and reduced precipitation will cause the reverse; storms with increase intensity will destroy mangroves. Activities such as development of aquaculture, changes in land use (salt harvesting, sedge and rice cultivation), over-exploitation (wood, timber), and water pollution exacerbate the impact of climate change. Sea level rise has affected Viet Nam's coastal wetlands, especially the extremely vulnerable mangrove forests in Ca Mau, Ho Chi Minh City, Vung Tau and Nam Dinh.

Figure 4-12. Mangrove deforestation between 1943 and 2008



In the last 60 years, Viet Nam's mangrove forest cover plummeted, as the mangrove area was 408,500ha in 1943 and only 209,740 ha in 2008, meaning that 198,759 ha (48.5%) was lost (Figure 4–12) at an average annual reduction of 3,200 ha, with particularly high rates of losses between 1985 and 2000 when on average approximately 15,000 ha/year was lost. Research in tidal wetland in Tien Yen and Dam Ha district (Quang Ninh province) shows that sea level rise caused a change in sediment composition, an increase of salinity and water level in the mangrove, and a reduction of some mangrove species such as *Avicennia*, *Sonneratia,* and *Rhizophora*, reduced river flow in the dry season, and inhibition of the development of *Sonneratia* spp., and therefore threaten the existence of the mangrove (Hoàng Văn Thắng, 2008). The changes in the mangrove mentioned above as well as the changes in the intertidal flats system and estuaries in Tien Yen and Dam Ha regions causes difficulties for birds to feed, and a reduction of the diversity and abundance of water birds, fish and shrimp. The climate change adaptive capacity of wetlands and floods in these areas is at mid-level, and therefore its vulnerability is at mid-level too, but it reduces the livelihoods of local communities. Due to mangrove forest degradation and deforestation, the extensive shrimp production within mangrove forests has seriously decreased, from about 200 kg/ha/crop (1980) down to only 80kg/ha/crop currently; approximately 800kg of aquatic products were formerly harvested per hectare, however, it is currently only 1/20 of the previous level. Mangrove provides protection from wind damage during storms, protecting sea dykes (currently 1,113 km of the total 2,380 km of sea dykes is protected by mangrove, corresponding to a mangrove forest cover of 69,611 ha), limiting erosion and pollution of the marine environment, protecting the coastline, expanding the land area, regulating climate, maintaining livelihood (Phan Nguyên Hồng, 2006; Phạm Văn Ngọt et al., 2012), thereby reducing the exposure, vulnerability and risk of human systems and coastal wetland ecosystems to extreme hazards. The decrease of mangrove areas affects livelihoods (fishing, aquaculture, beekeeping, ecotourism, etc.); reduces its protection capacity to wind and storm waves; and reduce its role of a natural “trap” for filtering natural pollutants, thereby increasing hazards and environmental pollution. This will increase the level of exposure, reduce the adaptive capacity of coastal ecosystems and related communities, and increase the vulnerability of the whole natural ecosystem and human ecosystem. Mangrove also has a significant role for CO_2 storage: the storage of mangrove in Ca Mau National Park is 1/3 of total annual CO_2 emissions of Viet Nam in 2011 (112.67×10^6 Mg CO_2) (Nguyễn Tài Tuệ et al., 2014). Increased temperature and CO_2 concentration will increase photosynthesis in mangrove; biological productivity of mangrove will increase if within the adaptation threshold. Thus the vulnerability of the natural ecosystem and human ecosystem would reduce in future.

Figure 4-13. Forest Fire Risk in Viet Nam in 2010 and 2090



(Source: Phạm Minh Thoa, 2013)

Note: dark green–less fire possibility; light green–low fire risk; yellow–moderate fire risk; orange–high fire risk; red–very high fire risk.

Drought also creates conditions for forest fires in the Central Highlands and the Mekong River Delta, where thousands of hectares of forests have been damaged (ADB, 2009). Forest fire is one of the biggest threats to forest ecosystems. Climate change increases the risk of forest fire all over the country (Figure 4-13). In particular, the Southern provinces and the Central Highlands are at extremely high risk of forest fire, and the Northern provinces are at high risk of forest fire. The higher forest fire risk, the higher forest vulnerability.

Prolonged drought that occurs frequently will result in crop failure, and even if we alter the structure of the agricultural ecosystem, high-value crops might disappear, and might be replaced by drought-tolerant crops with low nutritional value. Increased temperatures cause the dispersion of aquatic and marine resources, leading to reduced quantity and quality of coastal ecosystems. The rise in temperature causes land degradation, desertification and salinization of arid and semi-arid lands. Drought has affected the northern and central provinces, and has resulted in a depletion of the water level in rivers and lakes (Mai Hạnh Nguyên, 2008), which causes ecosystems more vulnerable.

According to an average global emissions scenario (B2), the average temperature will increase by 2ºC - 3ºC over most of country by the end of the 21st century (MONRE, 2012); annual precipitation increases by 2% - 7% in most of the territory, except the Central Highlands and South Central regions where the annual precipitation increases up to 3%; the 3 main groups of climate change impact on Viet Nam's ecosystems have been developed as follows:

If the average temperature increases by 2-3ºC over most of the country by the end of 21st century, significant increases of temperature, heat waves and prolonged drought will have effects on tropical forest ecosystems as forest fire risk is increasing, and grassland ecosystems will be destroyed due to lack of water. This problem commonly occurs in the Central region and the South. The dipterocarp forest ecosystem in the Central Highlands has been reduced significantly and is at risk of disappearing from this region. The total area of remaining dipterocarp forest is approximately 300,000 hectares, equivalent to nearly 1% of the total land area of the country. The area of evergreen closed tropical rain forest is also significantly reducing, with the total area in 2100 expected to be only about 650,000 hectares, or 1.9% of the total national land area, compared to 3.6% in 2000. The area of tropical moist deciduous semi-covered forest is 1.2 million of hectares covering 3.51% of current total land area, will reduced by 100,000 hectares by 2050 according to the scenario. In general, climate change will create favourable conditions for the growth and development of *Acacia* because of the increase in areas that are likely to have a climate suitable for it and the decrease in unsuitable climate areas. The climate-region suitable for *Acacia mangium* will increases and the most suitable period will be in 2020-2030. In general, the climate trends are suitable for the growth and development of *Acacia mangium*. Climate in the period of 2010-2030 is particularly suitable for the development of *pinus latteri*, but in the period of 2030-2050, the area of this forest type will reduce significantly. The climate region that is suitable for *Pinus kesiya* will increase and the more suitable region will decrease. (Phạm Minh Thoa, 2013).

Vietnamese scientists have found a close relationship between the rise of prolonged heat waves, environmental pollution and the development of coral off the coast of Quang Nam. Both hermatypic coral and soft coral cannot withstand temperatures above 29ºC, especially over prolonged periods. Thus, if the temperature increases 2-3 ºC, significant impact on coral reefs and its bleaching are expected.

Temperature increases and sea level rise which change the submerged depth are likely to have a strong impact on sea grass and mangrove. Thus, the degradation of coral reef ecosystems, sea grass ecosystems and mangrove ecosystems will increase by the end of this century. An example of the impact of increased temperature on coastal and marine area is the impact on sea turtles (Bernard, 2001). Due to the incubation temperature determining the sex of sea turtle hatchlings, the more the beach temperatures rises, a greater number of females will be produced.

In terrestrial ecosystems, a change in climate shifts the typical groups of plant distribution from lower altitudes (600m to 1,600m) to higher altitudes (700m-1,700m), in which the typical subtropical belt is 1,700-2,200m in the Hoang Lien Son Mountain range (Lao Cai province). Distribution of many plants has gradually shifted upwards to 600 m compared to previous records of distribution zones, such as the Fansipan spruce (*Abies delavayi* subsp. *fansipanensis)* which was concentrated at 2,000-2,400 m and now shifted to higher altitudes of 2,200-2,800 m; the Fansipan maple (*Acer campbelii* var. *fansipanense)* was common at the altitudes of 2,000-2,200 m and now shifted to 2,200-2,800 m; and the Evergreen Maple *(Acer oblongum)* which was common below 1,600m, now shifted up to 2,200 m (Truong Ngoc Kiem, 2014).

The total precipitation increases 2-7% over almost the entire territory, except the Central Highlands and South Central the increase is under 3%, and precipitation decreases in the dry season and increases in the rainy season. Heavy rain causes flash floods, mud and floods, and landslides lead to significant decrease in tropical forest areas, meadows etc. Drought with prolonged heat waves cause forest fire. Rice paddies and fruit trees are dying due to shortage of water causing cop failure. Climate change has reduced the soil nutrition to supply to agriculture and forest ecosystems.

In marine ecosystems, the increase in unexpected precipitations, wind, and storms leads to destruction of coral reefs and mangroves. Especially, due to the increase in storms and rain, mud and sand is transported from the mainland to the sea, covering coral reefs and sea grass beds. The northern coast and bay region have numerous large rivers with an annual total water volume of 190 billion m^3 and 180 million ton silt. The increase in rainfall in the rainy season combined with upstream deforestation lead to the quick accumulation of flood water in the rainy season. The large amount of fresh water that reaches the sea and coral reefs reduces the salinity and increasing turbidity, reducing the photosynthetic capacity of the symbiotic algae on coral significantly which leads to coral bleaching and rapid death on a large scale. Thus the impacts of climate change cause serious decline of important marine ecosystems (Võ Sĩ Tuấn et al., 2005).

Sea level rise will also induce strong impact on the coastal ecosystem. According to the average global emissions scenario, mean sea level is projected to rise in range of 57 cm to 73 cm in Viet Nam, with the highest sea level rise in Ca Mau and Kien Giang (62 cm to 82 cm), the lowest sea level rise in the region from Mong Cai to Hon Dau (49 cm to 64 cm); approximately 8% of forest and natural vegetation area may be flooded, of which 67.5% in the Mekong River Delta, 22.5% in the Southeast region, and 5.9% in the Northeast. The most seriously affected regions are mangroves in Ca Mau, Ho Chi Minh City, Vung Tau and Nam Dinh. With rising sea water levels, ecosystems in the region that are affected by the tide will gradually move towards the mainland, especially in Red river delta and Mekong river delta, the current fresh water ecosystems will move deeper into the interior. The area for aquaculture such as shrimp, crabs, clams and oysters will also move towards the areas which were previously freshwater areas.

Analysis in the coastal region of Ben Tre province, according to the climate change and sea level rise scenarios, shows that vulnerability in the coastal region can be ranked in descending order as follows: estuarine water areas (high vulnerability), mangroves (average to high vulnerability), tidal mud flat and sands (average vulnerability), and sand dunes (low-average vulnerability). Meanwhile, the vulnerability of livelihoods based on the ecosystems is classified as follows: fishing, inshore fisheries (average-high vulnerability), extensive/intensive shrimp cultivation (average-high vulnerability); clam nurseries, oysters (average vulnerability); crop cultivation (average vulnerability) (Lê Anh Tuấn et al., 2012).

As mean sea level rises, about half of the 68 wetlands of national importance in Viet Nam will be seriously affected; saltwater will penetrate deeper inland, killing many species of freshwater flora and fauna, affecting fresh water supply for households and crop irrigation in many regions, including 36 conservation areas of which 8 National Parks and 11 natural reserves in areas that are prone to flooding.

4.3.3. Impact on food systems and food security

Rice, sugar cane and maize (annual crops), and cashew nuts, coffee and rubber (perennial crops) are examples of Viet Nam's agriculture that will be affected by climate change according to the analysis below:

Agricultural production systems for national food and export vary by region, depending mainly on the ecological advantages, economic structure and livelihood characteristics of households in the region. As for rice, the Mekong River Delta plays an important role, accounting for 53% of the cultivated area in the country (Figure 4-14a) and a key role in food security, it has ecological advantages, provides the main staple food, creates jobs for rural people, and exports, but it also has a high rate of exposure and vulnerability to extremes and faces the highest sea level rise.

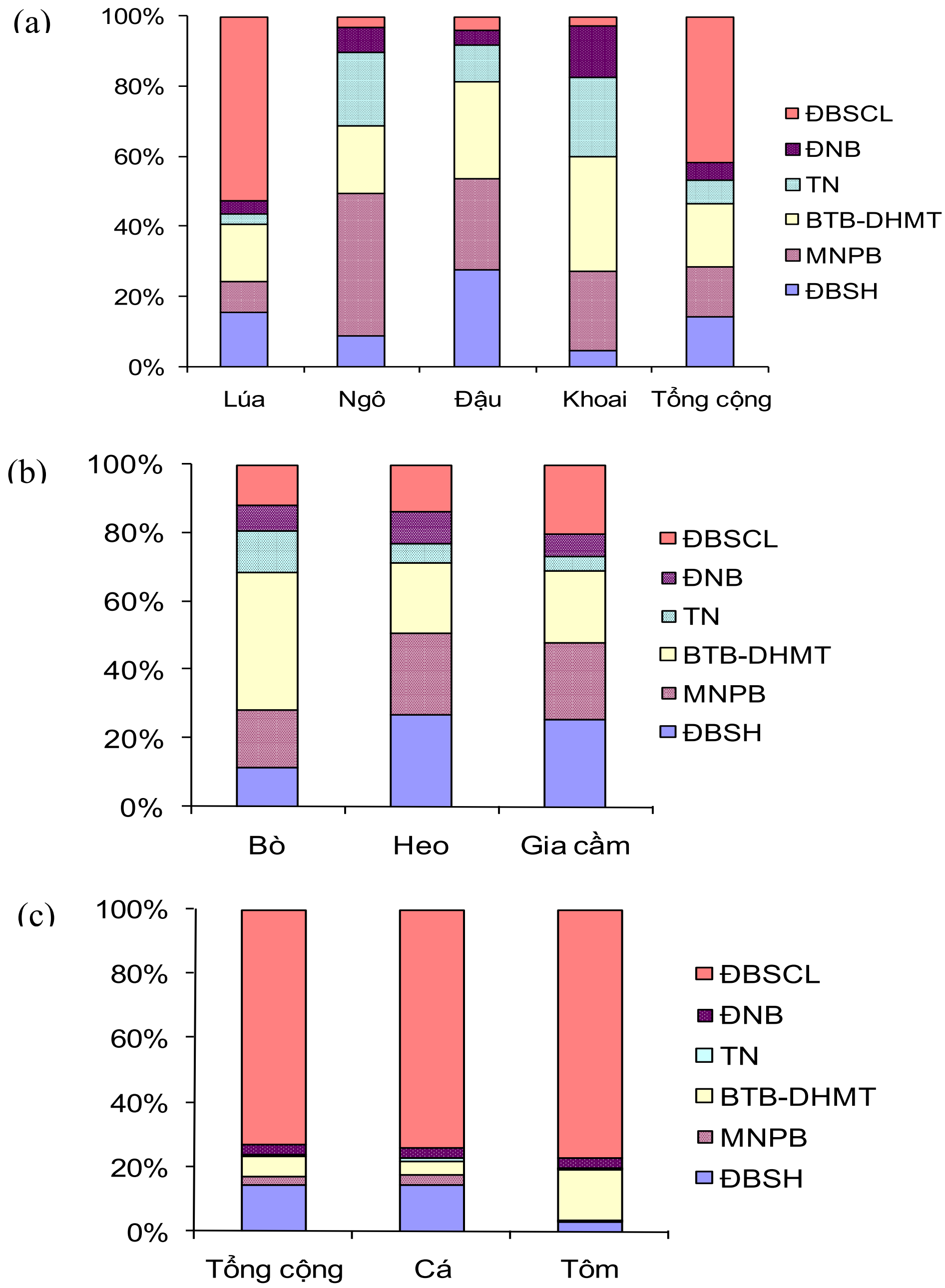
4.3.3.1. Food security

Current and future national food security is mainly based on agriculture production, especially rice. The area and productivity of cereals increased steadily over the period of 1995-2011 (Figure 4-15). In this period, the growth of cropped area (1.2%/year) and productivity (4%/year) of cereals (mainly rice, maize) and beans, resulted in an increase of production per capita of 3.7 %/year (Vũ Hoàng Linh and Glewwe, 2008), which was enough for domestic consumption and sufficient for export (mainly rice). In the total cultivated area and food crop production, rice accounts for about 90% of which 52% is from the Mekong River Delta. However, future agriculture production in general and food crop production in particular will face many challenges due to the increase in food demand, the effects of climate change, and the degradation of natural resources.

The national food security strategy of Viet Nam (Government of Viet Nam, 2009a) covers all the above factors and also pays attention to reducing the vulnerability and improvement of the lives of food producers – especially rice farmers. In particular, rice as the main staple food crop must ensure national food security (Table 4-5). However, disasters and climate change will likely affect agricultural production and food security.

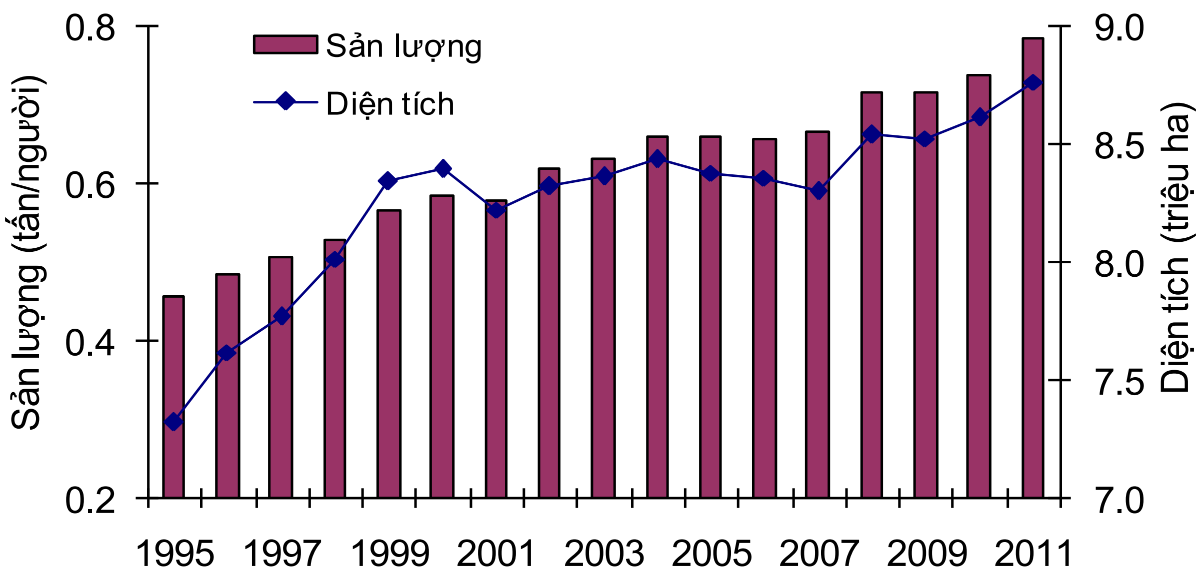
As presented in the previous sections, climate extremes are increasing and they damage ecosystems and reduce food production, which causes difficulty to access food. Without effective response measures to climate extremes, food security will be threatened seriously.

Figure 4-14. Area and production of the main agriculture products (%) by geographic region of Viet Nam



a: Area of food crops
b: Number of livestock and poultry
c: Production of fish and shrimp
ĐBSH: The Red river delta
MNPB: Midland and Northern Mountains
BTB-DHMT: North Central and Central Coast
TN: The Central Highland
ĐNB: The South East
ĐBSCL: The Mekong river delta
(Source: General Statistics Office, 2013)

Figure 4-15. Cultivated area and cereal yields in Viet Nam (1995-2011)



(Source: GSO, 2013)

Table 4-5. Targets of the National Food Security Strategy to 2020 with vision to 2030

Target	Area	Output/Quantity
Rice	3.8 million ha	41 - 43 million ton
in which, there are two crops on	3.2 million ha	
Maize	1.3 million ha	7.5 million ton
Fruit trees	1.2 million ha	12 million ton
Vegetable	1.2 million ha	20 million ton
Livestock (meat)		8 million ton
And milk		1 million ton
Aquaculture		4 million ton
Nutrition, access to food and livelihood		
Calorie consumption / person		2600 - 2700 Kcal/day
Malnourished children< 5 years old		< 5 %
Access enough food since 2012		100 %
Increase in farmers' income compared to 2009		2.5 times

4.3.3.2. Agriculture production to ensure food security in a climate change context

One issue of concern for agricultural development and food security in Viet Nam is to provide enough food containing adequate nutrition for everyone and especially poor households in rural and mountainous areas and ethnic people in the Northwest, Central Highlands and Central Coast region as well as the Mekong River delta, so they can escape from poverty sustainably (Beddington et al., 2012). However, disasters are a major obstacle to this process. Between 1976 and 2005, flooding and saltwater intrusion damaged 40,000 hectares of cropland and destroyed more than 100,000 ton food (Mai Văn Công et al., 2009).

Droughts have damaged 74,000 hectares of coffee (UNEP, 2000), caused water shortages for over 120,000 hectares of arable land, mostly concentrated in the Central Highlands, Ninh Thuan and Binh Thuan province. Drought leads to saltwater intrusion, particularly in the Mekong River delta, where the area of the cultivated land affected by saltwater intrusion is 676,000 hectares, or 40% of the total 1.7 million hectares of agricultural land. In the dry season, the area of Mekong River Delta affected by tides leading to saltwater intrusion can be nearly 1 million hectares (Nguyễn Thị Hoàng Anh et al., 2012; Wassmann et al., 2004; Đào Xuân Học and Hồ Thái Đại, 2005). According to a MARD report, 100,000 hectares of the total 650,000 hectares of high-yielding rice cultivated in the coastal region of the Mekong River delta are at high risk of saltwater intrusion during the dry season every year (MARD, 2011).

Climate change can impact directly and indirectly on agricultural production, possibly reducing agricultural productivity in Viet Nam by 2 -15 % (Zhai and Zhuang, 2009). Climate extremes such as floods, droughts, salinity, etc., can decrease rice production in Viet Nam by about 2.7 million ton per year in 2050 (Yu et al., 2010). Reduced rice productivity caused by climate change is different by region, for example, rice productivity could in 2050 be reduced by 4.3% - 8.3% in the Mekong River delta, 7.5-19.1% in the Red River delta, and the decline may be higher in the Central Highlands as production is dependent on rain. Mean sea level rise is projected to increase by 30 cm in 2050, and the rice area affected by salinity (>4g/l) in the dry season can reach 294,000 hectares with the current irrigation system and system operation (MONRE, 2009; 2012), leading to a decline in yield and cultivated area of rice and other crops requiring fresh water. Agriculture in the Mekong River delta and the North Central Coast region will be severely affected by sea level rise (Nguyễn Hữu Ninh et al., 2007). The exposure to sea level rise will be the highest for rice production and aquaculture; and will be high for industrial crops and livestock in Viet Nam. Furthermore, rice production accounts for 75% of cultivated area and uses about 60% of labour (Vũ Hoàng Linh and Glewwe, 2008), so climate extremes will cause significant damage to rural livelihoods. In the context of climate change, the expansion of the scale of production and export may be increasingly at risk due to the impact of the vagaries of weather and climate, especially climate extremes.

4.3.4. Impact on residential areas, infrastructure and tourism

The main impacts of climate change such as storms, floods, mud and rock floods, flash floods, landslides, salinity intrusion, drought, forest fires, coastal and riverbank erosion, sedimentation of estuaries, etc., strongly affect residential areas, infrastructure and tourism in all regions.

Impact on residential areas

Residential areas located in different climate and geographic regions of Viet Nam and share different exposures and vulnerability. The Northern delta region experienced 106 heavy rain events in the period 2001 to 2010, causing serious floods. The more than 100-year record precipitation in the North took place from the night of 30 October 2008 to 4 November 2008. This caused widespread inundation in Ha Noi, with 31,517 households flooded, and 4,439 households temporarily relocated. This heavy rain also submerged 12 communes with more than 120,000 people in Ninh Binh province. Flash floods caused by typhoon Damrey destroyed at least 1,194 houses and damaged 11,576 other houses in the higher areas. In 2010, the Central region was subjected to 4 historical floods damaging 6,000 houses, and nearly 500,000 houses and 300,000 hectares of rice and crops were flooded (CCFSC, 2012).

Drought happens frequently in the Central Highlands. In 2012, drought occurred in most regions and lasted continuously in the last few months of the year, which was different from what happened in previous years as Dak To, Kon Tum, M'Drak, Buon Ho etc. were areas suffering most from the severe drought (CCFSC, 2012).

The Southern region is one of 3 deltas most vulnerable to climate change as the terrain is lower than the expected sea levels, with many parts only 20-30 cm above mean sea level (Le Huy Ba and Thai Vu Binh, 2011). Floods and storm surges in 2000, 2001 and 2011 in the Mekong river delta damaged over 900,000; 350,000 and 177,000 houses, respectively (CCFSC, 2012).

Impacts of climate change are pertinent in urban areas, which have high density residential areas and are centres of socio-economic development of provinces, regions and the country. Over the past 10 years, the number of urban areas increased rapidly from 629 in 1999 to 762 in 2013, and the overall urbanization rate increased from 20.7% in 1999 to 31.5% in 2011 (Trần Thị Lan Anh, 2012). The urbanization rate in Viet Nam was forecast to reach 38% of total population in 2015 with 870 urban areas and 45% of total population in 2020 with 940 urban areas (Government of Viet Nam, 2009b), corresponding to 44 million urban residents in 2020. Without effective measures to respond to climate change in areas of high density of housing, welfare and infrastructure support in urban areas, vulnerability will increase considerably.

The five major cities directly under the central management, Ho Chi Minh City, Ha Noi, Hai Phong, Da Nang and Can Tho, as well as the entire coastal urban system are strongly affected by climate change. Floods have affected 47% of poor people in Ho Chi Minh City (ADB, 2010). Nearly half of the wards are regularly flooded with a total area of 110,000 hectares and 12% of the city population. Drought also occurs during 3-4 months each year, and was especially serious in 1993, 1998 and 2002. Urbanization is concentrated in peri-urban areas with low-lying land, where ponds, lakes and canals are filled up, which significantly reduces the water regulation function. About 72 % of the City's terrain is up to 2 m above mean sea level as the City is expanding towards the southern wetlands (ADB, 2010). The loss of water areas (lakes, ponds), reducing urban green area, as well as increasing building density is leading to temperatures in the City centre that are higher by 8-10 °C compared to average temperatures of the surrounding area, which affects human health as well as energy demand (Trần Thị Vân et al., 2011).

For example, Da Nang city in the Central Coast region is subject to severe disasters such as storms, floods, water logging, drought, salinity, river bank and shoreline erosion, which have led to significant loss of life and damage to property. In the period of 2005 to 2011, 14 typhoons made landfall near Da Nang, damaging 118,384 houses, flooding 28,423 houses and 3,657 classrooms, and destroying 26,623 hectares of forest. Prolonged drought in dry season months significantly affects agricultural production and water supply of the city. Erosion happens along the banks of the rivers Yen, Cu De and Vinh Dien and the shoreline in Ngu Hanh Son and Lien Chieu districts; in some places it extended up to more than 50m inland, causing houses to collapse and leading to a loss of residential and production land, property and means of production (DONRE Đà Nẵng, 2012).

According to the climate change scenarios (MONRE, 2012), there will be about 115 urban areas in Viet Nam, including category five cities and special cities that will be strongly affected by climate change, of which there are 21 coastal urban areas, 6 bay-side urban areas, 12 major riverside urban areas and 76 urban areas along smaller rivers and canals or low-lying urban areas (Trần Thị Lan Anh, 2012). The coastal urban and residential areas are most vulnerable areas to climate extremes.

Many poor migrant workers living in low-quality housing and low-income settlements are facing many significant barriers in their lives, such as access to land use rights, house ownership and services such as electricity, water and sanitation (UNDP, 2012) and therefore are highly vulnerable to climate extremes.

Impact on national infrastructure

Infrastructure includes transportation systems, electricity supply, water supply, collection and treatment of solid waste, housing and urban development works. These systems currently do not meet Viet Nam's urban development demands. Infrastructure designed for normal environmental conditions (excluding the impact of climate change and sea level rise), will not be sufficiently safe and does not meet future demand (Trần Thị Lan Anh, 2012).

Investment in urban water supply systems happens according to the town and city category. The total design capacity of water supply systems is 6.2 million m^3/day, and the rate of water loss is about 30%. However, the water supply systems meet only 70% of urban demand and 20-25% of rural demand (Trần Hiếu Nhuệ, 2011).

The water drainage (sewer) systems in Viet Nam are mainly are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in one system. The drainage system in urban areas are severely degraded, only meet 60% the drainage needs, and included 50% damaged sewers, 30% degraded sewers and only about 20% of new sewers in still good conditions (Trần Hiếu Nhuệ, 2011). Up to 2009, wastewater treatment plants had been built in six major urban areas including Da Nang, Ha Long, Ha Noi, Ho Chi Minh City, Da Lat, and Hue, with total treatment capacity of 380,000 m^3/day, compared to the daily wastewater volume of 4.3 million m^3. Thus, Viet Nam treated only 8% of the total waste water volume in 2009 (Albrecht et al., 2011).

Flash floods in Bat Xat district (Lao Cai province) in 2008 destroyed local water supply works (Mai Thanh Sơn et al., 2011). Water drainage systems in Ho Chi Minh City and Ha Noi are almost "paralyzed" during heavy rains (Trần Hiếu Nhuệ, 2011). In central provinces, typhoons with heavy rains affect the water drainage system, and especially water supply systems and environmental sanitation after floods. In Quy Nhon city, a typhoon in 2008 destroyed five water supply pipelines, and 2,900m of canals were eroded (IWE, 2010). In Hoi An city, salinity caused difficulties for supplying water, consequently the water intake in the Vinh Dien river for the water supply plant was shifted 10 km away from the plant (Trần Mạnh Liểu et al., 2011). In Hue city, during severe drought in 2002, salinity reached the Van Nien water plant causing its interruption from May onwards, and posing the risk of closing the plant (SDU-MOC, 2010). Da Nang city uses water from the Cau Do river but the surface water resources was salinized, therefore the An Trach pumping station was operated for prevention of salinity. In 2010, the water source was salinized in 52 days with the highest salinity level of 1.080 mg/l, and by 2013 the water source was salinized in 95 days with salinity up to 6,961 mg/l. The Cau Do river banks were severely eroded, which caused risk of damaging the pipelines of the Cau Do water plant. Due to drought and saline soils, Go Cong district had to build a water pumping station in Binh Duc (Chau Thanh) to receive freshwater, resulting in increased costs (Trần Hiếu Nhuệ, 2011). Climate extremes such as typhoons, thunderstorms and heavy rains cause damage to power transmission systems, urban lighting and power stations, resulting in power outages and increased cost of production and equipment repairs. Increasing temperatures, drought and hot weather lead to increased power demand, overload, damage to electricity supply equipment, reduced power generation efficiency of thermal power plants, and they cause water shortages for cooling systems. Climate change modifies the rainfall regime, hydrological cycle and river flows, and alters output of hydroelectric power plants. Drought also leads to the fact that many hydroelectric reservoirs store water below their design capacity which adversely affects electricity production. Heat waves increase water and energy demand, and create additional pressure on the related infrastructure. Drought in the period 1998 to 1999 caused the lowest level of drinking water and irrigation water supply in many provinces in the Central region.

The operation of solid waste collection and treatment systems is not efficient. Landfill is the main method used in urban areas, with 98 landfills nationwide, of which 16 are considered sanitary (located mainly in large cities), whereas others are not yet sanitary landfills. Viet Nam only has two solid waste-to-energy plants, which are Khanh Son (Da Nang) and Song Cong (Thai Nguyen). The waste collection rate in big cities is about 60-70%, and in small urban areas is 20-40%. There is still hazardous waste from industrial zones and hospitals, etc., that is not separated and treated appropriately, but is dumped along with other solid waste, turning landfills into sources of environmental contamination (Vũ Thị Vinh, 2012). Solid waste collection and treatment systems in many urban areas are affected by climate change. Waste collection points and also landfills within low-lying area are sometimes flooded. Heavy rains cause garbage to flow from collection points into streets, and waste water from landfills flows into surrounding residential areas, resulting in pollution. Floods affect daily waste collection, which increases environmental pollution and negatively affects public health, and thus increases vulnerability.

Statistical data show the effectiveness of infrastructure in terms of household access to basic services. In 2010, 90.51% of households had access to a clean water source, 75.66% of households used hygienic toilets, and 98.41% of households used electricity (GSO, 2011). However, these indicators are different and depending on urban category and region.

The country's transportation system includes roads, railways, waterways and air. The total length of highways is 14,790.46 km of which nearly 85% are surfaced. The total length of provincial roads is 27,700 km, more than 50% of which are surfaced. There are about 8,500 km of roads in urban areas of grade III or higher, mostly asphalted, with pavements and drains along the roads. Inner city roads and roads in residential areas are often much narrower than the main roads, with lanes and alleyways only 1-2m wide. The total length of the railway system is about 2,600 km with a density of 0.8 km/100 km2, including 6 main railway lines such as the Ha Noi – Ho Chi Minh City route with a length of 1,726 km. Inland waterways include the main rivers such as the Red and Da rivers in the North, the Tien and Hau rivers in the Southwest region and Dong Nai and Sai Gon rivers in the Southeast. The total length of all types of rivers and canals in Viet Nam is about 42,000 km. The main seaports are Hai Phong and Cai Lan ports in the North, Tien Sa and Quy Nhon ports in the Central Coast, and Sai Gon and Cat Lai ports in the South. There are 27 airports, including 8 international airports (World Bank, 2011).

The country's transportation is vulnerable to the impact of climate change. Between 2001 and 2005, climatic disasters caused the loss of 2,571 billion dong in the transport sector. The transportation system damage was estimated at around 100 million USD per year due to floods and landslides (Doãn Minh Tâm, 2001). According to the climate change scenarios of Viet Nam, if the sea level rises 1 m, over 4% of the railways, over 9% of the national highway system and about 12% of the provincial highway system will be affected. The Mekong River Delta's transportation system will be worst affected, including 28% of the highway system and 27% of the provincial highways. In the Central Coast nearly 4% of the highway system, nearly 5% of the provincial roads and above 4% of the railway system will be affected. In the Red river delta, about 5% of the national highways, more than 6% of provincial roads and nearly 4% of railways will be affected (MONRE, 2012).

Many important transport routes in Viet Nam are heavily and regularly affected by floods, such as Highways 1A, 14, 19, and the Ho Chi Minh Highway, as well as several highways in the Northwest region, the Central region and the Central Highlands (Lee and Nguyen Tu Dan, 2005; Doãn Minh Tâm, 2001; Lê Quốc Hùng, 2013; Nguyễn Đức Lý and Nguyễn Thanh, 2010; Nguyễn Hoàng Sơn, 2011; Nguyễn Thám và Phan Văn Trung, 2011; Vũ Ngọc Trân, 2011; VIGMR, 2005). The road systems in the mountainous Northwest region are frequently destroyed by landslides due to heavy rain (Đỗ Minh Đức, 2009; Doãn Minh Tâm 2001; Bùi Diệu Tiến et al., 2013; Chu Văn Ngợi and Nguyễn Thị Thu Hà, 2008; Doãn Minh Tâm, 2009). Road and railway works in the Red River Delta, Mekong River Delta, and Central Coast region are often flooded and damaged by floods and storm surges. The floods in December 1999 in Thua Thien Hue, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa provinces destroyed or damaged 1,073 bridges and sewers, 36 km of roads, and nearly 2 million m^3 of soil (due to landslides); the total damage reached VND 120 billion. 16,932 m of canals and two pumping stations were damaged, 6,000 m^3 of soil collapsed and 35 transport routes were flooded due to the floods in 2008 in Yen Bai province. The volume of mud on roads and in sewers along roads that had to be cleaned was 40,000 m^3, and nearly 700 m^2 of asphalted road surface was damaged (SDU-MOC, 2010).

A typhoon in 2010 damaged the Binh bridge in Hai Phong city; broke 80 electricity poles; destroyed 200 m of breakwater structures of the Hon Dau tourist area and sea walls along the eastern road Do Son tourist area; 6 m of fishing port embankment on Cat Ba island collapsed and 50 m of sea walls cracked; and in Cat Hai 20 m of road embankment collapsed and sea dikes were damaged (SDU-MOC, 2010).

In the period 1999-2008, disasters in Quy Nhon city damaged or destroyed 4,584 m of river and sea dikes, 49,710 m of road, 53 bridges and sewers (IWE, 2010).

Many regions and inner road were inundated to 0.5 to 1 m in Nha Trang city due to the floods of 2010, such as Hung Vuong, Tran Quang Khai, Nguyen Thien Thuat; and local traffic was congested (DOSTKhánh Hòa, 2013).

In the period of 2005-2011, typhoons caused landslides of 96,500 m^2 of road and 2,500 m^2 of dikes in Da Nang city (DONRE Đà Nẵng, 2011). Most houses in the old quarter in Hoi An city were flooded for 2-3 days due to the floods in 2009, within the 69 km^2 of inner city, 53% accounting for 47 km of asphalted roads and 20.7 km of concrete roads were flooded (Trần Mạnh Liểu et al., 2011).

Sea dike erosion happened seriously in My Tho city in the past 10 years, especially weak dike sections. Sea dike erosion caused the loss of protection forest by 8-10 m/year. The remaining protective forest belt is very thin; and some places are not protected by forest. Along the sea dikes in My Tho, 2,000 ha of protection forest were lost due to cavitation (SDU-MOC, 2010). Most of the districts in Can Tho city experience flooding during high tides or rainfall of more than 100 mm/day, inundating to a depth of 20-50 cm or even over 1 m, lasting between a few hours and a whole day, causing traffic jams. Landslides at the Tra Nieu bridge in 2010 caused bridge deformation, cracks in the concrete bridge foot, and it destroyed 30 meters of the approach road (SDU-MOC, 2010).

Heavy flooding in Ha Noi in 2008 affected many power transformers which afterwards were moved to a higher position (WB CRC, 2010). A major typhoon in 2006 destroyed or damaged communications systems and electricity infrastructure of Da Nang city: four switchboards were disconnected, the peripheral system was almost completely damaged; 75 power substations were damaged, 310 electricity poles were broken or had fallen, 35 km of medium and low voltage lines were cut (DONRE Đà Nẵng, 2011). In Quy Nhon city, typhoons toppled 8,630 m electricity lines over the period of 1999-2008, drought led to water shortages for the Song Hinh hydropower plant (IWE, 2010).

Houses and public buildings (offices, schools, hospitals) in urban areas are also strongly affected by climate change, as per geographical region. The population and housing census of 2009 showed that nationally 99.94% of all families have a house and 0.06% are homeless. In urban areas 99.93% families have a house and 0.07% are homeless while in rural areas the proportion is 99.96% and 0.05%, respectively. According to construction quality, 40.9% of houses in urban areas are permanent houses, 53.1% are semi-permanent houses and 5.9% are less-permanent houses. Paradoxically, the region most affected by climate extremes and sea level rise is the Mekong river delta but that is also the region with the lowest percentage of permanent houses. In urban areas, 17.4% of households have space of 6-10m^2/person and 4.8% households fall under 5m^2/person. In Hanoi, 30% of the population live in apartment that has space under 4 m^2/person and over 300,000 people live in a space of less than 2 m^2/person (World Bank, 2011). Areas with many less-permanent houses and small per capita living space, though permanent public works, hospitals, schools will be less adaptable to climate change, as homes are easily destroyed when facing storms, hurricanes combined with sea level rise. The quality of buildings affected by saltwater in the coastal zone is at risk of rapid decline. When public buildings and houses are destroyed this implies serious damage to people, property as well as repair and reconstruction costs. If the sea level rises by 1 m, then nearly 35% of people in the Mekong River Delta and over 9% of people in the Red River Delta and Quang Ninh province are directly affected, as well as about 7% of the population in Ho Chi Minh City and 9% of the population in Central coastal provinces (MONRE, 2012).

Impact on tourism

Viet Nam is one of the top 5 tourist destinations in the ASEAN region and 100 attractive World tourist destinations. Viet Nam has abundant natural resources for tourism and attractive cultural history, and it can offer many specialized forms of tourism, such as landscape tourism, ecological tourism, historical tourism, adventurous tourism, environmental tourism, community tourism, sustainable tourism, green tourism and even disaster tourism. Viet Nam has eight World heritage sites recognized by UNESCO. The Dong Van karst plateau (Ha Giang province) was recognized as a Global Geopark due to its special landscape. Viet Nam also has biosphere reserves that are unique for ecotourism, such as the Can Gio mangrove forest, and in Dong Nai, Cat Ba, the Red River Delta, coastal areas and islands in Kien Giang, Ca Mau, and the west of

Nghe An province. There are five marine protected areas: Nha Trang bay, Cham island, Phu Quoc, Con Co, and the Chua mountain. With a coastline of 3,260 km, Viet Nam has 125 small and large beaches with beautiful scenery, including 20 world-class beaches, which are ideal for resorts and luxury travel. Da Nang beach was voted as one of the six most beautiful beaches in the world by the Forbes magazine, and in October 2011 An Bang beach of Hoi An city (Quang Nam province) was ranked in the top 50 most beautiful beaches in the world (Tran Du Lich, 2011). Moreover, the richness of historical culture and traditions of 54 ethnic groups, and rice culture expressed through folklore, festivals, and cuisine facilitates the development of tourism. Viet Nam has five intangible cultural heritages recognized by UNESCO including: Hue Royal Court Music; the Space of Gong culture in the Central Highlands; Quan Ho folk songs; Ca Tru singing; and Southern folk music and Hoi Giong festivals (GSO, 2011).

The number of international visitor arrivals Viet Nam reached 34.6 million in the period 2001-2010, with an average annual increase of 9%. Beach tourism accounts for 70% of tourism revenue, as it attracts 60% of international visitors and 50% of domestic visitors annually (GSO, 2011). Tourism is vulnerable to environmental change, as most tourist destinations of Viet Nam are vulnerable to the impact of climatic extremes and sea level rise. Besides some positive effects such as extending tourist seasons due a reduction in the number of cold spells, climate and weather extremes have negative effects on tourism. Tourist spots and infrastructure are prone to flooding, erosion, degradation and sedimentation, even destruction by typhoons and rising sea levels. Rising temperatures may increase the risk of fire; damage public works; and increase the cost of cooling systems, food, water, and insurance of the potential risks of guests. Prolonged rain makes buildings susceptible to mould and devalues buildings and monuments.

Rainstorms combined with storm surge and sea level rise causes beach erosion, which may damage and narrow the beach or even totally loose beaches or destroy coastal monuments as well as tourist infrastructure. The Do Son beach’s erosion rate is 0.36-0.45m/year, and it is estimated that the beach will be 15-40% narrower over the next 50 years (DONRE Hải Phòng, 2012). Climate change also affects travel and can increase the time and cost of tourist programmes when changing or cancelling trips because of unusual disasters. Especially when means of transport such as trains and planes do not operate, travellers stranded in places affected by disaster face many disadvantages. Cruise tourism is also significantly affected by disasters as cruise liners cannot arrive as scheduled, and damaged seaports cannot meet operational requirements.

The tourism industry contributes greatly to the national economy and has a large workforce so the degradation of tourist sites caused by disasters also reduces incomes and can lead to job losses. Climate extremes also affect local resident’s livelihoods and their living conditions, potentially forcing them to migrate, which can lead to mixing culture, and degradation and loss of intangible cultural characteristics at tourism sites. When tourist spots are affected by flooding, sea level rise, biodiversity degradation or environmental pollution these spots lose their attractiveness, and the health and safety of visitors may be affected, causing a bad reputation and limiting tourism development.

The limestone karst caves of Ha Long bay, Huong Son, Phong Nha-Ke Bang have problems with falling and breaking of stones. Cat Ba, Ha Long and Long Chau Islands have unique and beautiful topography thanks to the cleft line, the caves under the foot of limestone cliffs, but the sea level rise will inundate these types of terrain and the unique mangrove landscape of tropical coastal zones could be lost. The ancient capital complex of Hue is inundated and experiences typhoons and tropical storms every year. The mossy ancient walls of Hue city are leaning as a result of whirlwinds, and the foundations of the walls were soaked which caused subsidence. The tourist villages along the Huong river were flooded with muddy water in the rainy season (SDU-MOC, 2010). Hoi An city's old quarter is inundated annually due to typhoons and tropical storms, leading to the gradual degradation and damage the 17th century architecture, at enormous repair costs. Hotels located in flooded areas have to move travellers and many travel programmes are cancelled.

Ecotourism and community tourism associated with village landscapes, mangroves and islands in coastal tourist areas are all affected by disasters. Rain associated with a typhoon in 2008 caused landslides in tourist areas such as Ghenh Rang, Quy Nhon (IWE, 2010). Monuments of the Cham culture such as the Nhan tower, the Ho citadel and the natural heritages like the Vang Cave and Lop Stone Roof of Phu Yen province are being ruined by climate change. The Cham pagoda towers are made of brick and stone but due to hot and humid weather, wind, rain and sea water vapour, the surface of these heritages is decaying. The Space of Gong cultural heritage associated with the human-ecological environment in mountainous districts in Phu Yen is gradually being eroded by the loss of the forest and residential areas of ethnic groups (SDU-MOC, 2010). The Khai Long tourist area in Ca Mau province has been closed after 5 years of operation due to erosion caused by sea level rise.

The impact of climate change on Viet Nam's tourist industry is becoming more severe because almost all coastal urban areas were exposed and vulnerable to climate extremes have been given the orientation to develop the tourist service-sector as a primary economic sector.

4.3.5. Impact on human health, safety and social welfare

Climate extremes such as storms, floods, heat waves, cold spells, and droughts strongly affect health, welfare and human security. These phenomena may induce enormous or unseen effects on public health, therefore, health, welfare and medical services and community safety must be taken into account. The phenomena of global warming, sea level rise, and the hole in the ozone layer, etc., have been affecting human health. Effects on health are indicated by the incidence of diseases and the number of deaths and injuries. In some instances, climate change works as a contributing factor causing respiratory, cardiovascular, digestive, neurological, psychiatric diseases; infectious diseases caused by water, air and insects or animals; accidents and injuries.

Global warming changes the annual temperature and season. In the North, the winters will be warmer, leading to changes in the bio rhythm of humans. Climate change increases the likely prevalence of tropical diseases such as malaria and dengue fever; accelerates the growth and development of many types of bacteria and insects, which are disease carriers; and increases the number of people with contagious diseases (Campbell-Lendrum và Woodruff, 2007). Disasters such as storms, storm surges, floods, droughts, heavy rains and landslides are increasing in intensity and frequency, so the number of deaths is increasing, and there are indirect effects on human health due to environmental pollution, malnutrition, diseases, the failure of population control plan and the failure of socio-economic development, reduction of employment opportunities and income from crops and livestock.

The impact of climate change on human health and safety in Viet Nam can be clearly recognized. Floods and water pollution have devastating consequences and can have effects on human health and safety. Injuries occur during floods and psychological consequences follow floods, natural disasters and economic decline accompanied by diseases associated with poverty such as malnutrition and infectious diseases. Floods also destroy health infrastructure, especially in the mountainous areas, so it reduces the ability to provide health services. Water pollution is not only caused by floods but also due to drought, leading to digestive diseases.

Increased temperature and heat waves: heat combined with drought is becoming more severe, and in many cases it has caused serious consequences on public health such as arising epidemics related to digestion and respiration, especially affecting children and the elderly, and also reducing labour productivity.

Compared with other regions, the South Central Coast region is particularly at risk of water shortages due to heat waves, as well as floods. Water shortage and water excess are both associated with gastrointestinal infections. Changing rainfall regimes impact on areas where malaria or dengue fever are endemic and they may spread to the vicinity as well as in areas that were previously without epidemics.

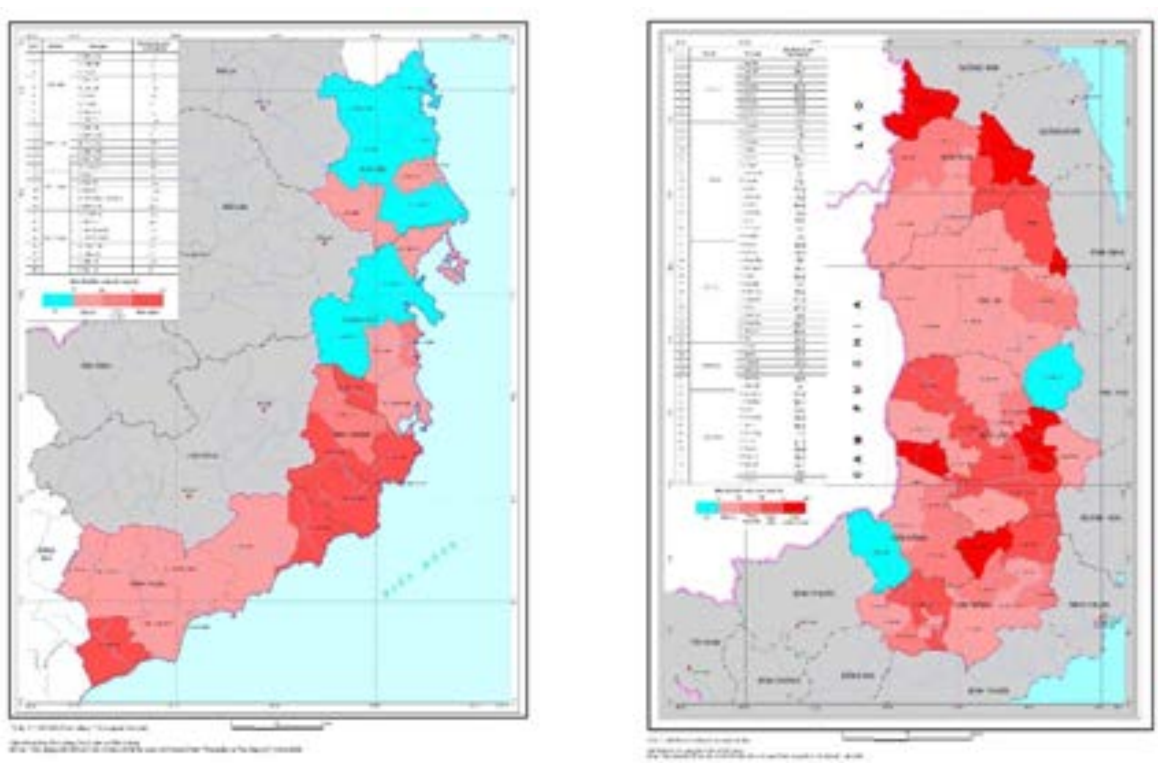
Cold spells may last for 10 days or even 15-20 days, and can lead to serious harm to public health, especially affecting the elderly, children and people with chronic respiration or bone diseases. Climate change can lead to extinction of some plant species, the appearance of new species may generate different types of spores, mould or pollen that can cause allergic reactions. Bird migration patterns can change and cause changes in the epidemiology of some diseases which can spread from birds (poultry) to humans. Ecosystems and fauna change can in turn cause the emergence of new biological agents and diseases (such as the virus causing SARS).

In Viet Nam, besides human losses due to disaster, it is difficult to find evidence of the adverse effect of climate change on public health, information on the consequences of health as well as inference from climate and weather regulation to health, so we could not calculate all the risks.

The consequences of climate change for health depend on adaptation and the ability to control and limit the impact on individuals, communities, and the nation (in many cases, health consequences are increasing but due to the medical activities there are improvements, so conventional statistical evidence shuggests that the consequences were reduced). Climate change and harm to health are always proportional. Poor communities, mountainous areas, the elderly, women and children groups are always more vulnerable to climate change. If we combine the above factors, we can identify groups of people at particularly high risks. The incidence of diarrhoea decreased from 12,369/100,000 people in 2000 to 9,588/100,000 people in 2010, with the highest morbidity rate in summer, from May to July (Nguyễn Thị Phương Liên et al., 2013).

The total number of children hospitalized between June and September due to the effect of heat waves on public health in Vinh city over three years (2010-2012) was 1.56 times higher when compared to the period from February to May in the same locality. Floods in the Mekong River Delta increases diarrhoea, skin diseases caused by contaminated water, flu, and diseases spread by mosquitoes (Few and Pham Gia Tran, 2010). Diarrhoea, skin and eye disease caused by exposure to contaminated floodwater also increased (Few and Pham Gia Tran, 2010; McElwee et al., 2010). According to the Viet Nam Ministry of Health, the increase of diseases is related to the change of climate, for example respiratory diseases, hepatitis B, rheumatism, typhoid, malaria and dengue (Hoang Xuan Huy and Le VanChinh, 2007; McElwee et al., 2010). During the floods in 2000, diseases such as diarrhoea, dysentery, typhoid, and dengue fever increased sharply. More than half the population are women, who were suffering from gynaecological diseases (UNDP, 2006). To prevent health consequences, there is a need for a health care system, social security and community safety. This currently weak system increases the impact of climate change compared to what the health sector could contribute. The Viet Nam Government is currently prioritizing support and investment in the health care system in the Mekong River Delta. Economic weaknesses play a fundamental role in health vulnerability: poor people have limited capacity to prevent and cure diseases (Few and Pham Gia Tran, 2010).

Figure 4-16. The level of water shortage in (a) the South Central region and (b) the Central Highlands



(a) **(b)**

(Source: Trần Thục, 2008)

Drought causes severe water shortage in the dry season in the Central Highlands and the South Central region, and affects the lives and activities of people (Trần Thục, 2008) (Firgure 4-16). During a prolonged drought, farmers in the coastal areas of the Mekong River Delta and in the South Central region have to buy drinking water for their daily needs with a high price. Because it is almost impossible to find a solution to the problem of drought, many young people have had to leave their family and rice fields and moved to the cities or suburbs to find jobs in industrial zones, which raises many other social issues.

Saltwater intrusion threatens biodiversity, and directly affects agriculture, aquaculture production, and freshwater ecosystems in the coastal parts of the Mekong River Delta. It also indirectly affects livelihoods and the local economy due to freshwater shortage whilst the demand for water is increasing under high population pressure, agricultural and aquaculture intensification, as well as industrialization and urbanization of the Mekong River Delta (Moder et al., 2012; Trần Anh Tú and Trần Đức Thành, 2008). Additionally, salinization also affects drinking water sources of people in coastal areas where there are no water supply systems. For example, in Long Dien Tay commune of Bac Lieu province, about 35-80% of households regularly use saline water (Đặng Kiều Nhân et al., 2007). The shortage of fresh water for household water supply will be exacerbated in the future by the impact of climate change, mean sea level rise and water pollution due to industrialization and urbanization (Trần Quốc Đạt et al., 2011; Kirby et al., 2010). Thus, the salinity adversely affects the health and life of communities, especially coastal communities in the Mekong River Delta.

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Chapter 5

Managing the Risks from Climate Extremes at the Local Level

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Executive Summary

In the last two decades, the changes of weather and disaster risk are fluctuating more than in the past, in many parts of the world and Viet Nam. Risk of disaster and impacts of climate change may be not at the same level across regions in terms of danger, destruction, exposure to hazards and vulnerability therefore the response at local level may be different [5.1]. In addition to regional differences, there are many other factors affecting disaster risk management (DRM) and climate change adaptation and to limit or enhance the ability of localities to cope with extreme climate phenomena. Limiting inequalities and ensuring that communities have access to support and basic services before and after the disaster is a necessary condition to enhance the adaptive capacity of communities [5.5].

When a major natural disaster occurs, the destruction can surpass the resilience of local communities and cause heavy losses. In such cases, the deployment of emergency relief is very important and urgent, and can be seen as a strategy to cope with disaster in the short term [5.2.1]. Evacuating and moving people to safe places before a disaster occurs, as well as the relocation or migration of people are measures to cope with disaster risk in many localities/provinces. However, the study of migration in Viet Nam due to natural disasters or other reasons are limited due to lack of survey data and statistical sociological data [5.2.2].

Land use planning considering the risks of natural disasters is an important adaptation measure to minimize the damage in the future. Ecosystems conservation is principally to protect people against extreme climatic phenomena, however, can be trade-offs with other valuable benefits for humans [5.3.3].

DRM and climate change adaptation in Viet Nam are carried out in the two directions, from the national level down to the local level; and simultaneously, the local level (districts and communes) reflects and reports to the upper levels (provinces, regions, areas) to adjust strategies, thereby helping this two-way relationship to work most effectively [5.1]. Institutions related to disaster management in Viet Nam today, there is the Central Committee for Flood and Storm Prevention and Control (CCFSC) and the National Committee for Search and Rescue (NCSR). These are the units responsible for directing and operation, with the functions of responding to and mitigation of disasters [5.4.1].

In order to strengthen the capacity of decision-making processes of local communities in terms of solutions to cope with natural hazards and other extreme weather phenomena that affect production in Viet Nam, the role of the People's Committee and organizations (such as the Farmers' Association, Women's Union, Veterans and Youth associations) and other social organizations at the commune/village levels play an important role as main partners in developing action plans [5.4.2]. These organizations are very important in sharing and helping each other in difficult situations [5.4.3] and in capacity building through training, teaching or reforming institutions in localities [5.4.5].

Along with the application of scientific and technical advances, local knowledge has a key part to play in the lives and production of local people. Promotion of local knowledge and combining that with scientific knowledge must be applied in an appropriate manner during the process of socio-economic and cultural development [5.4.4]. The initiatives that are based on the experiences and the best practices are also important. For example, the motto

of “4-on-the-spot” has proven to be effective and meets the requirements of the local community [5.4.5].

In Viet Nam, DRM and climate change adaptation were and are integrated into national development strategies and plans. Community-based adaptation to climate change has been deployed in Viet Nam and is backed by the Government. Most provinces have developed their action plans to respond to climate change, which refer to the integration of climate change into socio-economic development plans of the localities [5.6.1].

5.1. Introduction: why local level management of climate extremes is important

Viet Nam is one of the countries severely affected by natural disasters and extreme events. Natural disasters in Viet Nam are a barrier to economic growth, sustainable development, and poverty reduction, are the major impediment for the country's development goals. About 59% of the total land area of Viet Nam and 71% of the population are at risk of storms and floods (World Bank and GFDRR, 2010). The total estimated damage due to storms, floods and drought in Viet Nam for the period 1995-2006 was VND 61,479 billion, not including massive loss of lives, infrastructure and effects on livelihoods (ADPC, 2008). In the “Global Climate Risk Index 2015”, Viet Nam was ranked seventh in the world regarding climate risks over the period 1994-2013 (Kreft and Eckstein, 2013).

Disaster risk management (DRM) and climate change adaptation in Viet Nam are carried out in the two directions, from the national level down to the local level; and simultaneously, the local level (districts and communes) reflects and reports to the upper levels (provinces, regions, areas) to adjust strategies, thereby helping this two-way relationship to work most effectively (CCFSC, 2009). Local levels related to natural disasters or extreme phenomena in this report regions, provinces/cities, districts, communes/wards and villages/ hamlets. For provincial and lower levels, many studies were conducted focusing on the dangers and typical extremes (DIPECHO-DANI, 2007, WRD, 2010; World Bank, 2010a). The issues related to natural disasters and extreme events due to climate change should be studied at different levels, outlining a comprehensive picture of regional, provincial to district, commune and village levels. Besides, there should be a connection between national and sub-national levels in two directions, to assess, respond to and support when disasters/extreme events occur. The Law on Disaster Prevention and Control of Viet Nam emphasizes basic principles of disaster prevention, such as being proactive, timely response, expeditious and efficient recovery (National Assembly, 2013). Active prevention has been considered important for the community to prevent, avoid, and mitigate damage when a disaster happens.

Chapter 5 presents the importance of state agencies, the social and political organizations and local communities in DRM. Each locality is exposed and vulnerable to certain risks. The disaster risks are not identical in nature, intensity and frequency in each locality. Therefore, DRM is also different in each locality. This chapter focus to discuss three topics including:

(i) How to manage the risks of current disasters;

(ii) The impact of extreme weather events on human security at the local level; and

(iii) The ability to respond to, adapt, and mitigate vulnerabilities, and manage disaster risks and climate extremes at the local level.

5.2. Responding to disaster risk at the local level

Current mechanisms to deal with disaster risks in localities focus on three solutions: (i) emergency assistance and disaster relief, (ii) population movements, and (iii) recovery and reconstruction. Each strategy will be discussed in a section below.

5.2.1. Emergency sssistance and disaster relief

Humanitarian assistance is often required when other measures to reduce disasters have been unsuccessful, and plays a critical role in helping local people cope with the effects of disasters. Such relief often helps to offset distress and suffering at the local level and to assist in recovery and rehabilitation. There are many different support ways within the communities, such as neighbours, local rescue teams or the local force, and local authorities. When a disaster occurs, the use of local forces available to rescue, support is the fastest and most efficient way. The local force is usually militia, civil defense, youth groups, shock teams, the military forces based in the area. The local force implements emergency response such as assisting with evacuating people from risky areas to safe shelters; participating in search and rescue work; and ensuring the provision of logistics services, in such as food, clean water, medicine, etc., and overcoming the consequences of natural disasters such as sanitation, disease prevention, and providing assistance to affected families (JANI, 2011). An example is from Quang An commune, Quang Dien District, Thua Thien Hue province. The commune has a “shock team” consisting of 32 members guided by the district level Red Cross on rescue. Shock teams of 10-20 young people have been formed in all villages. These forces have operated very effectively in recent years, for example in response to typhoon Ketsana in 2009 (JANI, 2011). At the provincial level, the provinces quickly provide rice for emergency relief immediately after each flood. For example, Thua Thien Hue province has allocated 300 tonnes of rice to timely relief to hungry families in the aftermath of typhoon Xangsane, also known as typhoon No. 6 in 2006 (Thua Thien Hue, 2006).

When the worst natural disasters occur and the destruction surpasses the resilience of local communities, then external relief is very important and should be done in a timely and effectively manner. Disasters cause loss and damage to property, infrastructure, and casualties, and there are post-disaster consequences of environmental pollution, disruption of livelihood activities, diseases and injuries and the psychological impact on people. Therefore, national and international resources must be mobilized quickly and effectively. In order to have a basis for emergency assistance to disaster risks, the effects of disasters must be promptly assessed at the commune and the district and province level (through the steering committee of flood prevention at all levels), collecting statistical data about the loss of life and property and socio-economic impacts. Based on this, sub-national levels develop relief proposals. The proposals must be specific in terms of number of people, objects and areas that need emergency relief items such as food and medicine, or how many additional military forces and social organizations need to be mobilized to support local people to respond, etc. Based on the reports of the sub-national levels, the central Government will make decisions on emergency assistance to the sub-national levels. For example, in the case of typhoon Linda (typhoon No. 5, 1997), the Government allocated VND 100 billion from the state budget, of which VND 50 billion for disaster relief and VND 50 billion to recover health and education facilities, (Thủ tướng Chính phủ, 1997). In addition to the emergency relief effort from the state budget, social charitable organizations provide relief in many different ways (for example, Buddhist monks from temples, philanthropists who are traders, or companies, etc.) and help affected people directly to solve urgent problems such as provision of food, money, books, water, etc.

International relief focuses on solving problems related to the medium and long term livelihoods and is often conducted through local and international non-governmental organizations. These organizations must also develop proposals based on data from disaster impact assessments by localities and data from their own local assessment. The information required for proposals includes the situation of: (i) housing, (ii) employment, (iii) livelihoods, (iv) water and sanitation, (v) education facilities, (vi) information dissemination, (vii) child protection, and (viii) the needs of the affected communities. Based on the results of the assessment, specific practical solutions will be proposed, such as providing cash, clean water, essential utensils and water, support counselling, monitoring market prices as well as the continued assessments of livelihoods after the disaster to determine interventions on livelihoods (Oxfam et al., 2006). For example, Oxfam, World Vision and UNICEF helped people in Ninh Thuan province to cope with drought through the provision of food, water, containers, seeds and rehabilitation of water sources (Oxfam GB et al., 2005). After the double floods in September – October, 2009, in order to provide additional support for the province to respond to the floods, Oxfam Hong Kong implemented the project "Humanitarian Aid to Flood in central Ha Tinh province" (Oxfam, 2011) with a budget of US$ 669,480, aiming at "reducing the effects of flooding in the districts most prone to risks and most damaged in Ha Tinh province" through the provision of essential supplies directly to victims affected by the floods, in particular by: (i) cash, (ii) water supply facilities, (iii) hygiene and public health, together with (iv) support to help restore the lives and other activities.

Emergency assistance and disaster relief often plays a critical role in helping local people cope with the effects of disasters in the short term (IPCC, 2012). However, relief cannot cover all the damages caused by natural disasters, therefore, in many cases insufficient relief reduce the resilience to disasters, resistance and community sustainability. Not all disasters engender the same response, as local communities receive different levels of assistance. Relief cannot be the same for all villages and households that are affected by natural disasters. In many cases, disaster damage and relief needs are assessed differently by local authorities and non-governmental organizations. For example, Oxfam supported farmers in some villages in Kon Tum province after the typhoon Ketsana. The villages where the Dak Glei district People's Committee had determined to be focus were not the ones that Oxfam selected. Upon investigation, Oxfam found that households selected by the People's Committee were not strongly affected and did not suffer truly from typhoon Ketsanam (Saul, 2009). In order to determine the actual damage caused by a typhoon, Oxfam adopted a mechanism for collecting and processing the feedback from beneficiaries and non-beneficiaries and the local authorities, through various channels such as community meetings, field trips, interviews and hotlines. Information is shared and disclosed to ensure this mechanism works well. (Oxfam International, 2011). However, there are still many limitations in promoting the participation of women in decision making process on the subject of selecting storm affected people (Oxfam International, 2011). Thus, relief may also cause disunity in the communities because of the determination of the extent of damage and because the relief is focused on the poor. The poor can get relief from many different organizations, while the near-poor households may be excluded from the relief list.

5.2.2. Population movements

Population movements occur before, during, and after some disaster events. Depending on the nature of disaster, population movement is different. The following are common types of population movements related disasters in Viet Nam:

a. *Emergency evacuation from disaster affected areas:* areas with a high risk of flash floods, landslides; residents in flood drainage corridors of rivers and streams. The climate phenomenon hits suddenly, especially extreme climate phenomena such as whirlwinds, typhoons, and floods lead to evacuation. For example, to deal with typhoon Damrey (storm No.7 2005), Hau Loc district (Thanh Hoa province) evacuated 29,000 residents in the 3 days before the storm (from 24 to 26/9/2005) to strong, multi-storey concrete buildings within villages, schools, and the administrative centre of the district (JANI, 2011). Similarly, the evacuation of 60,000 people (16,000 families) in Quang Nam happened in time before storm No.9 (Ketsana) at the end of September 2009, which minimized the damage to people and property of the people and government. Approximately 2/3 of the population was evacuated in Quang Nam folloing the motto of "local evacuation, interspersed evacuation", which fast, effective and convenient - evacuated from non-permanent to permanent houses, evacuated from the coast to higher zones. Some were moved further away with the help of the army, such as the people from Tam Thanh commune who were evacuated to schools in Tam Ky city center. (JANI, 2011).

b. *Resettlement from disaster risk prone areas to residential clusters.* In the context of migration in Viet Nam, Government's resettlement program must be mentioned. The current resettlement program is diverse and includes resettlement of people exposed to natural disasters, especially extreme events and other forms of environmental degradation (e.g. river bank erosion). The Living with Floods Program in the Mekong Delta was implemented as an adaptation strategy and was renewed several times, including construction and improvement of residential clusters. Resettlement to residential clusters had positive effects: the disastrous flooding in the Mekong Delta in 2000 killed 539 people, but the flood level in 2011 was similar to the level in 2000 and yet it killed only 69 people, which is partly due to the resettlement to residential clusters. A relocation program for people in areas at risk of landslides in the Northern mountainous provinces has also been effective. However, resettlement itself however can also be problematic, with weak planning, a lack of transparency and financial accountability, and limited community participation, while resettled households face many difficulties such as debt, lack of jobs and income generation opportunities (UN,

c. *Spontaneous Migration*: reasons for people to migrate could be poverty, crop failure, natural disasters and climate change, depletion of environmental resources and social factors. Slow-onset climatic phenomena, such as repeated drought, desertification, coastal erosion, and sea level rise, tend to affect a large number of people, impacts on livelihoods and may trigger permanent migration. The relationship between migration and climate change is complex. Migration can be regarded as an adaptation measure, create new opportunities and livelihoods and increasing resilience to the adverse effects of environmental pressures and climate extremes. It can also be a long-term adaptation measure, especially to respond to slow-onset climate change phenomena and environmental degradation (UN, 2014).

In general, the outcomes of migration and resettlement could be positive or negative. They could create new opportunities and livelihoods and increasing resilience, but also create new vulnerabilities, especially for the poor and vulnerable. Research implemented by Lê Anh Tuấn (2010, 2011a) showed the potential relationship between disasters-climate change, resource degradation, poverty and migration in the Mekong Delta (Figure 5-1). The phenomena of natural disasters, rising sea levels, saltwater intrusion, flooding and erosion reduce the area of land for cultivation, cause lack of food, housing and reduce natural resources. As a result, many poor people living in rural areas and coastal areas are vulnerable to the events, which force them to have migration plan. Migration can be both temporary and seasonal migration to settlements where migrants can find a job and long-term livelihood. The wave of migration from rural to urban areas, from provinces in Northern and Central Viet Nam lead to the fact that cities in the South such as Ho Chi Minh City, Bien Hoa, etc. become overloaded and increase the growth of pollution, unemployment, traffic congestion, and even crime. However, a failure to adapt to urban life makes some migrants return to the countryside. This group then will exploit the limited resources left there, causing an increase of ecological risk. These factors make threats of natural disasters and climate change more severe and rural poverty can become entrenched.

Figure 5-1. The Relationship between Climate Change - Resource Depletion and Migration

(Source: Lê Anh Tuấn, 2010)

5.2.3. Recovery and reconstruction

The Government of Viet Nam pays attention to reconstruction and rehabilitation after a disaster. Right after a disaster, many relief advocacies have been done to help restore production and promote the reconstruction of local infrastructure. The Law on Disaster Prevention and Control (National Assembly, 2013) states clearly the provisions regarding overcoming consequences of natural disasters in the Section 3. In the documentation for flood prevention in the Mekong Delta also mentioned remedial phase and reconstruction work are needed to be done for local authorities (WRD, 2010). The domestic and international non-governmental organizations are also interested in supporting communities to rebuild after disasters. For example, after typhoon Ketsana (2009) the International Federation of Red Cross and Red Crescent Societies (IFRC), the Viet Nam Red Cross (VNRC) and the Development Workshop France (DWF) built 650 anti-storm houses in 7 provinces in Central Viet Nam (Thanh Hoa, Nghe An, Ha Tinh, Quang Nam, Quang Ngai, Kon Tum, Gia Lai provinces) (IFRC et al., 2010). The "Rehabilitation and Reconstruction after typhoon Ketsana" project (Plan and World Vision, 2010) with total budget of US$ 1.1 million was implemented by the PLAN Viet Nam and World Vision Viet Nam in Quang Tri, Quang Nam, Quang Ngai and Kon Tum provinces. The program provided roofing and building materials for 441 families to repair and build new houses; provided school supplies, toys, furniture for more than 5,000 students; and repaired classrooms in the four provinces. In addition, about 20,000 families were assisted with seeds and fertilizer to re-start their winter-spring paddy rice crop which had been devastated by the storm. Oxfam repaired bridges and 500 km of rural roads in the province of Kon Tum to help children go to school safely (Oxfam International, 2011).

An important issue in reconstruction and rehabilitation after a disaster is a clear distinction between the reconstruction process and its results (IPCC, 2012). Regulation of grassroots democracy creates an important prerequisite for local people to participate in the resettlement programs, which means that the affected people should be provided with sufficient information, be involved in the discussion, be consulted and monitor the implementation of local projects (UN, 2014). However, this regulation has not been widely implemented in the process of recovery and reconstruction after disasters.

Post-disaster stability, recovery and reconstruction are essential and must be considered as one of the measure to minimize the damage and the disruption of socio-economic activities. Reconstruction and rehabilitation after the disaster must prioritise vulnerable groups in the community, especially children, women, the elderly and people with disabilities. Community health are also a focus in reconstruction and recovery phases, but the effectiveness of related programs is not yet high. Qualified staff in health clinics are limited, so the sick at local level still choose traditional village healers instead of the clinic (Oxfam GB et al., 2005).

Besides the reconstruction and rehabilitation of infrastructure, livelihood recovery is very important for the community. Livelihood recovery in affected communities has mainly been the concern of the non-governmental organizations in Viet Nam (DRAGON Institute et al., 2013). In addition, there are types of natural disasters such as drought, cold weather damage, which do not have direct impact on infrastructure but they seriously affect the livelihoods of the people. For example, the project “Sustainable Livelihood Development and Ethnic Minority Diversity in Lao Cai Province” supported by Oxfam UK helped build and maintain the integrated disaster model (floods, landslides, drought, cold damage) in agricultural production (DONRE Lào Cai, 2011).

In addition to the natural disaster response measures mentioned above, the risk-forecasting issues and community capacity building also require attention at the local level. These issues are discussed further in the next section of this chapter.

5.3. Anticipating and responding to future disaster risk

There are many approaches on the subject of responding to future natural disasters. This section will analyse communicating risk (section 5.3.1), structural measures (5.3.2), land use and ecosystem protection (5.3.3) and storage and rational use of resources (5.3.4).

5.3.1. Communicating risk

5.3.1.1. Message design

Viet Nam has message templates for extreme weather warning for typical cases. The Central Steering Committee for Flood and Storm Prevention and Control (CCFSC) (CCFSC, 2012) issued 16 templates for documents and reports. The provincial Committees for Flood and Storm Prevention and Control (CFSCs) and the Committees of Search and Rescue (CSRs), under the Provincial People's Committee, use the templates to issue reports through the media and send to competent authorities.

5.3.1.2. Modes and timing of risk communication

The agencies responsible for the study of meteorology and hydrology, weather forecasting and disaster management in Viet Nam have applied multiple mathematical models for weather prediction and disaster warning, to increase the accuracy of the forecasts. Local agencies also apply models for weather forecasting and disaster warning for their region, such as the flood forecasting model for the Red–Thai Binh River system (Hoàng Văn Đại và nnk, 2013, pp 41-48); the flood forecasting model for the Mekong delta (Nguyễn Việt Hưng, 2013, pp 112-117); flood and inundation warning and forecasting technologies for the Ba river basin (Đặng Thanh Mai và nnk, 2013); and reservoir system operation methods for real time flood control in the Vu Gia - Thu Bon river (Tô Thúy Nga và Nguyễn Thế Hùng, 2013).

The weather forecasts are reported daily in mass media such as newspapers, radio and TV. News related to natural disasters is provided more frequently. According to Prime Minister Decision 133/2009/QD-TTg (Thủ Tướng Chính Phủ, 2009a), natural disasters at sea that require warning include tropical depressions, storms, tsunamis, strong winds, strong thunderstorm, fog, and high waves. Additionally, the Ministry of Natural Resources and Environment (MONRE, 2011) issued Circular No. 35/2011/TT-BTNMT detailing the implementation of the regulation on announcement of tropical depressions, storms, and floods. There are many studies to prolong the forecast lead-time to help people and industries have more time to prepare well, as methods exist for 5-day rain forecast or flood alert for a longer range forecast (Tô Thúy Nga và Nguyễn Thế Hùng, 2013, page 33). The Weather Forecast Bulletin was extended from 24 hours up to 48 hours ahead and agencies experimented with forecast up to 72 hours ahead (Công Thanh, 2008). Through the media (newspapers, radio and TV), forecasts of the northeast monsoon, widespread heavy rains and hot days are predicted 1-2 days in advance and forecasts of extreme and damaging cold weather has been announced 2-5 days in advance. Weather prediction for a longer forecast duration has been achieved with higher accuracy compared to before.

5.3.1.3. Information and early warning systems

Information plays an important role in warning of impending hazards, particularly for putting local responses in place and evacuating people, moving goods and securing houses and construction works or blocking off areas. Providing timely risk information helps to mitigate the damage to lives and property and the quick recovery of socio-economic activities. Information and Early Warning Systems (IEWS) are among the most important measures to reduce damage to people and the economy by floods, droughts, storms, forest fires, and other hazards. Early warning systems are effective with the synchronous coordination from central to local levels along with appropriate policies, and will bring positive changes in disaster prevention. However, although there have been efforts to improve monitoring and forecasting equipment and software, as is the case for the Mekong river, the accuracy of predictions still remains limited because of uncertainties in the collected data (Erich and Thanongdeth, 2002).

Viet Nam has recently paid more attention to early warning of natural disasters, including short and long-range forecast. The Law on Disaster Prevention and Control (National Assembly, 2013) also affirmed the importance of information and early warning of natural disasters. However, early warning systems rely on the weather forecasts, which must provide short-range warnings with enough time to be able to deploy emergency prevention actions. Although it reduces damage to lives, people's livelihoods are still significantly affected, especially weather-dependent livelihoods such as agriculture and fishing.

Warnings with full, accurate, timely and consistent information play an important role in preparedness and mitigation of damage to the community. Annual and seasonal short-range forecasts and longer-range warnings in the context of increasing disaster are important and necessary, contributing significantly to improving the prediction of extreme weather phenomena and climate (Phạm Văn Tân, 2010). However, seasonal forecasts are usually presented with probability and averages for a specific area within a certain period, and they are less likely to forecast extreme events. Warnings of phenomena that accompany a storm such as heavy rain should be included in storm forecasting. For example, warnings of heavy rain during or after a storm will support timely evacuation and flood prevention, especially in areas prone to flash floods. Wrong or inaccurate forecasts and warnings can cause dangerous impacts, especially in the case of typhoons, floods or landslides. Inaccurate forecasts may lead to the situation that affected areas receive no warnings for preparedness while non-affected areas prepare unnecessarily to respond to the impact. The warning information must be communicated directly to citizens and stakeholders in an appropriate and timely manner. Depending on the target audience, suitable language must be used to convey information. Apart from the conventional media like local TV and radio, the local armed forces and other on-site teams can provide information directly to local people. Some of the “shock forces” have been equipped with portable speakers to do this work, but some others have not yet been equipped. In addition, through verbal communications, people can access weather warnings easily and remember well. Verbal communications take place between buyers and sellers in markets and among people in other public areas. The media should be promoted in order to maximize information access by multiple audiences, especially the elderly, people living alone, women and children who have fewer opportunities to watch TV or listen to radio, etc.

The coordination of flood discharge from reservoirs with flood forecasting, and flood control guidance by the Ministry of Natural Resources and Environment is noted, for example the multi-reservoir flood discharge procedure on the Ba River (Thủ Tướng Chính Phủ, 2014a); the multi-reservoir flood discharge procedure for A Vuong, Dak Mi 4 and Song Tranh 2 reservoirs in the annual flood season in the Vu Gia - Thu Bon basin in Quang Nam province (Thủ Tướng Chính Phủ, 2014b); or for Son La, Hoa Binh, Thac Ba and Tuyen Quang reservoirs in the flood season (Thủ Tướng Chính Phủ, 2014c). However, operating procedures have not yet been implemented in most hydro-power systems and only focus on the flood season, whilst not many water-discharge operating procedures have been developed for the dry season to prevent drought and salinization.

5.3.2. Structural measures

Vietnam attaches great importance to the construction of works and building of management systems and institutions for disaster prevention. The goal of the structures is linked to the national socio-economic development plan and particularly that of the localities. Flood prevention is considered a basic requirement of all forms of development. More specifically, in the development plans, the upgrade of sea and river dykes to reduce the damage from floods is emphasized. Structural measures for flood mitigation including maintenance, upgrading and replacement of old dykes as well as flood control structures and reservoir systems (UNDP, 2005). The dyke systems help protect the lives, property, infrastructure and production of the people, but also negatively affect soil nutrients and water inside the dyke. (Pilarczyk and Nuoi, 2005). If the flow regime in the upstream declines due to drought or expanding of irrigated areas and especially the inappropriate operation of hydroelectric dams in upstream riparian countries, salinity will incurse deeper into the Mekong Delta (Dat et al., 2011; MRC, 2010; Woodroffe et al., 2006). In addition, flood control systems in the Mekong Delta also significantly change the flood dynamics, leading to problems such as increased water level and velocity in the lower provinces such as Can Tho city (Birkmann et al., 2012; Hoa et al., 2007, Tri et al., 2012), causing negative impacts on the ecosystem of the floodplain. Moreover, the planning and construction of roads without careful consideration of impact on river flows also cause problems like erosion, water congestion in the rivers, streams and downstream channels (Douven et al., 2012).

The height and strength of the flood control dyke system are also very important, especially when extreme flood occur. In recent decades major floods occurred regularly in the whole country and there is a growing trend both in number and intensity of floods, including in the Red–Thai Binh River system, where in the last 60 years four major floods occurred, in 1945, 1969, 1971 and 1996, with flood levels over the dyke design level in Hanoi by 0.7m to 1.5m. Design flood level and design flows for dyke construction should be determined on the basis of forecasts of extreme events. For example, according to the strategic development orientation on water management in Viet Nam (Thủ Tướng Chính Phủ, 2009b), the design probability for Hanoi city up to 2020 is 0.2% (events with a 500-year return period). The authorities of Can Tho city became aware early on that risks could become similar to those in big cities like Hanoi, Ho Chi Minh City and Bangkok. An Urban Water Management Plan was proposed, including the "Viet Nam - Mekong Delta Region National Urban Upgrading Project: Can Tho city sub-project" by the World Bank and the People's Committee of Can Tho City (World Bank và Uỷ ban Nhân dân Thành phố Cần Thơ, 2003); a research project was implemented on sector based salinity thresholds for Can Tho city (Lê Anh Tuấn, 2012a); as well as a flood prevention research project (Viện Khoa học Thuỷ lợi miền Nam, 2013); and a proposal was made on surface water management in Can Tho City (Viện Khoa học Thuỷ lợi miền Nam, 2014).

Besides dykes, the structural measures also include other flood prevention infrastructure. This includes flood-resistent houses and shelters that non-governmental organizations in Viet Nam are helping communities to build in seven different provinces (IFRC et al., 2010), and urban drainage systems and reservoirs. However, there are downsides to flood prevention measures, such as embankment projects that prevent floods in one area may cause flooding elsewhere, or create environmental consequences, such as the dyke system in the Mekong Delta (Dương Văn Nhã, 2005).

5.3.3. Land use and ecosystem protection

Changes in land use not only contribute to climate change related disaster risk reduction but they help communities to respond to economic, policy, and environmental change. Changing land use can facilitate mitigation and DRM (IPCC, 2012).

According to Storch et al. (2013) land use assessment and planning in Ho Chi Minh City must be put in the context of climate change and adaptation to risk. An increase in population in Ho Chi Minh City led to massive urban development; lakes, rivers and canals were filled up, and unplanned construction is obstructing the water flow while drainage systems are patchy, asynchronous and do not meet the development requirements, so that many places have been flooded (Nguyễn Đăng Tính và Dương Văn Viện, 2007).

Land use planning that consideres natural disaster risks is an important adaptation measure to mitigate future losses. If urban centres expand into areas at high risk of natural disasters, adaptive land use zoning and appropriate building standards are needed to help mitigate the risks effectively. For example, construction planning and selection of sites for the constructing of schools and hospitals in relatively high areas means that they are not prone to flooding. Social services must remain operational during disasters, and they also act as shelters for the people in low-lying areas when flooding occurs (Huong và Neefjes, 2010).

The experience and knowledge of local people can help them adjust the farming models that suitable for difrfernt types of soil. For example, farmers in the brackish water zone in Tra Vinh, which is the area most sensitive to salt water intrusion, change seasonal cropping schedule or patterns to adapt to serious saltwater intrusion (Văn Phạm Đăng Trí et al., 2013b). The CLUES project of the Research Institute on Climate Change - Can Tho University contributed to research and evaluation of rice varieties suitable for different areas that are impacted by climate change, for example flood-affected areas in An Giang province, sediment-affected areas in Can Tho city, areas with acid sulphate soils in Hau Giang province, and areas affected by salinisation in Bac Lieu province (ACIAR, 2011).

Ecosystems conservation help to protect people from climate extremes. Ecosystems have an important role in reducing the risk caused by the impacts of extreme climate events to people and society. Mangrove planting model has been implemented in many places in the North, Central and Mekong Delta. The ADAPTs mangrove planting model developed by the Centre for Social Research and Development (CSRD) was conducted in Thua Thien – Hue, which has contributed to the wave drag, wind resistance in the Tam Giang lagoon area. Mangroves including local species (like *Thespesia populnea* (L), *Sonneratia alba J.Sm in Rees* and *Avicenia alba BL)* help reduce erosion and protect residential areas and infrastrcuture such as embankments and harbours in Thua Thien - Hue (Lê Quang Tiến, 2012). Many studies have shown that mangroves can reduce 70-90% of wind and wave energy in coastal areas and storm damage reduction depends on the status of mangroves (Catherine et al., 2012). Viet Nam has considered the ecosystems as a basic solution for activities to respond to extreme weather events and integrated this in national development planning. However, decision makers will have to trade off ecosystem benefits to reducing climate risks and other valuable benefits for humans (Catherine et al., 2012). For example, the expansion of triple rice-crop areas in the Mekong Delta reduced the space for flood water storage from the two low-lying areas in Long Xuyen Quadrangle and the Dong Thap Muoi, causing that many downstream areas were more deeply flooded over a longer period of time, and riverbanks were eroded because of increased river flow speed (Lê Anh Tuấn, 2013a). According to 24-

year longitudinal study (1963-1999) of the International Rice Research Institute (IRRI) (Dobermann et al., 2000), continuously growing three rice crops per year will reduce yields: on average 1.6% /year during the dry season, approximately 44% in 24 years (winter-spring crop); 2.0% /year in the first crop in the rainy season, i.e. 58% in 24 years (summer-autumn crop); and 1.4% /year in the last crop in the rainy season, i.e. 38% in 24 years (autumn-winter crop).

Viet Nam has started to pay attention to links between ecosystem services and the protection of forest, wetlands, and biosphere reserves. Some projects have already been implemented in Viet Nam, such as the program for Payments for Forest Environmental Services (PFES), Program 327 and Program 661. The Asia Regional Biodiversity Conservation Program (ARBCP) assessed the potential of payments for environmental services (PES) and develop a PES pilot in Lam Dong and Son La provinces. Payment for services programs have also conducted in the marine environment and wetlands, such as the Hon Mun Marine Protected Area Pilot Project in Nha Trang, Viet Nam (Lê Văn Hưng, 2013).

5.3.4. Storage and rationing of resources

Storage of adequate stocks of essential supplies for each household and community in a certain period during the disaster season is very important. Essential supplies covered in this section are diverse and include food, clean water, energy (electricity, oil), medical services, and other essential items. Essential items like food are usually reserved in the family by women (Suu et al., 2010). Others (such as fast food, medication, ...) are especially important when people evacuate and are unable to carry essential items themselves or for households (such as cooking equipment). In case of insufficient supplies, the regulation and support by local authorities is very important.

In fact, there has been the very expensive lesson that because of not preparing adequate essential items, in many places famine threatened when disaster had just occurred. Conversely, some places reserved enough food before flooding, and although completely isolated for days because the traffic was cut off, life of the population contimnued and there was no starvation. For example, Tay Giang district in Quang Nam province was flooded and isolated by typhoon Ketsana for almost half a month. However, people in the area still had enough food without calling for aid (JANI, 2011). Stored food and other essential supplies included fried rice, noodle and dried food, because of their long shelf life. In many cases local people often only prepare these items for 2-3 days while it is recommended to prepare for 15 day periods (JANI, 2011).

Besides the food, people must store drinking water. Clean water plays an important role in the nutritional safety of those experiencing flood and drought. People in many areas of Quang Nam province shared their experience of storing drinking water by filling water jars up to two thirds of their volume so that the jars can float during the floods and they can still be used (JANI, 2011). Local people in Quang Dien (Thua Thien-Hue) reserve drinking water in buoyant nylon bags (JANI, 2011). Water is especially important during drought, when rationing of water use and water recycling are important. The distribution of food and drinking water often occurs when natural disasters occur and people do not have enough reserves of those necessities. For example, to deal with drought in Ninh Thuan in 2005, the central government and local authorities support 10 kg of rice per individual per month, and 40 litres of water per day per household (Oxfam GB et al., 2005).

Energy. including batteries and fuels must be stored for use when natural disasters occur as well. Electric outages occur frequently during storms and floods, which also causes the interruption of essential social services, such as healthcare. Solar (photovoltaic) system on the roofs or near the local health centres in remote areas would ensure that they can operate during or right after disasters, ensuring that health services are not discontinued (Huong và Neefjes, 2010).

5.4. Building capacity at the local level for risk management in a changing climate

Section 5.4 describes the principles and practical examples of solutions to improve local adaptation capacity through strengthening the decision making capacity and promoting the role of social organizations in helping local communities to effectively implement DRM. The situation in Viet Nam in recent years shows that knowledge, awareness and timely responses of the Government, social organizations and communities have important implications for the management of disaster risks.

5.4.1. Proactive behaviours and protective actions

Vietnamese authorities at different levels are concerned with active responses and disaster prevention and the involvement of citizens and local community organizations in this work is promoted. Steering Committees for Flood and Storm Prevention and Control (CFSCs) and the Committees for Search and Rescue (CSRs) were established at the provincial level and down to the commune/hamlet levels. In the Central Coastal Region, a Disaster Prevention and Control Fund was established under the Decision 1253/QD-BNV of the Ministry of Home Affairs (MOHA, 2008) to support provinces from Thanh Hoa to Binh Thuan in disaster prevention, control, and resolving of the ensuing problems. However, in practice, the coordination between the parties at all levels to implement measures is still limited. In addition, grants from the Central budget are limited while local budgets are not enough for the disaster prevention and preparedness plan.

The role of the community in disaster prevention and responses are also mentioned in the legal system in Viet Nam. At the national level, the Prime Minister approved the scheme on raising awareness on community-based DRM in 2009 (Thủ Tướng Chính Phủ, 2009c). Accordingly, depending on the provincial disaster and socio-economic conditions, each province develops its own implementation plan. At the local level this is supported by domestic and international non-governmental organizations. The non-governmental organizations play a pertinent role in proactively preventing and responding to disaster risk at the local level, especially in community-based DRM programs. One of the practical activities is the construction of flood-resistant houses or shelter, in provinces that are frequently affected by disaster (IFRC et al., 2010).

Readiness and effectiveness of prevention activities also depend on the frequency and the nature of hazards, practices, priority needs, and the social structure of the community. In the central and northern regions, danger can come frequently and affect severely and widely, so readiness and prevention must be paid more attention compared to the South. Moreover, in a locality with a strong social structure and the involvement of community organizations, prevention activities are more effective. It is necessary in the short term, to continue to improve the planning of infrastructure with a long-term vision, master planning for disaster mitigation at commune level, including the construction of hazard maps, production plans, organizing volunteer teams, training and capacity building, etc. In addition, the integration of climate change into socio-economic development plans is essential (Lê Anh Tuấn, 2011b).

Awareness, willingness and actions to prevent natural disasters depend on the circumstances and livelihood strategies of households. Research findings in An Giang and Dong Thap provinces are that the poor as well as households with relatively safe and convenient conditions (natural conditions, infrastructure, and living close to towns) are less proactive in prevention. Poor households are awarene of prevention but their priority is to secure their daily livelihood needs, so they tend to deal with natural disasters reactively instead of engaging proactively in long-term adaptation (Sanh và Can, 2009).

5.4.2. Strengthening capacity for local decision making

The decision-making capacity of community organizations and local people to manage risks is a critical factor in community-based disaster risk reduction. The National Strategy for natural disaster prevention, response and mitigation to 2020 emphasizes a comprehensive disaster management approach with community participation, including: (1) community participation in disaster management, and (2) mainstreaming disaster risk management into local development plans. Decree No. 66/2014/ND-CP provides detailed guidance on the implementation of some articles of the Law on Disaster Prevention and Control 2014 (Thủ Tướng Chính Phủ, 2014d), including decentralization and responsibilities in disaster management assigned to all levels.

Important factors that contribute to improving the effectiveness of risk management of the community's decision-making capacity of community organizations and local people enough to take on the management of risk. In Vietnam, the national strategy on prevention and mitigation of natural disasters through 2020 emphasizes the approach overall disaster management with community participation, including: (1) disaster management with the participation of the community and (2) mainstreaming disaster risk management into development plans of local.

In order to strengthen capacity throughout the decision-making process of local communities regarding solutions to respond to natural hazards and extreme weather phenomena in production in Viet Nam, the People's Committees and socio-political organizations (such as Farmers' Association, Women's Union, Veterans' Association, and Youth Union) at the commune/village level play an important role as the key partners when developing action plans. As shown above, the CFSC-CSR, which is normally established at the district level, is established at commune level for localities that are facing high disaster risks. This is the unit responsible for decision-making and implementation of prevention and response measures in a specific place.

The four on-the-spot motto including leadership on-the-spot, forces on-the-spot, means and materials on-the-spot, and logistics on-the-spot, assigns ownership and responsibility for risk management of authorities and communities at grassroots level. The phrase 'on-the-spot' can be understood as a specific lower level administrative unit lower, which can be provincial, district or commune level, or it may simply mean a household. This motto originated from experience in dyke protection work and has been extended to apply to the field of prevention and mitigation of natural disasters. The motto was concretized in legal documents since 2006 (Item D, Section 7, Article 10 in Chapter III of Decree No. 08/2006/ND-CP, dated January 16, 2006, Government) (JANI, 2011). In order to apply this motto, decision making capacity of local communities is extremely important.

According to JANI (2010, p.32), to promote efficiency of the four on-the-spot motto, the staff of the CFSC&CSR at all levels and local forces should be regularly trained in rescue activities and developing detailed response plans for each type of disaster and each location that is facing high disaster risk. Leadership on-the-spot is a crucial element of the motto, as smart and experienced leadership is needed as well as effective coordination to promote the strength of local forces. On the subject of disaster management, guidance and decisions should be made from one leader only. There is a need for a good mechanism and a clear financial policy for disaster prevention and control, including evacuation, etc., in order to promote the overall strength of local governments and local people for the mobilization of local forces, means and facilities, supplies and logistics.

The issuing and implementing of community-level decisions is usually done in emergency situations rather than recognizing the need to priority setting, planning and preparedness. To achieve goals of the decisions and to implement local plans, training and capacity building on community-based needs assessment, planning, implementation, monitoring and evaluation is needed. In fact, this has been done but not sufficient in terms of numbers of people involved and the frequency (Be và nnk, 2004; Sanh và Can, 2009). Moreover, the regular replacement of local officers also limits the effectiveness of capacity building of local cadres. The reality in the Mekong Delta showed that confidence of residents in community leaders has a decisive significance. For example, prevention and mitigation of flood damage was very efficient in Christian communities in Kien Giang and Hoa Hao communities in An Giang and Dong Thap provinces, where there are often charities involved in humanitarian relief work (Sanh và Can, 2009).

5.4.3. Social drivers

Social relationships of individuals, households and communities play an important role in responding to disasters, including the period before, during and after the events occur. These relationships include both formal and informal groups such local political-society organisations, religious and belief organisations, relatives, friends, neighbours, etc. According to tradition, the spirit of "solidarity" or "leaves protect the tattered", Vietnamese are willing to share and help each other in difficult situations. In rural areas before the rainy season local people usually help each other through practices like “exchange worker” or “alternate” to repair and make houses more solid. In the regions severely damaged by disasters, the mass organizations and the local Red Cross directly support and solicit donations to help people overcome distress (FAO, 2003). The local social organizations such as the Farmer’s Association, Women’s Union, Veterans Association, Youth Union, the Elderly Society, etc. also help their group members through contributions from revolving funds, or support in case of unexpected distress (FAO, 2003). Religious organizations also contribute to enhancing the capacity to cope and adapt to disasters (IRIN, 2013). In summary, social organizations contribute significantly to improve the capacity of communities to cope with natural disasters and climate change, so programs or projects concerning climate change adaptation and disaster prevention should pay more attention to these relationships. In addition, Decree 66/2014/ND-CP (Chính phủ, 2014) guides campaigns, donations and allocation of resources from the community (Article 13), and the rights and obligations of international organizations and foreigners involved in adaptation and disaster recovery in Viet Nam (Section 4).

5.4.4. Integrating local knowledge

Indigenous or traditional knowledge is the knowledge of local communities that have been built and developed over time and that plays an important role in the life and production of local people, as well as in DRM. Many studies have been conducted in Viet Nam that applied the particoipatory rural appraisal (PRA) method, combining local knowledge for early warning with disaster assessment, and proposing solutions for disaster management in the Mekong Delta (Be và nnk, 2004; Sanh và Can, 2009) and the central region of Viet Nam (Sen và nnk, 2012). Combining local knowledge with scientific knowledge and experience from elsewhere helps to assess needs, formulate and implement plans, and evaluate the DRM, especially climate change adaptation. Trần Thục et al. (2008) combined local knowledge with scientific knowledge and geographic information system (GIS) for mapping risk management in Thua Thien - Hue.

Indigenous knowledge is also a repository of valuable information to suggest new technical solutions for scientists as well as experts in planning and policy development (Vũ Trường Giang, 2009). The application of the four-on-the-spot motto to the prevention and reduction of disaster risk was included in legal documents (JANI, 2011). Similarly, “living with the floods” in the Mekong Delta started as climate change is happening and will continue.

In the same locality, different social groups (according to the economic status of households, livelihood activities, gender, age, residential area, etc.) may have different views and knowledge. All this knowledge helps to get an objective view of different aspects for need-assessment as well as developing and implementing plans, and assessing and building local institutions. Applying local knowledge through a participatory approach will encourage the participation of local people in the decision-making process and improve the capacity of people in DRM.

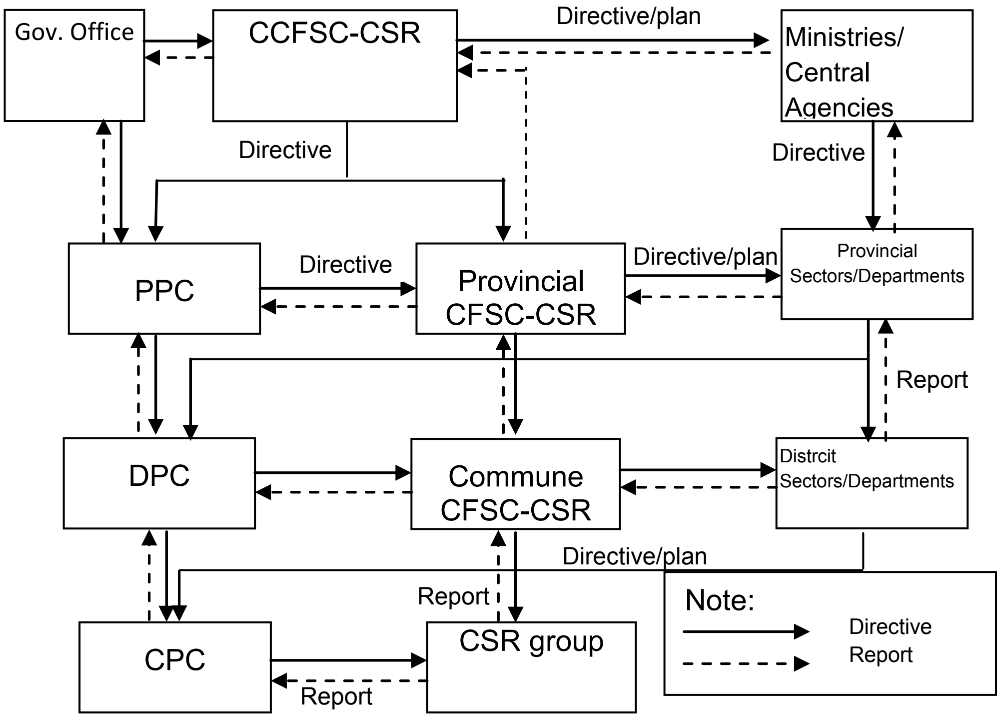
Some provinces in the Red River Delta, the Central Coast and the Mekong Delta region restored and designed "ecovillage" models following the concept of “ecovillage, also known as ecovillage economy model is the socio-economic development model associated with environmental protection and conservation of ecosystems and natural landscapes” (MPI, 2012). Some ecovillage models in the north are “Dao ethnic ecovillage in Ba Vi” (MPI, 2012), and Lum Pe upland ecovillage in Phong Lai commune, Thuan Chau District, Son La province (DOSTSơn La, 2003).

5.4.5. Local government and nongovernment initiatives and practices

Establishment of organizations to effectively and fairly manage risk of those affected is important - from developing strategy, planning and implementation to evaluation. The CFSC-CSR were established prevention and mitigation of natural disasters at four levels: central, provincial, district and commune (Figure 5-2). The role of the committees is different at each level. At the provincial and district levels, this committee is responsible for coordination of implementation. At the commune level, the CFSC-CSR and the rescue force at village/hamlet level are mobilizing and organizing resources to cope with floods or storms. This role is reflected in the four-on-the-spot motto to cope with floods or storms.

Local authorities are gradually integrating flood and storm prevention and climate change adaptation into local development plans, especially in urban development planning. The Prime Minister has approved the scheme Development of Viet Nam Urban areas to respond to climate change from 2013 to 2020 (Decision No. 2623 / QD-TTg dated 31/12/2013) (Thủ Tướng Chính Phủ, 2013a). Accordingly, local authorities integrate climate change issues into urban planning and local social-economic development planning. However, according to observations by the authors, the integration of climate change into development plans of the local authorities had not been done in a comprehensive manner. Community action to respond to climate change under the Viet Nam Urban Forum (VUF) supported the search for solutions to prevent flooding in urban areas and responding to climate change at the local level. Many ministries, international organizations, and non-governmental organizations are involved in the implementation of these solutions (http://urbanclimatevn.com/).

Figure 5-2. The organizational structure and coordination of CFSC-CSR systems at all levels



(Source: Sanh và Can, 2009)

The political-social organisations such as the Red Cross, the Women's Union, Farmers' Association, Youth Union, Veterans' Association, etc., and national and international non-governmental organizations play important roles and significantly influence disaster responses at the local level through research, training, community capacity building, provision of rescue equipment, training of women, strengthening of local institutions, and many other activities. The activities of local community-based organizations as well as non-governmental organizations flood and storm prevention have in recent years been generally effective and should be expanded and applied flexibly, depending on the specific circumstances of each locality (Sanh và Can, 2009).

Building flood resilient residential clusters, teaching children to swim, establishing childcare during flooding, and the four-on-the-spot motto, proved to be effective and meet the requirements of the local communities (Be et al., 2004; Tuan, 2007; Sanh và Can, 2009, JANI, 2011). The combination of disaster prevention and mitigation with local socio-economic development showed to be effective in some localities. The policy of the Government of shifting rice production systems to more adaptive farming systems to improve livelihoods of farmers, such as rotation of rice–shrimp and rice-vegetable proved to be effective in adapting to salinity intrusion in the Mekong River Delta (Kakonen, 2008; Yan et al. 2009). The development of farming systems that integrated aquaculture in coastal mangrove forests can both preserve mangrove forest resources and improve the livelihoods of the rural population, whilst it is adapting and mitigating storm damage and sea level rise (Kam et al. 2012). Many places have developed disaster warning maps, leaflets, etc., to guide and improve the knowledge, awareness and attitudes of communities to actively respond to disasters. This is a harmonious combination of structural and non-structural measures.

5.5. Challenges and opportunities to respond to and manage disaster risks

5.5.1. Factors affecting climate change responses and disaster risk management

In the past two decades, weather and natural disasters have changed in many parts of the world and in Viet Nam. Disaster risks are not the same due to the different hazards, exposure to hazards and vulnerability of communities in different regions. For example, floods in the Northern and Central midlands are mainly flash floods caused by fast flowing water in a narrow and short basins, as flood water goes up fast but with a short flooding time as the flood water also withdraws fast (Phạm Thị Hương Lan và Vũ Minh Cát, 2008). Those flashfloods are completely different from the floods in the Mekong River Delta, which happen in a wide and long basin, with floodwater going up slowly but with long flooding periods (Lê Anh Tuấn, 2012b). Therefore, the responses in different localities are different. The following section presents a few factors that make the difference in responding to climate change and DRM at sub-national levels.

5.5.1.1. Gender, age, and wealth

Impacts of climate change on different social groups depend on their vulnerability (Wisner et al., 2004; Janos, 2006). The poor, ethnic minorities, women and children are the most vulnerable to the impacts of natural disasters and the effects of climate change, and in fact, natural disasters and climate change may exacerbate gender inequalities, create additional workloads for women, as well as increase vulnerability of women in poor households (UN & Oxfam-Việt Nam, 2009). Support for these vulnerable people to cope with climate change and disaster risk is a challenge for Viet Nam in particular and developing countries in general.

Birkmann et al. (2012) showed that in recent years, from 1994 to 2006, children under 6 years old accounted for 74% of deaths caused by floods in Dong Thap province, and the majority of these fall into poor families, as their parents had to earn a living and could not take care of them. Ensuring the safety for children during disasters is an important part of dealing with climate change and DRM in Viet Nam. In 2013, the Government of Viet Nam issued the national programme on child injury prevention for 2013-2015 (Thủ Tướng Chính

Phủ, 2013b) with the aim of limiting the number of children who die from accidents and injury, especially due to drowning. Besides, non-governmental organizations are also concerned about this. World Vision International has formulated proceedings for disaster prevention in schools on the basis of experience and integrated this program into schools in Quang Ngai province (World Vision, 2010).

Gender equality in Viet Nam has greatly improved through the strengthening of legal documents (such as the Law on Gender Equality) and the expansion of the Women's Union network from the central to local levels. However, gender inequality still exists, especially affecting ethnic minority women (UN & Oxfam-Việt Nam, 2009). The participation of women in decision making at the household has improved, but men are still the final decision makers. On the other hand, the participation of women in local government still limited (Vu Minh Hai, 2004; Nora et al., 2012). This affects the participation of women in the process of planning and decision making for climate change adaptation, at both the household and community levels (UN & Oxfam-Việt Nam, 2009).

In addition to gender issues, inequality in society also exists between regions, urban and rural areas, the Kinh people and ethnic minorities, and between the richest and the poorest groups in society. As reported by Oxfam and Actionaid (2012), in areas where natural disasters occur, poor households living in low-lying areas, coastal zones, river banks, mountains etc. are most vulnerable. The majority of poor households are facing food shortages during pre-harvest seasons and natural disaster seasons. Poor ethnic minorities still face many limitations in disaster prevention because may not speak the Kinh language fluently, there is a lack of visual media, and their access to information on disasters is limited.

5.5.1.2. Livelihoods

The livelihoods of people, particularly livelihoods that rely on natural resources such as agriculture and fisheries are very exposed to danger and affected by extreme weather phenomena such as storms, floods, drought, or other factors such as diseases or market prices. Adaptive capacity of individuals and communities for these phenomena depends on their access to 5 capital-resources for livelihoods, including natural capital; critical infrastructure and production facilities (physical capital); skills, knowledge, health and labour capacity (human capital); social networks and community (social capital); and financial resources (financial capital).

The access to livelihood capital resources mentioned above is significantly different among communities or even among groups within the community due to differences in economic, social and environmental conditions (Nguyen Thanh Binh et al., 2012). There is a close relationship between the access to, the right to decide how to use and own the resources and the rational use of natural resources for sustainable livelihoods (Tạ Thị Thanh Hương, 2010). Sustainable livelihoods play an important role in DRM and CCA.

The disaster-prone areas, poor communities, and ethnic minorities are very vulnerable and need external help. With different capital resources, the Government has implemented many programs to improve the ability to adapt to disasters, such as dyke systems for flood or salinity intrusion prevention, residential clusters, and support to housing. However, many programs to adapt to disasters have not really paid attention to sustainable livelihoods of the people. For example, there are no opportunities for people to develop their livelihoods when moving to resettlement areas (Do Van Xe, 2008; Nguyen Thi Thanh Mai, 2012; Tran Thi Le

Tam, 2012); or dykes cause water levels to raise and affect other communities outside (Nguyen Thanh Binh et al., 2012). Therefore, the construction of disaster mitigation and climate change adaptation programs should consider these aspects in order to minimize negative impacts on livelihoods, not just within a small group, but also the larger community.

In addition, many livelihoods in Viet Nam's depend on agriculture while water resources strongly depend on other nations, so any upstream intervention (hydropower, irrigation, etc.) affects Viet Nam, especially in the context of climate change and sea level rise. Thus, future livelihoods will be much affected without reasonable development policy.

5.5.1.3. Health and disability

Scientists still debate which diseases are related to climate change because each type of disease has a different infection route or cause, which will be affected differently by climate change (Phạm Huy Dũng và Phạm Huy Tuấn Kiệt, 2008). Research in Viet Nam suggests that climate change may impact directly or indirectly on diseases and public health (Phạm Huy Dũng và Phạm Huy Tuấn Kiệt, 2008; Le Anh Tuan, 2013b).

The phenomena of climate change such as droughts, floods, storms and prolonged heat, etc., or environmental contamination (water or air) cause difficulties for the interaction between humans and the living environment, especially in the case of hard physical labour. These phenomena can impact directly on pathogens, or give rise to new pathogens (e.g. SARS, bird flu) or a direct impact on people and making people more susceptible to some diseases, including infectious and non-infectious diseases. Injury is common in flood seasons because of accidents such as falling and bumping into objects under a water when moving through the flooded areas (Few và Tran, 2010). Moreover, children and pregnant women are particularly susceptible to waterborne diseases such as diarrhoea and cholera, as well as the elderly and people with cardiovascular disease who particularly are at risk from heat stress (UN & Oxfam-Việt Nam, 2009).

Some patients are affected indirectly by climate change and the environment through vectors. For example, malaria and dengue fever are spread mainly via infected mosquitoes biting persons, and the development of the mosquitos depends on environmental conditions. There are 50-100,000 dengue cases annually in Viet Nam as the trend is increasing, and the morbidity rate per 100,000 citizens increased from 54 cases in the period 1997 to 2001 to 81 cases in the period of 2001-2006, which happen mainly in the South and Central region (Phạm Huy Dũng và Phạm Huy Tuấn Kiệt, 2008). Regarding the development of this disease, it increases from June and peaks in September, coinciding with the rainy and flooding seasons (Nguyễn Trần Hiển, 2013).

According to a study in Ben Tre by Đặng Ngọc Chánh et al. (2012), the incidence of diseases that are somehow related to climate change was between 80.8% and 85.8 % of the total number of health consultations in the coastal communes in the region. The study also showed that the incidence of diseases differs among age groups, economic status, and the hygiene situation of families. Compared to the group under 40 years old, the incidence of diseases in the age group 40 to 60 was 1.16 times higher, and for above 60 years old it was 1.85 times higher. The disease rate of the poor is 1.84 times higher and that of the near-poor is 1.16 times higher than groups with average or better economic conditions, which may be because the poor receive less support to health care in comparison with other groups (Đặng Ngọc Chánh và nnk, 2012).

The above analysis shows that diseases related to weather and environment are likely to increase and make up a relatively high proportion of diseases in Viet Nam. Their development is not only related to the climate factors but also depends on other factors such as age, environmental sanitation, regional factors, economic conditions, investments in health, medicine, etc. Any future national program on health care for climate related diseases must take into account all the above factors, especially the vulnerable groups such as the poor, near poor, elderly, and people in deep-lying, flood and disaster prone areas.

5.5.1.4. Human settlements

Effective DRM and climate change adaptation are closely related to the characteristics of the population and local socio-economic conditions. The population distribution in Viet Nam is uneven between regions, urban and rural areas, with high population density in the plains and sparse population in the mountains. Another feature is that residential areas are usually located along rivers and urban areas are concentrated in coastal areas. This creates favourable conditions for the exchange of goods and promoting economic growth; however, it also poses many challenges for sustainable development in the context of the present changes in the natural environment and society. Viet Nam ranks 6th among countries in the world with the highest proportion of their population living in Low Elevation Coastal Zones (Hugo, 2008). A comparative study of 84 developing countries showed that the consequences of sea level rise of 1 meter would affect 10.8% of Viet Nam's population - the highest among the countries analyzed (Dasgupta et al., 2007).

Although the Mekong Delta is vulnerable to climate change, local people’s awareness and response capacity of local communities are very low (Nguyễn Thanh Bình, 2012). For example, in terms of housing conditions, the Viet Nam Households and Living Standards Survey in 2010 indicated that the percentage of permanent houses was 49.2% nationally, but only 11.0% in the Mekong Delta; conversely, the percentage of simple houses was 5.6% nationally and 16.8% in the Mekong Delta, particularly among the poor and ethnic minorities this rate of temporary houses was even higher (GSO, 2011). Temporary and simple houses are very vulnerable to disasters, so due to storm No. 5 (typhoon “Linda”) in 1997, 107,819 houses of people in the Mekong Delta completely collapsed and due to storm No. 9 (“Durian”) in 2006 41,787 houses collapsed (data collected by the authors from the non-published reports of the Central Steering Committee for Flood and Storm Prevention and Control (CCFSC)).

In order to enhance resilience to disasters and climate change, planning and rational population distribution are essential, especially building flood-proof residential areas in the Mekong Delta (UN-Việt Nam, 2014). According to the assessment, the program of building flood-proof residential areas in the Mekong Delta was highly effective. However, the relocation of people into the flood-proof residential areas also gave rise to difficulties, especially in matters relating to livelihood, income, and loans due to relocation. The resettlement process contains many shortcomings, such as a poor planning, unclear financial management responsibilities, limited participation of the community, and ambiguity and inconsistent mechanism for loans and support for housing (UN-Viet Nam, 2014).

The changes in socio-economic impacts significantly on the resettlement of people. The issue of population growth, urbanization, migration to the cities for jobs have been increasing pressure on urban areas with poor infrastructure which are also susceptibility to natural hazards. A report of the World Bank (2011a) showed that the urban population in Viet Nam began increasing rapidly since 1986. According to the General Statistics Office of Viet Nam (GSO, 2001 &; 2012), the urban population in Viet Nam in 1990 accounted for 20% of the total population, 24% in 2000 and 32% in 2011). With the present urbanization rate, the urban population will exceed the rural population by 2040 (World Bank, 2011a). Therefore, urban planning, population redistribution in modern ways, combined with DRR are very necessary in the urban areas of Viet Nam.

5.5.2. Costs of managing disaster risk and risk from climate extremes

5.5.2.1. Costs of impacts and costs of post-event responses

The costs of impacts and costs of to recover from disasters include direct and indirect costs related to health, human and ecosystem-environment, historical-culture values, etc. Research by the World Bank in 2012 showed that from 1989 to 2008, the annual damage caused by the disasters in Viet Nam was at least 1% of GDP, approximately 4,550 billion VND (equivalent to 332 million USD). The assessment of disaster damage in Viet Nam usually gives lower than real values because not all direct and indirect losses are calculated, as is the case for long-term losses. According to calculations done by UNISDR and World Bank (2010), in general, damage caused by storms and floods was most and accounted for 90% of the total damage caused by the disasters.

Viet Nam has a reserve fund for disaster prevention and post-disaster measuers every year. However, the available funds are less than the actual demand. Analysis of World Bank (2012) suggest that the cost to recover from disasters in Viet Nam is about US$ 500 million annually, and the government spends only about US$ 210 million to repair damaged socio-economic infrastructure. This study also showed that under the impact of climate change, the frequency and intensity of natural disasters may increase, so the funding needs for post-disaster recovery will increase and the difference between needs and demands will be larger.

The official damage assessment by the State in Viet Nam generally focuses on direct economic losses and there is a lack of sufficient data to evaluate the indirect or long-term consequences after disasters. This is because there are no standard methods for assessment, and there is no consistent approach among localities (World Bank, 2012) and there is no disaster insurance system for people. Moreover, official reports by localities often focus on local losses and recovery costs of public infrastructure, while the loss of livelihoods, health, housing and environment of the people are not fully calculated (Navrud et al., 2012). A study for 706 households in Quang Nam province (Navrud et al., 2012) indicated that the estimated losses of households in Quang Nam in 2007 was 200 USD / household on average, accounting for about 20% of annual income; 50% of the losses are from crops and livestock and 39% from housing and household items. However, these costs are usually not adequately calculated in the local official reports. In addition, the statistics on the cost for post disaster recovery do not include contributions in cash or in labour for post-disaster recovery from humanitarian organizations and local people (Navrud et al., 2012).

5.5.2.2. Adaptation and risk management

There is not much research on the cost of adaptation to climate change and DRM in Viet Nam, only for some specific fields. Assessment by the World Bank of the economic impact of climate change on agriculture shows that the benefit of adaptation measures is around 1.3-1.6% of GDP which is higher than the cost of adaptation measures (World Bank, 2010b).

Based on a study of several economic sectors in Viet Nam, the researchers confirmed that climate change affects the poor most and appropriate adaptation actions can help avoid the impact on them. Adaptation measures should support sustainable development in Viet Nam whether climate change is going to happen or not, such as research and extension for agricultural development, expanding and upgrading irrigation systems, maintaining and upgrading systems for managing salinity and floods for ujrban areas and agricultural production, especially in the Mekong Delta and the Red River Delta (World Bank, 2010b).

5.5.2.3. Consistency and reliability of damage estimations

Estimations of damage caused by natural disasters is cross-sectoral, complex and long-term work. This requires coordination between socio-economic sectors because the damages include indirect and intangible harm to society. These losses are not only material, but also in livelihoods and spiritual values during and after natural disasters, environmental losses, and loss of cultural heritage (Bùi Đại Dũng, 2010).

In Viet Nam, the estimated value of damage to the ecological environment caused by natural disasters is currently limited. This is not new but there is limited capacity in terms of manpower, equipment and legal framework for estimation of losses and damages (Bui Dai Dung, 2010). Estimated damages are inconsistent and unreliable so identifying the affected objects and boundaries is unclear, whilst there is only interest in estimates of direct losses and affected objects, and there is a lack of standard estimation methods (Benson, 1997; World Bank and GFDRR, 2010). In addition, the cost estimation for impacts and adaptation is vague. One of the difficulties is the lack of statistics on damages and assessment of indirect losses to e.g. livelihoods, eco-environment and cultural heritage (Benson, 1997 pp78-79; Be et al., 2004; Son, 2006; Thomas et al., 2010; World Bank and GFDRR, 2010; ADPC, 2014).

5.5.3. Limits to local adaptation

Despite efforts and achievements, the effectiveness of local responses is still limited. Lessons learned in recent years to respond to natural disasters are very valuable in responding to climate change in the future. The main causes of local limitations include:

- Local authorities lack human and financial resources to synchronously integrate climate change adaptation into local development plans. Core issues, objectives and priority measures in the short and long term are often poorly recognized;
- The decentralization of responsibilities, cooperation and coordination among agencies in identifying and implementing measures to respond to climate change are not effective. Each sector usually has his own plans instead of an integrated overall plan to effectively implement the objectives of sustainable socio-economic and environmental development of the localities;
- Medium-term development plan at the provincial/district levels are often changed and these development plans are short (5 years) compared with the time frame of climate change. The vision and objectives that are the basis for identifying priority measures over time is often unclear. Decisions focus on scenarios of climate change impacts instead of mainstreaming into socio-economic and environmental changes at different levels;
- Some localities are afraid that mainstreaming climate change into the approved plan may change the existing development-investment plan or may cause difficulties in calling for investment;

- Gender issues have not been given sufficient attention in plans for DRM and responding to climate change;
- Officials involved in disaster management in localities often lack expertise, especially community-based DRM and climate change adaptation. Therefore, training in knowledge and skills and reasonable remuneration for the staff involved is essential, especially at grassroots level (UNISDR, 2010).

5.6. Strategies for managing disaster and climate change risks

5.6.1. Mainstreaming climate change into planning

DRM and climate change adaptation have been integrated into national development strategies and plans, including the poverty reduction strategy, the 5-year social-economic development plan and the 10-year socio-economic development strategy. This is a good start, but integration of DRR into development planning at all levels could improve, especially at the sub-national level. The National Strategy for Natural Disaster Prevention and Mitigation to 2020 (Thủ Tướng Chính Phủ, 2007), has set out tasks, solutions and action plans to achieve the long-term goal. The Action Plan to implement the Strategy gives priority areas for the coming years, including “Capacity building of officials responsible for flood control at different levels”, “Raising public awareness” and “enhancing the integration of prevention and mitigation of natural disasters into socio-economic development plans”.

Each locality has its own socio-economic development plan (or master plan) based on the status of economic activities and the social situation of the locality. However, natural disasters, extreme weather and climate change impacts on local activities are poorly considered in these development plans. The integration of climate change must be done in collaboration with relevant sectors and areas, and with the participation of communities and social organizations, who must review institutional policies in order to assess whether they are in line with socio-economic development under conditions of climate change.

The development of climate change adaptation plans based on climate change scenarios and weather conditions in each locality, and mainstreaming climate change and disaster risk reduction into development planning of the locality has significant implications to sustainable development at present and in future. The mainstreaming should follow the following principles (Lê Anh Tuấn, 2011b):

- Mainstreaming climate change response must be part of the overall development strategy and policy of localities.
- Research and scientific evidence is needed to determine future risk and severity of natural disasters and climate change that matches planning time-lines. At the same time, training of policy makers and local people on climate change impacts and adaptation measures is needed.
- The development of integrated measures must be carried out with the cooperation and consent of communities. Local people must be informed, consulted and must participate in discussions, making proposals and monitoring specific response actions.
- Integration of DRM and climate change adaptation must be linked to the development objectives and indicators and implementation measures should be consistent with the sectoral plans and local productions.

- Mainstreaming DRM and climate change adaptation must be linked to the development objectives and indicators and implementation measures should be consistent with sectoral plans and local production.
- There should be harmony and balance between the non-structural and structural measures in mainstreaming.
- Selecting the right response measures should be based on priorities in order to minimize the possible damage to the majority of communities, and should consider the conditions and the actual ability of sectors and health in the locality.
- It is necessary to consider combining various response measures to increase uniformity in a comprehensive manner, the effectiveness solutions, to save resources that must be mobilized and to strengthen the sustainability of development.
- The possible downsides of proposed measures should be noted, to limit the negative or unfavourable factors during the implementation. It is necessary to consider that there may be trade-offs, and avoid mistakes that could be hard to correct later. Conflicting interests between community groups should be noted in the proposals.
- The principle of gender equality in mainstreaming climate change adaptation into plans should be taken into account. Initiatives to adapt to climate change should consider the contributions of both women and men.
- If necessary, pilot projects in local communities should be proposed to assess and consider future up-scaling.

However, to do this, first of all, localities need to review disaster risks and the potential impact of climate extremes on their localities, as each locality affected by different natural disasters and the exposures and vulnerabilities are different among localities. Most provinces have developed their provincial action plan to respond to climate change, according to the National Target Programme to Respond to Climate Change in 2012, however, the feasibility of these plans should be assessed and reviewed.

5.6.2. Community-based adaptation

Community-Based Adaptation (CBA) enables communities to plan and better achieve adaptation to climate through a community-focused process, with priorities, needs, knowledge and community capacity (IIED, 2009). Part of CBA entails hazard risk assessment, and assessment of vulnerabilities and capacities of the community. Among other names, this has also been called community-based disaster risk management (CBDRM) (IPCC, 2012).

Community-based prevention and mitigation of disaster in Viet Nam is of interest of the Government and has been implemented over many years with the motto “the people know, the people discuss, the people implement and the people supervise”. Over more that 10 years of deployment of community-based disaster risk management (CBDRM) in Viet Nam was highly appreciated, so the Prime Minister approved the project “Enhance Community Awareness and Community Based Disaster Risk Management” for 6,000 villages with high risks of natural disaster. (Thủ Tướng Chính Phủ, 2009a) (Decision No. 1002 / QD-TTg dated 13/7/2009).

It is recognized that the principles of community-based DRM are similar to the four on-the-spot motto, which was developed from the experience in flood and storm prevention and control in the north of Viet Nam in the 1970s (JANI, 2011). Gradually, this motto is concretized in legal documents, for example in the National Strategy on Disaster Prevention and Reduction by 2020 (Thủ Tướng Chính Phủ, 2007) which says that disaster prevention and control must comply with the four on-the-spot motto. The four on-the-spot motto could apply to disaster management before, during and after disasters, so that effectiveness of responding to disasters as well as resilience of communities after disasters are very high.

Building "eco-villages" is one of the effective measures to respond to climate change. According to a scientific research workshop on designing an eco-village model for community-based adaptation to climate change in the Mekong Delta, organized by the Viet Nam Environmental Protection Administration (2013) in Hanoi, 8 criteria were developed for eco-villages, including: water supply (supply adequate safe water for families in the eco-village), wastewater treatment (waste water treatment tank distributed to each household), solid waste treatment (ensuring effective temporary storage, solid waste sorting and collection), transport (ensuring adequate transport), lighting (using clean energy resources), energy (use clean energy), trees (ensuring that open spaces in the eco-village are covered with trees), community activities (ensuring enough space for daily activities, and that floors are higher than the highest sea-level rise scenario).

5.6.3. Risk sharing and transfer at the local level

At the central and provincial levels, annual budget is available to support disaster affected people and to repair the dike systems. Risk insurance including micro-insurance, is the most common formal risk transfer mechanism at the local level. An insurance contract covers losses geographically and temporally, and can assure timely liquidity for the recovery and reconstruction process. As such, it is an effective disaster risk reduction tool especially when combined with other risk management measures. For example, in most industrialized countries, insurance is utilized in combination with early warning systems, risk information, disaster preparation, and disaster mitigation (IPCC, 2012). However, disaster insurance in Viet Nam is not common, risk-sharing is not done officially, and is mainly based on family and neighbour relationships, i.e. people helping each other, and support from social organizations such as Women's Association, Farmers' Association, civil society organizations such as non-government organizations.

5.6.4. A transformative framework for management strategies

Viet Nam has established Committees for Disaster Prevention and Control and Search and Rescue at all levels. Most of the members of the Committees are not professional personnel, with officers usually appointed from the different institutions and working concurrently for DRM, which is not very efficient. Administratively, there are two structures, one of them is on DRM and is under the Ministry of Agriculture and Rural Development, and the Committee for Search and Rescue is directed by the Deputy Prime Minister, which has caused inefficient coordination and guidance in DRM. The Committees for Disaster Prevention and Control and Search and Rescue at sub-national levels encounter similar problems with multiple functions and concurrent responsibilities. The DRM Standing Office is usually created from the water management units under the direction of local departments of agriculture and rural development (DARDs) whose members usually have good knowledge of water, but they cannot always deal with the reality and the complexity of DRM. Viet Nam needs to train more professionals to be specialized in DRM.

5.7. Information, data, and research gaps at the local level

One of the difficulties that local people and authorities are facing in planning and implementing adaptation measures is to fully receive and grasp data or information that specialized agencies provided. This problem may stem from the following reasons:
- *Accessibility and understanding capacity of local people and authorities*: Data/information is published only on some channels, which means that only certain groups of local people can access. For example, wealthy or middle income people can access information in the media and on Internet more easily than poor people living on the river who are high vulnerability to natural disasters. When people receive suiutable information there is no concern. However, for example, the announcement of flood levels, river flow parameters, or complex maps are not suitable for local people. Therefore, in addition to just publishing information to people and local authorities, capacity building in terms of using the data and information is also important. Moreover, if there is involvement of local people and stakeholders in the collection and processing of data into information for making decisions on adaptation will be more useful (CSIRO and DRAGON Institute, 2012).
- *The quality of data and information:* The government with international support has invested considerably into monitoring systems and data analysis to get more accurate information to respond to disasters and climate change in Viet Nam (see section 5.3.1.2, 5.3.1.3). However, the level of detail of temporal and spatial observation data or projections can be used for the regional level, but is hard to use at the community level. Reports on the economic and human losses caused by natural disasters are an important basis for activities before and after the disasters. Methodologies for data collection and analysis to write these reports must be studied in order to have more accurate and objective reports.
- *Transparency / understandability of information for each audience*: The way to present and and the level of detail of information is different for different audiences. Publications such as brochures, that are simple and designed with intuitive drawings will help local residents and officials understand and apply the information to perform adaptation most effectively. In addition, complex data or technical information should be transformed into understandable indicators that can be visualized by thematic maps, which could help local people or officials to capture information easily (Moglia et al., 2012).

Apart from the information sharing from the national and sub-national authorities to local communities as outlined above, the collection and synthesis of data and information available in the communities for higher level disaster planning and management are also important. The data and information at community level would be the basis to formulate a practical strategy and response plan, so the deployment of these plans will be more acceptable to communities (Nhan et al., 2012).

There are various data and information for responding to natural disasters and climate change adaptation. In order to manage data effectively, geographic information systems (GIS) should be used to integrate spatial and non-spatial data from multiple sources and at different levels of detail. The GIS tools for spatial analysis models combined with specialized computer models will make analysis of data more accurate and objective (Chau et al., 2013). Besides, WEBGIS is gradually developing, resulting in easier sharing of maps for many different end users. An example of the successful application of WEBGIS in on sharing information for flood and storm disaster prevention through the website "Viet Nam Information System for Irrigation Management" developed by the Center for Water Resources Software under the Viet Nam Acadamy for Water Resources (http://hochuavietnam.vn). However, the information on the website is at the level of detail for provinces and support technicians and researchers. Therefore, the application of WEBGIS should continue to be deployed more widely, with more visualizations, more information, and becoming more useful to local people and officials for responding to disasters.

5.8. Summary

Natural disasters restrict socio-economic development, including in Viet Nam. Most hunger and poverty reduction programs and projects in Viet Nam emphasize the impacts caused by natural disasters and climate change on the lives and property of poor communities, which are most vulnerable due to limited access to and ownership of land, water resources and capital for cultivation and production.

Management of disaster risk and climate extremes at the local level has significance implications for improving the capabilities to respond, adapt and recover from the disaster risks. If there is a good disaster management mechanism in localities, damage to people and property can be minimized, resulting in fast recovery of social activities after the disaster. Viet Nam has developed many laws and policies, along with the establishment of institutions and programs related to disaster prevention. DRR and climate change adaptation capacity at the community level can be different because of natural characteristics, financial conditions, infrastructure, human resources, social organizations and institutions of each locality.

The study also makes some recommendations: Due to the growing challenges of natural disasters, climate change and water resource security in Viet Nam, resource management agencies and local communities must cooperate, have political commitment and make effective financial investments in inventory, planning, exploiting, distributing, using and protecting water. Master plans could be developed consistently from the community level upwards and should not be limited to a specific locality but made at a larger scale such as the inter-regional level and cross-country. A legal mechanism should be formulated through political negotiations, to balance and resolve the contradicting use of water resources and disaster prevention between countries in river basins. Besides, the Laws on Water Resources Protection, Environmental Protection, and Disaster Prevention and Control need to be strengthened, amended and further concretized to meet newly arising situations in the present and in future. Activites harming national resources must be penalized according to legal instruments. Education to raise awareness on disaster prevention, environment and forest protection, economical use of natural resources and water resource protection must be frequently conducted. In addition, propaganda to raise awareness of communities and officials should be conducted. Local authorities should cooperate with scientists to develop appropriate adaptation measures for communities. Strengthening scientific cooperation with national and international organizations also must be promoted, to improve information sharing and knowledge, and to have reasonable options for resource extraction, environmental protection, disaster prevention and responses to climate change at the local level.

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Chapter 6

System for Managing Disaster Risks and Climate Extremes in Viet Nam

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Executive Summary

Chapter 6 presents the System for Managing Disaster Risks and Climate Extremes in Viet Nam. Based on analytical assessment of the existing structure, strengths and weaknesses of the disaster prevention and reduction system, the chapter proposes recommendations to enhance the efficiency of the disaster prevention and climate change adaptation system.

Viet Nam has set up the Disasters Risk Management (DRM) system from central to local levels, which is well organized and constantly strengthened and improved. Viet Nam has developed and implemented the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, and the National Strategy and Action Plan on Climate Change. All ministries and provinces are responsible for coordinating with the Central Committee for Flood and Storm Control (CCFSC) under the Ministry of Agriculture and Rural Development (MARD). Ministry of Natural Resources and Environment (MoNRE) and National Centre for Hydro-Meteorological Forecasting (NCHMS) provide support to CFSC when extreme weather occurs and provide early storm warning through the extensive nationwide broadcasting system at local and provincial levels, including special frequency for offshore fishing fleets.

This chapter mainly covers the issues related to current status of the DRM systems and climate extremes in Viet Nam such as legislation documents, DRM systems, the implementation process and practical experience gained over years in of Viet Nam, as follows:

Section 6.2 introduces the current legislation system on DRM and climate extremes in Viet Nam with the formation and development process of the legislation system. Many laws that are directly related to natural disasters such as Law on Dykes (2006), Law on Disaster Control and Prevention (2013), as well as policies, strategies and programmemes related to DRM and climate change. The section also evaluates the shortcomings of the current legislation system.

Section 6.3 summarizes the roles, functions, tasks and organizational structures of the government organizations and the political-social organizations, the private enterprises related to disaster risk management and climate extremes. Among those, CCFSC, the National Committee for Search and Rescue, departments under MARD and MoNRE are at the highest level with specific tasks and functions. In addition, the roles, functions, effectiveness and limitations of political-social organizations and private sector are aslo addressed. Research bodies such as the Viet Nam Academy of Science and Technology, research institutes under ministries are introduced and assessed. Communications system plays a very important role in the DRM and its roles, functions and specific tasks are introduced. This section also examines and identifies achievements as well as shortcomings of the DRM systems in Viet Nam, including the limitations in coordination between ministries and organizations.

Section 6.4 outlines the current status of integrating DRM and climate change adaptation (CCA) into national socio-economic development plans and policies, which is important and urgent to ensure sustainable development in the context of climate change. This content is showed in the Law on Disaster Control and Prevention and is one of the seven disaster control and prevention principles. Governmnet policies and the implementation process within ministries as well as lessons learned and limitations are also addressed. The section also introduces lessons learned and achievements in improving the effectivness of integrating DRM and CCA into provincial socio-economic development strategies and plans such as An Giang, Nghe An provinces, as well as agricultural planning and social welfare policies. However, the allocation of funds and responsibilities is spread out among ministries and sectors without coordination. In this section, a framework for integrating DRM and CCA into socio-economic development plans and policies is also proposed.

Section 6.5 presents financial issues and budget allocations related to managing disaster risks and climate extremes in Viet Nam. Although financing DRR is a high priority, it is still limited within the total government budget and social resources that could be mobilized. The government ensures necessary resources and mobilizes contributions from communities and the whole society to invest in DRR. There are limitations in mobilizing social resources, inconsistent investment and inefficient fund management to meet the requirement for disaster risk management.

Section 6.6 introduces methods and tools used in DRM practices, including DRM capacity building such as risk assessment and DRM information system maintenance; risk awareness raising, training and setting up early warning systems. This section also considers the application of technologies and infrastructure development, strengthening human resources and reducing vulnerability, investments in Environment funds and ecosystem-based adaptation. Risk-sharing through agricultural insurances, disaster risk insurance funds and disaster insurances for businesses, as well as impact management are also described in this section.

Section 6.7 refers to the link between DRM system in Viet Nam with challenges related to CC, Viet Nam is aware of the link between DRM and CC response, resulting in the formulation of the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, to continuously study the impact of global CC, sea-level rise and other unusual climate phenomena for prevention planning. This section reviews the effectiveness of the DRM in the context of climate change, with two independent management systems currently in Viet Nam including national DRM system under MARD and the national system for managing activities related to CC under MoNRE. Additionally, uncertainties and adaptive management of the national system, addressing root cause of vulnerability, and a systematic approach to disaster risk and adaptation are also mentioned in this section.

Section 6.8 concludes and makes recommendations related to specific legislation system and governmental management system as well as the actual implementation of managing diasters risks and climate extremes in Viet Nam based on current assessment of the system and the specific conditions of Viet Nam.

6.1. Introduction

The national DRM system is extremely important, which is at the core of countries' capacity to address current and future challenges in the exposure level, vulnerability, and climate extremes. DRM is the process of designing, implementing, and evaluating strategies, policies, and measures to raise awareness of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster prevention, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC, 2012 page 34). The objective of Chapter 6 is to review the status of national systems for managing disaster risks and climate extremes in Viet Nam.

DRM can be divided to comprise two related but independent components: disaster risk reduction and disaster management. **Disaster risk reduction** refers to both a policy goal or objective, and the strategic and instrumental measures employed for forecasting future disaster risk, reducing exposure, hazard, or vulnerability, and improving resilience. This includes mitigateing the vulnerability of people, their livelihoods and assets, and ensuring the appropriate sustainable management of land, water, and other components of the environment (IPCC, 2012 trang 34). **Disaster management** refers to social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster prevention, response, and recovery practices at different organizational and societal levels. These processes include the activation of early warning systems, contingency planning, emergency response, and recovery. Disaster management is required due to the existence of 'residual' disaster risk that the disaster risk reduction processes have not eliminated or prevented completely (IPCC, 2012 trang 35).

In Viet Nam, the legislation and regulation system mainly focus on disaster risk prevention and reduction. However, disaster risk depends on the physical nature of the threats, the level of exposure and the vulnerability (see fig.1-1, Chapter 1). Therefore, DRM is comprehensive and systematic in terms of guidance, organization, capacity and skills to implement strategies, policies and response capabilities to minimize the exposure, reduce vulnerability and minimize the possibility of hazards and the adverse impacts if hazards occur (MARD and UNDP 2012). DRM shows the continuity of disaster risk and the ongoing efforts to manage these risks.

6.2. Current Legislation System for Managing Disaster Risks and Climate Extremes and in Viet Nam

Viet Nam has put great efforts in desining the legislation system for managing disaster risks and climate extremes events. In 2007, Viet Nam issued the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (Viet Nam Government, 2007). In 2008, the National Target Programmeme to Respond to Climate Change was approved by the Decision No. 158/2008/QD-TTg dated on December 2nd, 2008 (Viet Nam Government, 2008]. Recently, the Law on Disaster Control and Prevention (National Assembly of Viet Nam, 2013) affirmed the determination of Viet Nam Government in disaster control and prevention.

Table 6-1. Policies and legislation on Disaster Risk Management

1. National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, Decision No. 172/2007/QD-TTg dated on November 16th, 2007.
2. Law on Disaster Control and Prevention, 2013 (Law No.: 33/2013/QH13).
3. National Programmeme on Community-based Disaster Risk Management (CBDRM) (Decision No.1002/QD-TTg dated on July 13rd, 2009)
4. Master Planning for Search and Rescue to 2015, with vision up to 2020 approved by Prime Minister on 28th February 2006 (Decision 46/2006/QĐTTg)

Table 6-2. Policies and legislation on Climate Change

1. Directive No.35/2005/CT-TTg dated on October, 17th 2005 on implementation of the Kyoto Protocol of the UN Framework on Climate Change
2. National Target Programmeme to Respond to Climate Change (NTP-RCC)
3. National Strategy on Climate Change
4. National Action Plan on Climate Change
5. Resolution No.24-NQ/TW dated on June 03rd, 2013, at the Seventh Congress of Central Executive Committee of the Communist Party of Viet Nam, XI Congress, on proactivate response to climate change, enhancing resource management and environmental protection. [Communist Party of Vietnam, 2013]
6. The Climate Change Adaptation Action Programmeme Framework for agriculture and rural development sector in 2008-2020 (approved in the Decision No. 2730/QD-BNN–KHCN dated on September 05th, 2008. Ministry of Agriculture and Rural Development.

In addition, Law on Dykes (2006), Law on Environmental Protection (2013), Law on Water Resources (2012), Law on the Protection and Development of Forests, Land Law, Law on Mineral Resources (2010), Fisheries Law (2003) and other legislations such as Ordinance on Exploitation and Protection of Irrigation Works (2001), Ordinance on the Exploitation and Protection of hydraulic and meteorological works (1994), Ordinance on Dykes (1989), Ordinance on Flood and Storm (1993) (both were amended in 2000) and the decree guiding the implementation of laws and ordinances also refer to the integration of DRM into the planning of socio-economic development .

According to the report on "Assessing the impact of the draft Law on Disaster Control and Prevention", the current legislation system of disaster control and prevention is quite bulky (MARD, 2012b). There are more than 150 documents related to flood prevention, but most of them are regulations/bylaws which are not adequate to address the major social issues and concerns related to disaster control and prevention and mitigation.

A bulky legislation system may cause overlapping and difficulties during implementation, meanwhile existing gaps still have not been adjusted. Few disasters have not yet had their own legislation such as heat waves, freezing and damaging cold. Especially, in the case of concurrent events, it lacks systematic coordination for the prevention, response and recovery of all types of disasters (MARD, 2012b).

According to Lempert et al 2004, there is a lack of mechanism to deal with non-compliant cases; lack of policy to encourage participation in disaster insurances. Under the provisions of the international agreements and treaties, an effective disaster prevention need to include all stages of the DRM cycle including disaster risk assessment, monitoring and warning, prevention and reduction, preparedness for response, as well as emergency response and post-disaster recovery. Currently in Viet Nam, disaster prevention activities mainly focus more on response and recovery than on the other stages.

6.3. System for Managing Risks from Disasters and Climate Extremes in Viet Nam

Managing the risks from Climate Extremes and Disasters comprise multiple actors from national to local levels (fig.5-2. Chapter 5) and national and international organizations. DRM becomes more urgent in the context of climate change. In the UNDP report on “Strengthening Institutional capacity for disaster risk management in Vietnam, especially disasters related to climate change" (2011) it is indicated that Viet Nam has established a good DRM system from national to local level, which is well organized and continuously improved to meet increasing challenges. These organizations have clear functions, responsibilities and operational regulations in governing and coordinating disaster prevention and reduction.

6.3.1. Government Agencies

At the national level, CCFSC is responsible for coordinating disaster reduction activities in Viet Nam. The Minister of MARD is the Chairman of CCFSC and is responsible for reporting to the Prime Minister. Two Vice-Chairmen are the Minister of National Defense and the Chairman of the Government Office. CCFSC is also composed of other ministers, heads of ministerial-level agencies and the Government, who are responsible for supporting and coordinating the flood prevention work. Corresponding to the CCFSC, there are Committees for flood and storm control (CFSCs) at provincial, district and commune levels (see Section 5.4.5 Chapter 5). The Water Resources Directorate under MARD, is tasked with management of irrigation, dykes, disaster prevention and rural clean water throughout the country (Decision 58 / 2014 / QD-TTg dated on October 22th, 2014):

- Department of Disaster Control and Prevention was formerly named Department of Dyke Management and Flood Control (DDMFC) under the Water Resources Directorate. Under the Decision No. 5349/QD-BNN-TCCB dated on December 15th, 2014 by the Minister of Agriculture and Rural Development, it was renamed as Department of Disaster Control and Prevention, playin the role of advising and enforceing law on disaster control and prevention.
- Centre for Disaster Prevention and Mitigation was established in 2010 and has functions of supporting and assisting the management and implemention of activities in the field of disaster prevention, mitigation and climate change adaptation throughout the country.

In addition, the National Committee for Search and Rescue, under the Government Office, is the leading agency for search and rescue, and is responsible for supporting the Prime Minister in enhancing cooperation between the ministries and provinces in searching and rescuing. The President of the Committee is the Deputy Prime Minister and the Vice President is the Minister of National Defense. The Committee is also composed of other Vice Presidents including the Ministers of the Public Security, the Communication and Transport; and the Agriculture and

Rural Development. Other members include 10 ministries, Viet Nam Television, and Viet Nam Women's Union. When disasters occur, the National Committee for Search and Rescue and CCFSC coordinate the search and rescue. In each sector, these two agencies form a Committee for Flood and Storm Control and Search and Rescue at the ministerial level, coordinating and collaborating with the CCFSC and provincial CFSC.

MoNRE is the lead agency to implement the Framework Convention of the United Nations on Climate Change (UNFCCC), the Kyoto Protocol and the Clean Development Mechanism in Viet Nam. The Minister of MoNRE established the Steering Committee for the implementation of the UN Convention on Climate Change and the Kyoto Protocol in 2007 to assist the Minister in directing, managing and coordinating implementation activities of the Framework Convention, the Kyoto Protocol and the Clean Development Mechanism. The agencies under MoNRE that are involved in climate change adaptation activities include:

- The National Hydro-meteorological Centre (NHC): According to the Decision No. 77/2013/QD-TTg of the Prime Minister dated on December 24th 2013, the NHC performs management functions, operates the national hydro-meteorological network, implements basic services, and provides hydro-meteorological materials and forecasting, broadcasts official news of tropical depressions, storms, floods and storm surges, monitors sea level and transmiss the data and provides tsunami warning (Vietnam Government, 2013).
- Department of Meteorology, Hydrology and Climate Change: According to the Decision No. 997/QD-BTNMT dated on May 12th 2008 (MoNRE, 2008a), the Deparment of Meteorology, Hydrology and Climate Change is responsible for coordinating negotiations and implementation of international agreements and coordinating with international organizations on climate change, performing the tasks of the Office of the National Climate Change Committee, Standing Office of the Steering Committee for the Implementation of the UNFCCC and the Kyoto Protocol; Standing Working Group on Climate Change Negotiation of Viet Nam.
- Viet Nam Institute of Meteorology, Hydrology and Climate Change: conducting scientific researches on climate change, developing climate change scenarios, conducting assessment of climate change impact and vulnerability and adaptation measures, developing technical guidelines for responding to climate change, conducting research on tropical meteorology and storms, sea-atmosphere interaction, climate, weather forecasting and broadcasting, climate change, natural resources and local climate etc. (MoNRE, 2008b).

The National Committee on Climate Change (NCCC) was established in 2012. The Prime Minister is the President of the Committee and the Vice-Presidents are Deputy Prime Minister and Minister of Natural Resources and Environment. The Committee is composed of ministers and leaders of relevant agencies and directors of research institutes. It is responsible for advising the Prime Minister in decision-making related to studying, proposing, directing, coordinating, cooperating to solve important issues that are multi-sectoral and multi-ministerial, and national programmes on climate change as well as managing the implementation of international cooperation on climate change.

6.3.2. Political - Civil Society Organizations, Community-based Organizations and Private Sector

The socialization of disaster risk and climate change management plays an important role in creating opportunities for people, political-civil organizations, community-based organizations, non-governmental organizations and private sectors to participate in the processes of developing legal documents, planning, managing and participating in disaster response activities. Socialization is mentioned in National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (the Prime Minister, 2007). Socialization helps promote the "State and people working together" spirit, of corporate responsibility towards society in disaster control and prevention as well as search and rescue.

In Vietnam, many political-civil organizations contributes to and supports Government agencies in managing risks from climate extremes and disasters. The Law on Disaster Control and Prevention (National Assembly of Viet Nam, 2013) has clearly defined the rights and obligations of agencies, political-civil organizations, political–civil–career organizations, community-based organizations, civil-career organizations. Viet Nam Fatherland Front calls for funding, provides financial support and emergency aid, and cooperates with the media from the central to local levels. The civil society such as Viet Nam Women's Union and Ho Chi Minh Communist Youth Union and the Veterans Association cooperate with local authorities to respond to disaster, relief and post-disaster recovery (MARD and UNDP 2012). Viet Nam Red Cross not only participates in direct relief when disasters happen and post-disaster recovery, but also contributes effectively towards disaster reduction and prevention through its network across the country. Specifically, Viet Nam Red Cross conducts communication programmes, training and public awareness-raising in disaster risk prevention.

The role of civil society organizations in DRM and climate change adaptation is increasingly recognized and affirmed. With the desire to jointly cope with climate change, the Network of Viet Nam NGOs and Climate Change (VNGO & CC) was established in 2008, today it comprises of more than 100 organizations registered as members. Climate Change Working Group (CCWG) was established in 2008 to create a forum for non-governmental organizations in Viet Nam and internationally who are actively participating in climate change issues. Disaster Management Working Group (DMWG) was established earlier, in 1999, to support information sharing and coordinating implementation of reliefs. The working group includes many non-governmental organizations operating internationally in the field of DRM and CCA as Oxfam, CARE International, Save the Children, World Vision, Plan International, the Red Cross and other organizations.

Private sector including private companies and state-owned companies engaged heavily in disaster response activities through donations or financial support in the form of a strategic partnership with the Viet Nam Red Cross and non-governmental organizations. Many initiatives and projects have been developed to enhance the participation of enterprises in DRR. A typical example is the project "Strengthening the public–private partnership in DRM and adaptive capacity of communities in Vietnam" by USAID and The Asia Foundation. It works closely with the Vietnam Chamber of Commerce and Industry (VCCI) to encourage initiatives public–private partnership and social responsibility of enterprises (USAID and the Asia Foundation 2014). The project built the website (http://ungphothientai.com/) for enterprises to access information on DRM, including publications and training materials. Another example is the initiative

"Strengthening the relationship between the community and businesses in flood risk mitigation in the Mekong Delta" of the Mekong River Commission (MRC) and the Asian Disaster Preparedness Center (ADPC) in collaboration with the VCCI and the Department of Dyke Management and Flood Control, took advantage of the opportunity to engage the private sector in flood safety and raising public awareness, training and capacity building to respond to disasters (MRC, 2010; Live & learn Center, 2011).

Disaster Risk Insurance plays an important role in supporting resources for private sector and communities to overcome the difficulties to cope with natural disasters and extreme weather phenomena, unfortunately, it has not been paid adequate attention in Viet Nam. According to the current legal document on business insurance in Viet Nam, there is no obligation to have disaster risk insurance, even the Law on Disaster Control and Prevention (National Assembly of Vietnam, 2013) which only encourages insurance companies to provide disaster risk insurance. Financial resources for disasters control and prevention is based on the Government budget, disasters control and prevention fund and voluntary contributions of organizations and individuals. Agriculture is the only sector that has insurance in Viet Nam. The plan began to develop in the 1990s, but the insurance company faced huge losses. Agricultural insurance programme began a pilot in 2011-2013, in 20 provinces under the Decision No.135-TTg (Prime Minister, 2011) with the support of the government. The new approach is also applied, for example, using the rice index, using risk management unit of livestock and fisheries at the commune level. The results of the programme are highly supported by the people, but the insurance company incurred significant loss (Le Tien Dat, 2014).

According to the Law on Disaster Control and Prevention, the disaster control and prevention fund was established at the provincial level under the management of the provincial People's Committee to assist local community when disasters occur. This fund does not include and is not derived from the Government budget, but instead was drawn from compulsory contributions of economic organizations in Viet Nam and abroad, and Vietnamese citizens who are between 18 years old and retirement age prescribed by the law. Also, in the central region, where there is high risk of natural disasters and extreme weather, the Central Vietnam Disaster Prevention Support Fund was established to support people in provinces from Thanh Hoa to Binh Thuan in preventing typhoon, flood and other disasters, reducing their damages, and overcoming the consequences (http://www.qmt.vn/TabID/62/CID/4/default.aspx). This kind of fund is a risk-sharing mechanism between businesses and communities.

6.3.3. Research and Communications

The effectiveness of national systems for managing climate extremes and disaster risks is highly dependent on the research outcomes, the readiness and timely dissemination of scientific data and relevant information on disasters (IPCC, 2012 page 349).

In addition to Viet Nam Academy of Science and Technology, Viet Nam still has many other research institutions on DRM and climate change under the Ministries such as Viet Nam Institute of Meteorology, Hydrology and Climate Change under the Ministry of Natural Resources and Environment, the Institute of Water Resources under the Ministry of Agriculture and Rural Development and Universities such as Hanoi National University, Ho Chi Minh City National University, the University of Natural Resources and Environment, the University of Water Resources, Hue University, Can Tho University. Many studies on DRM and climate

change have gradually raised people's awareness and supported the work of DRR and CCA in Viet Nam.
With regard to communications, Viet Nam has established a nation-wide communication system on disaster and disaster management from central to local level, for all target groups. In addition to the mass media including the Voice of Vietnam, Vietnam Television and local Broadcasting systems at provinces and communes, disaster information is also disseminated through announcements, decisions from authorities on disaster prevention and management such as the CCFSC and the Provincial Committee for Flood and Storm Prevention and Search and Rescue. The information contents include disaster forecasting and warning, policies on disaster, lessons learned on disaster prevention and management, scientific and technology advances, effective models in disaster management. On August 15th 2014, the Prime Minister issued the Decision No. 46/2014/QD-TTg stipulating disaster forecasting, warning and communication, which has clearly defined responsibilities of MoNRE and Viet Nam Academy of Science and Technology in issuing disaster forecasting and warnings (see Section 5.3.1 Chapter 5).

In addition, the education and training in various forms and at different levels have been conducted to raise awareness among communities and decision-makers. Many guidelines for disaster management and mitigation have been published and communicated to students, communities and business managers. For example, the "Four on-sites" motto in disaster prevention (CARE Vietnam, 2010), "Guidelines for implementing community awareness raising and community-based DRM" (MARD, 2011), "Handbook on Disaster Risk Prevention and Response for Business Enterprises" (To Kim Lien et al., 2012), or "Initiative on Risk Reduction Education for Students" (CECI, 2011).

6.3.4. Identify System for Managing Disaster and Climate Extreme Risks in Viet Nam

The Law on Disaster Control and Prevention and the Decree stipulating functions, duties, authority and organizational structure of the CCFSC and the Committee for Flood and Storm Prevention and Search and Rescue at sectoral and local levels have specific regulations on the coordination mechanisms in disaster prevention. However, currently in Viet Nam, coordination of the implementation of DRM among sectors still has limitations, "*lacking synchronized planning and timely adjustments",* and *"lacking resource mobilization policies for disaster prevention and disaster reduction*" (MARD, 2012b). The establishment of the CCFSC and the local Committee for Flood and Storm Prevention and Search and Rescue is to manage flood prevention but the management function has became larger than the initial criteria and goal. The members of the CCFSC and the local CFSC are multi-tasking, so they are always overloaded with work, especially during periods of frequent disasters. The Disaster Management Center under the Water Resources Directorate of MARD has just been renovated but the workload and job scopes often exceed the Center's capacity in terms of human and material resources (PDC, 2010).

The combination of strategic agencies to propose and develop disaster response programmes is closely linked to reality, and still overlapping. The coordination, evaluation, and reporting to ministries, sectors and provinces are not very effective.

In addition to the shortcomings due to inconsistent coordination among ministries, serious consequences could be caused by non-compliance with provisions of the law, the direction of governance agencies in disaster response (due to lack of legal mechanism). The gaps in integration of DRM into national and local socio-economic development have triggered deforestation of protected coastal areas for aquaculture farming, deforestation protected watershed areas for farmland, for hydropower development, all of which increase the risks and damage caused by disasters.

Therefore, there is a need to strengthen the operational coordination between ministries, sectors and functional units under the general direction of the Government in DRM. Another issue to be noted is that staff capacity in these organizations are mainly based on experience, few are formally trained in disaster and hazard management, and emergency response. Therefore, the Government should gradually build human reources with expertise, establish centers for disaster preparedness at the provincial level for timely direction and response when disasters occur.

6.4. Integrating Disaster Risk Management and Climate Change Adaptation into Plans and Policies

DRM and climate change adaptation should be components of a development plan to increase its sustainability. In other words, DRM and climate change adaptation should be "mainstreamed" into national development plans, poverty reduction strategies and setor development plans. The climate change adaptation activities must be integrated effectively into the strategies, policies and plans for socio-economic development at sectoral and local levels, aiming at ensuring effectiveness and sustainability of the development plan and preventing risks caused by climate change or unexpected consequences to the environment and society which may occur during the implementation phase of such plans and stratergies (Nguyen Duc Ngu, 2008).

6.4.1. Current Status of Integrating Disaster Risk Management and Climate Change Adaptation into Plans and Policies in Viet Nam

6.4.1.1. Government Policies and Guidelines

Since early 2000s, when disaster occurred more frequently and more intenssively along with stronger impact of global climate change, the government issued significant guidelines and policies as legal basic for mainstreaming DRM and climate change adaptation into socio-economic development process of the country. Currently the government continues to provide close guidance that helps sectors gradually improve policies to effectively implement the mainstreaming task.

The Law on Disaster Control and Prevention legalizes DRM mainstreaming into secroral development plans and socio-economic development plans (Article 4, Article 13, Article 15, Article 16) (National Assembly of Vietnam, 2013).

The importance and necessity of the integration are also emphasized in Agenda 21 of Viet Nam (Prime Minister's Decision No. 153/2004/QD-TTg dated August 17th 2004), and the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (Prime Minister, Decision No. 172/2007/QD-TTg dated November 16th, 2007). The National Target Programme to Respond to Climate Change also highlights the need to integrate climate change issues into development strategies, programmes, planning and socio-economic development plans (Government of Vietnam, 2008). The effectiveness of legal base is that DRM and CCA have been incorporated in the resolution on 5 year socio-economic development plans for the period 2011-2015 (National Assembly of Viet Nam, 2011) and socio-economic development strategy for 10 years from 2011 to 2020 (Government of Viet Nam, 2011b). On September 25th 2012, the Prime Minister issued a Decision approving the National Strategy for Green Growth. One of the objectives of the strategy is to conduct research and enhance application of appropriate advanced technologies in more efficiently use of natural resources, to reduce the intensity of greenhouse gas emissions and to contribute to an effective response to climate change.

6.4.1.2. Implementation within Ministries and Sectors

Recently a number of sectors and ministries have pioneered in developing guidelines on the integration of DRM and climate change into sectoral development planning and policies. For example, in 2012 the Ministry of Natural Resources and Environment published the Technical Guidelines for Mainstreaming Climate Change into Strategy and Plan (Tran Thuc et al, 2012); in 2013, the Ministry of Planning and Investment compiled the Technical Adaptation Prioritization Tool (APRT) Manual for SEDP planning.

Report on asessment of the integration of DRM into socio-economic development plan in Viet Nam of the Natural Disaster Mitigation Partnership (NDMP, 2007) has summarized the integration of DRM in the ministries as follows:

- Agriculture and rural development sector developed its Sectoral Development Plan for the period of 2006-2010 by designing a logical framework including national and ministerial level programmes to realize the plan. The plan considered criteria relating to agriculture, forestry and irrigation; the living conditions of farmers/ fishermen in mountainous and remote areas and other inhabitants, including disadvantaged areas where disaster and hazard frequently occur. It also identified that the exploitation of resources for economic development must be in line with agriculture rural development and protection of the natural environment. The Action Plan on Climate change response of agriculture and rural development sector period 2011-2015 and vision to 2050 was announced in 2011.

- Transportation Sector: DRM has been integrated into annual plan of each specialized department. Every year the Ministry of Transport prepares the summary on DRR works and each department develops its own DRR plan for the following year. Final report on Flood and Storm Control Programme in 2006 and Orientation toward 2007 included various disaster prevention and control activities. The Ministry also issued the Regulation on flood and storm prevention and post- flood and storm recovery for the road-sector. However, the main orientation just focus on the recovery work.

- Construction sector: the sector’s main tasks and solutions are directly related to the planning and implementation of DRR which include construction planning, especially in areas frequently affected by natural disasters. In fact, there are only 39 cities that have conducted urban and rural areas planning, all 93 cities and towns, 589 out of 621 towns and 161 industrial parks have construction planning. Construction planning accounts for only 18% of social planning. According to Mr.Tran Van Khoi, Deputy Director of the Planning - Statistics, Ministry of

Construction (NDMP, 2007), disaster risk assessment was carried out for the construction investment of the State's key projects, for example the consideration of safe distance from construction sites to erosion area, wind loads etc. and standards and regulations on flood and storm prevention and control. Disaster figures are also taken into account for the design of constructions in the flood area, and Mekong Delta and Central Coast. The "Viet Nam Construction Standard Manual" was developed and disseminated to provincial and city Departments of Construction. However, specific designs for disaster prone areas are not yet available (e.g. design for schools).

In addition to such intergration orientation and policies, provinces and sectors have organized various seminars, training courses, media communication about DRM and climate change; They have been deploying implementation plans for the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, and community-based DRR and climate change adaptation programme;

Non-governmental organizations in Viet Nam have conducted the pilot integration of DRM and Climate Change into plans at a several communes in Thanh Hoa, Yen Bai and Quang Tri provinces; prepared the Handbook on "Mainstreaming disaster risk reduction and climate change adaptation into socio-economic development plan at commune level". Results showed that some mainstreamed plans (e.g. the Thanh Lam commune of Ba Thuoc district, Thanh Hoa province) have been implemented effectively and contributed to decreased vulnerability and to improved resilience and recovery capacity, as well as reduced the impact of natural disasters on community. However, budget should be allocated annually for the development and implementation of the mainstreamed plan (Le Thi Thu Thao Hoang Thi Quynh Nga, 2013).

6.4.2. Lessons Learned and Shortcomings

<u>6.4.2.1. Lessons Learned</u>

Recently, under the support of the Asian Disaster Prevention Center (ADPC), An Giang province has completed a manual on mainstreaming DRR into socio-economic development at provincial and sectoral levels. An Giang province locates upstream of Mekong Delta and is regularly affected by flooding from Mekong River. It has succeeded in mainstreaming DRM into socio-economic development policy under the Programme of building overcoming-flood residential clusters. This programme is suitable and feasible for Mekong Delta, and has gained sympathy and support from the community. The pre-eminence of loan program in form of house ground (government budget) and deferred payment housing (Bank for Social Policies) has proved its effectiveness. Many of poor households that were regularly affected by landslide due to annual flood now own stable housing, children can go to school and communities can maintain good and stable living condition during flooding season. Instead of evacuating people and providing hunger relief during the flood, local authorities now only focus on guiding people in implementing production models, exploiting advantages during flooding season, creating peace of mind for the people.

Following An Giang province, Nghe An province developed a handbook on climate change adaptation, land use, gender and community development issues in developing socio-economic plan at commune level. Communes experienced with pilot mainstreaming can share their practical lessons to other communes and they can be good examples to share lessons of community level to higher levels such as district and provincial and central levels so that they could devise policies accordingly. Non-governmental organizations are always willing to share experiences and to engage in consultations with government agencies to develp guiledines for efective development and implementation of plans.

In fact, Viet Nam has been successful in mainstreaming DRM in agricultural planning, and social welfare policies. Specifically the change of plants and animals, shifting of crop seasons to avoid floods and storms, developing cultivating schedule for each type of crop to adapt to the change of climate and weather each year, for example, cultivation schedule to adapt to winter-spring, summer – autumn and winter-autumn rice harvests; schedule to control pets and rice diseases and avoid using specialized cures; proper cultivation schedule for vegetables, short-term harvested trees; tide calendar; plan for preparation and allocation of resources for the prevention of floods and droughts; plan for tax exemption due to natural disasters; and reserving food to support families affected by disaster.

Besides the success, a practical lesson is that there is a need to strengthen poor operational coordination between sector ministries in terms of funding and responsibility. For example, MARD is responsible for sea dykes, while the Ministry of Defence is responsible for coastal road for national security and MOT is responsible for socio-economic development purpose roads; the distance between these works is from several hundred meters to several kilometers, however there is almost no cooperation in construction. MARD and MOT agreed to construct hundreds of kilometer of sea dykes in corporation, however, fund has been allocated to both Ministries and Departments and the cooperation between the two is still very difficult. Another example is that fund for two programmes on public awareness is also allocated to two separate ministries.

6.4.2.2. Shortcomings

Even though the process of mainstreaming DRM and climate change into socio-economic development plans and policies has achieved certain results in Vietnam, there still remains many shortcomings and limitations in the implementation.

One of the shortcomings in Viet Nam today is that there is almost no integration of spatial planning, regional planning for long-term vision. Sectors mainly develop their plans independently with vision to 15-20 years forward, there is no connection among infrastructure engineering sectors, such as transport - irrigation - construction. For example, the construction of residential clusters is implemented by the Ministry of Construction while embankment filling soil brought in from irrigation canals and flood drainage channels, whereas flood and drainage and irrigation management are led by the Ministry of Agriculture and Rural Development. Therefore, residential clusters ending up obstructing flood drainage. The extended cannels for embankment work to construct residential clusters did not carry the flood away causing water levels to rise, particularly in 2011 many residential clusters were flooded. Poor coordination between sectors leads to the fact that many dyke systems are not in line with roads, bridges are not in line with sewerage system; many drains (locating beneath railways and roads along National Highway 1A) have inadequate apertures for the drainage of flood. Currently the Ministry of Agriculture and Rural Development is implementing irrigation planning for flood control for the municipality (including Ha Noi, Ho Chi Minh, Can Tho, Vinh Long, Tien Giang etcetc.) without cooperation with the Ministry of Construction who is responsible for planning the drainage for municipalities etc. In short, integration of spatial planning between sectors into long-term vision to cope with climate change has not been taken into account, therefore it needs to be addressed timely in the future.

In addition, there are other obstables against the integration programmes as follows:
- Several programmes and aspects mentioned in the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 have not been properly implemented or slowly implemented such as evacuating people along the rivers and streams, along flood corridor, planning population in flood area and natural diaster affected areas, etc.
- The analysis and evaluation of the impact of natural disasters and climate change on the development process have not been sufficient; natural disasters prevention and control supporting provincial socio-economic development has not been active. All of which have been in passive status resulting in mainly handling consequences.
- The Integration of DRR strategy and adaptation to climate change orientation into socio-economic development plan is of limit, heavily theoretical and based mainly on experience and qualitative forecasts. The integration has been implemented mainly in sectors directly related to natural disasters and vulnerability such as irrigation, agriculture and fisheries.
- Disaster risk management and reduction have been considered as main activities of the Steering Committee for Flood and Storm Control and Search and Rescue in the province. The involvement of all authorities is still limited. Disaster risk management and reduction are important aspects but they have not been intergrated properly in the socio-economic development strategy.

Based on experience of non-governmental organizations, Le Thi Thu Thao and Hoang Thi Quynh Nga (2013) have shown the most difficulty encountered is budget for the implemention. After the integration, several activities were added and the government has taken the initiative to mobilize resources from annual budget, programmes such as 135, 30A, 147, and programmes of NGOs in the province, and local people. However, the coodination can only be done on a small scale and additional fund for implementing the integration is essential to maintain it annually.

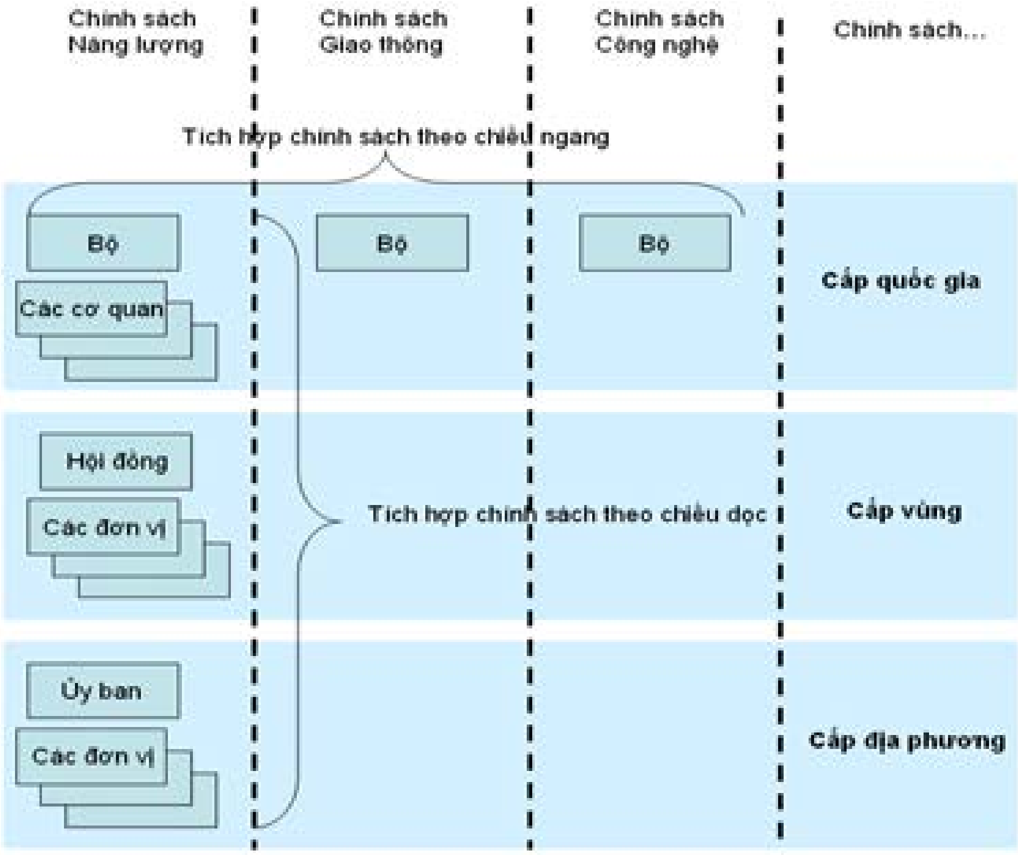
Besides funding issues, there are many other needed to be considered such as limit capacity of local official to conduct the integration work. Integration process takes time and manpower as much as to assess and collect information about vulnerability status from many levels. The solution, integration and mitigation plan have no breakthrough characteristic. The integration only introduced activities to reduce the vulnerability and DRR and has not provided comprehensive analysis of climatic factors in socio-economic development plan. Mechanisms for monitoring and evaluating the implementation of the intergrated plan became difficult because of financing challenges of short-term projects of non-governmental organizations…

6.4.3. Proposed Framework to Integrate Disaster Risk Management and Climate Change Adaptation into Socio-Economic Development Plans and Policies

6.4.3.1. Integration Purpose

The purpose is mainly to ensure the support to all activities from project-based approach to the implementation of the programme based on strategies and policies, including the integration of national development plan into sectoral development strategy and plan. Coping with climate change also requires mechanisms, policies and appropriate sanctionss to ensure better integration of climate change issues and climate change response into all strategies, policies and plans for socio-economic development, and environmental protection (Nguyen Duc Ngu, 2008). Based on a research by Tran Thuc et. al (2012), Figure 6-1 proposed the framework for the integration of DRM and climate change into socio-economic development plans of ministries, sectors and localities, which is now generally accepted. Here are some specific suggestions to improve efficiency and enhance integration.

Figure 6-1. Proposed framework to integrate disaster risk management and climate change adaptation into socio-economic development plans and policies



(Tran Thuc and et al., 2012)

6.4.3.2. Integration Risk Assessment and Management at Local Level

Risk management must be implemented at local level and be notified directly to community to enable them to access to vulnerable situation scenarios and adaptation strategies. The focus on enhancing the adaptive capacity of local people and existing adaptation strategies through the intervention of political, social, and provide financial resources and technology for local people will be the move towards a comprehensive strategy that intergrated DRR and climate change adaptation into development plans (see Section 5.6.1, chapter 5).

6.4.3.3. Strengthen Institutions and Policies

Strengthening specific guidelines for every ministry on mainstreaming disaster reduction; clearly defining responsibilities for national and local authorities; promoting the role of the coordinating body at national level in flood prevention and disasters mitigation; promoting local initiative; providing financial support to ministries to develop standards and sectoral regulations that intergrate disaster prevention and control and disseminating to communities; continuously conducting surveys to improve standards and regulations for regions affected by disaster;

forming specific proposals for disaster reduction and submitting for approval and funding annually.

Decentralizing investment projects to district and commune levels, including forests management and protection programme. However, for some areas it requires specialization and high technology such as new construction, repair and management of reservoirs which must be carefully reviewed and decided on reasonable level for decentralization management, it was learned that decentralization to lower level may cause unfortunate consequences. Briefly, decentralization must be in line with capacity building for district and commune levels as well as enhancing the supervision and guidance of provincial and national level. Strengthening the role of state management in mornitoring and supervising the implementation of disasters prevention and mitigation plan prior to rainy seasons.

Training staffs at provincial, district and commune level regarding knowledge of community-based DRM, training staffs at all levels and community regarding skills for disaster risk management and reduction planning. Integration of disaster prevention and control activities into those of political – social organizations such as Women's Union, Youth Union, Farmers Union, Veterans and Elderly Association (frequently and timely prior to annual rainy and flood season).

The Government should issue policy on intergration of "Disaster Risk Assessment" into all socio-economic development programme (planning), investment projects and development projects, including poverty reduction programme and programme 135. The Government should also have a policy that the poor can take loans to reinforce their houses before rainy season or build permanent houses that can protect them from flood (such as 2 floors houses , or 1 floor with a roof).

6.4.3.4. Information and Participation

Findings on climate and climate change must be published in a format that is understandable and accessible to vulnerable communities, *so as to* inform them about the local adaptation strategies. Local knowledge and information have been exploited indigenously to build programs and action plans for the development of sectoral policies. Taking full advantage of social media networks and the Internet potential channels, through which communication and information sharing could be viable (see Chapter 5).

6.4.3.5. Participation of Non-governmental Organizations and Communities

The capacity of countries to formulate development strategies depends on the participation of non-governmental organizations and communities. It is necessary to estatblish a close, active and systematic cooperation between authorities and communities that are vulnerable to risks, to enhance the participation of vulnerable groups in planning, decision making, implementation, monitoring and evaluation processes. This involvement should be defined in policies, laws and institutions.

Communities should be empowered to engage with national and local authorities to actively apply political system which meet their adaptation requirements.

It is also necessary that non-governmental organizations conduct advocacy for greater political commitment and financial support, provide knowledge and understanding of local politics and changes in social systems that affect vulnerability in communities.

6.4.3.6. Master Development Plans and Coodination

DRR and climate change adaptation must be mainstreamed into national, regional and local development plans, into sectoral policies and strategies (such as water resources, agriculture, environment, planning, finance, rural development). Climate change adaptation and DRR should be built based on a framework in line with applied tools, methods and experiences of different communities, socio-economic conditions.

It is necessary to conduct spatial planning for long-term vision, especially in the context of climate change. Emphasizing the need of coordination during planning and designing processes among infrastructure engineering sectors such as irrigation, transport and construction in order to create consistency and cohesion of the programme and avoid wasting investment. For example, the sea dyke system is a complex consisting of works used for salinity intrusion and fresh water retaining, disaster prevention from the sea, roads, coastal forests, also protecting coastal cities and residents, etc. If there is a good coordination among sectors such as irrigation, transportation, construction, agriculture and provinces, the sea dyke system can be a uniform complex with all above functions and can even serve some futher funtions such as demarcation between saline and fress water, between aquaculture and rice to improve livelihoods for people, tsunami and extreme storm prevention from the sea, etc.

6.4.3.7. Enhancing Local Adaptative Capacity

In order to develop long-term and sustainable adaptation measures at local level, communities need support in terms of finance and technology to help them implement available strategies and programmes to respond to climate change and disasters, manage natural resources, thereby reduce the risk of danger.

Le Thi Thu Thao et al (2013) shared lessons learned during the implementation of integrated activities at local level and suggested recommendations to improve the efficiency of such integration. It is necessary to have an overall direction from national, provincial and district levels that require the mainstreaming of DRR and climate change adaptation into socio-economic development plans to ensure consistency throughout the district, provincial and national levels. Officials participating in planning process should be well trained on methodology and tools for integration such as vulnerability assessment, integration process. In particular, the government should allocate funds for the implementation of integration plan to avoid the integration being mere proposals, since this is the most difficult problem as mentioned in Limitation section.

Integrated plan should focus on non-structural measures and projects; most vulnerable groups should be considered in the plan; documentation providing simple integration process suitable for human resources at each level should be avaiable. The participation of non-governmental organizations in supporting the implementation, monitoring and evaluation of integrated activities, particularly at provincial level, should be mobilized since most provinces are already implementing action plans to response to climate change. External factors affecting intergration process and the evaluation of effectiveness of the integration to make timely adjustments in the future should be considered. Mainstreaming requires a consistent implementation from national to local level, a good coordination between ministries, especially between MPI and Ministry of Finance (MoF).

Participation, contribution and feedbacks from stakeholders in the formulation and testing of integrated guidance should be enhanced. Integration guidelines should be tested and simplified to improve its effectiveness in practice. The communes which have conducted pilot integrated activites can share their experience to other communes as well as to higher level such as district, province and central levels so that they could devise implementation policies accordingly.

6.4.3.8. Development and Application of Tools to Minimize and Manage Risks

Available decision making tools have already begun the integration of climate change into plans and it is time to adjust the process.

Policies for reactions against disaster risk have shown greater impacts on the social gap of wealth and power. Experience from science and practice of DRR as well as the current institutional arrangement have contributed to significant progress. However, community action on climate change would risk wasting time and money in the "construction of a new system", if this knowledge is not inherited from DRR to adapt to climate change.

DRR provides methods and tools to solve radical causes of risk. The best approach is to combine works on radical causes in order to improve the situation of vulnerable communities. The timely integration of DRR and climate change adaptation meausres into development processes can be effectively implemented with the involvement of stakeholders at all levels.

6.5. Finance and Budget Allocation

Strategy for DRR and climate change adaptation should be of political priority, and sufficient budget should be provided for the implementation of national/ministrial development plans. The plans and strategies should include support for changing livelihoods and culture to diversify sources of income and support change strategy towards sustainable livelihoods for the poorest and most vulnerable.

DRR should ne integrated into development planning, budget for the implementation of the current plans and save money in the long run.

Financial mechanisms for adaptation should applied lessons learned from disaster mitigation. For example, using available knowledge and tools are more successful than "inventing a new system." However, these processes lack willingness in terms of politics or sufficient financial resources to ensure that no damage occurs.
Managers should pay attention to the incentives for organizations and tools that promote good awareness raising of risks, impact of natural disasters and climate change.

The Prime Minister has approved a list of 62 priority projects under SP-RCC programme with total budget of VND 20,527 billion, including capital from SP-RCC programme of VND 16,960 billion. Total funds which SP-RCC raised in 2010, 2011 and 2012 were US$ 140 million, US$ 220 million and US$ 260 million, respectively. In 2013, SP-RCC programme expected to continue to mobilize around US$ 278-328 million from foreign entities such as the French Development Agency, World Bank, international development agencies in Australia, the International Cooperation Agency of Japan, and Bank of import and export of Korea (SP-RCC, the Ministry of Natural Resources and Environment, 2014). Total capital proposed for allocation from 2014 is around VND 1,054 billion (TCOL, 2013).

However, currently annual investment budget for climate change response is allocated equally to the sector, and provinces, this approach is too widespread and ineffective. To overcome this problem, there should be investment policy for each region according to different priorities. Within prioritized areas, key and breakthrough projects need to be focused, which ensures the highest return on investment. In other words, we need to develop clearer mechanism and investment strategy that are able to attract attention and investment from international community and to ensure effective investment.

Even though financial resources for disaster control and prevention is of high priority, yet they are still within the state's overall mobilizable budget and social resources. The State shall ensure necessary resources, while raising the contribution of community and civil society to invest into disaster control and prevention works.

Regarding non-construction related measures, the state shall complete full investment in communication systems to ensure the safety of sea fisheries, the universalization of knowledge on disaster control and prevention to communities, strengthening disaster control and prevention institutions, afforestation of protective forests and mangroves, promotion of scientific and technological development activities of disaster control and prevention.

National reserve budget and resource are sufficient to perform required response and disaster recovery. It is a priority to spend ODA for disaster control and prevention, supporting community awareness raising, training of human resources and technology transfer for disaster control and prevention. It is necessary to mobilize social capital for disaster assistance, charitable Foundation, disaster control and prevention self_funding.

In order to implement the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, it requires US$ 18 billion (estimated by MARD), of which around US$ 13 billion is for construction measures (such as reservoirs, dams) and US$ 5 billion is for the non-construction measures (GFDRR, 2009).

In July 2009, the Prime Minister approved the "Community Awareness Raising and Community-Based Disaster Risk Management Programme" (CBDRM Programme) (Government of Vietnam, 2009) for 6,000 communes vulnerable to disaster. The total investment for the CBDRM programme of VND 988.7 billion (around US$ 54 million) was divided into three phases, starting in 2009 and concluding in 2020. The programme consists of two components: (1) Strengthening capacity for managing and implementing CBDRM for local officers at all levels: (VND 182.9 billion, equivalent to US$ 9.9 million) and (2) Improving communication and education and capacity of the communities in CBDRM (VND 805.8 billion, equivalent to US $ 44 million). Financial resources provided by the State (55%), residents (5%) and ODA (40%) - in the form grants.

MPI and MoF shall coordinate with MARD, CCFSC to balance and arrange annual investment under the provisions of the State Budget Law and other funding sources. The funding for the non-construction measures should be a priority.

Shortcomings
- Currently disaster prevention work is mainly carried out by the government. The government has focused on funding for disaster prevention. People are not really active in implementing disaster prevention actions.
- Lack of legal document regulating organizations and unions in fundraising and distribution money and relief supplies.
- Untimely adjustment of policies to mobilize resources to invest in disaster prevention and mitigation.
- Contributions and support from individuals, units and social organizations for disaster prevention and post-disaster recovery are mostly voluntary and charity, lack of a uniform distributing organization resulting in difference in funding allocation and unfairness.
- Limitation in investment: Inconsistent investment and does not meet requirements, the evolution of the disaster; Investment for the maintenance, management and exploitation of existing facilities are not adequate; Management and use of resources to support disaster recovery in some area lacks strictness and relies heavily on the report and recommendations of the locality resulting in a lack of transparency or wrongful usage.

6.6. Practical Methods and Tools

6.6.1. Capacity Building in Disaster Risk Management

6.6.1.1. Risk Assessment and Maintaince of Information Systems for Disaster Risk Management

According to the Law on Disaster Control and Prevention (National Assembly of Vietnam, 2013), information systems for Governance and in natural disaster prevention and control include:

a) Information infrastructure, including information systems for managing disaster prevention and control activities; automatic transmission monitoring equipment; and early warning systems;

b) Databases, including meteorological, hydrographical, oceanographic, seismic, earthquake and tsunami information database; database on disasters and damage caused by disasters; database on the system of disaster prevention and control works; database on infrastructure for disaster prevention and control; and monitoring data automatically transmitted during natural disasters.

Disaster risk assessment and maintaince of disaster information system plays an important role in supporting the preparation, response and management. However, there are limitations and challenges related to data.

Assessments of damage caused by disasters have been conducted by CCFSC for many years. CCFSC has developed mechanisms to collect disaster-impact data through representatives in provinces, districts and communes, constructing statistical charts on damage, which are regularly updated to suit the type of disasters and statistical methods locally.

Box 6-1. DesInventar software for assessing disaster damage and relief needs

Within phase 2 of the project on "Strengthening institutional capacity for Disaster Risk Management in Vietnam, including Climate Change related disasters in 2012-2016 - SCDM II" (UNDP 2012) funded by the United Nations Development Programmeme (UNDP) for the Ministry of Agriculture and Rural Development through the Disaster Management Centre (DMC) of the Water Resource Directorate (WRD), Damage and Needs Assessment (DANA) system is being studied to migrate to the DesInventar system.

DesInventar is a tool constructing databases of damage, losses and impacts from emergencies and disasters:
- Methodology (definitions and support in data management)
- Database with flexible structure
- Software for updating database
- Software for data analysis

The DesInventar software was used and converted to Vietnamse version in the phase 1 of the SCDM.

Although Vietnam has established data system on disaster damage from central to commune, the data collection is conducted manually, using the report and the data collected and aggregated from different sources. Few provinces have used softwares to forecast and assess disaster risk through funding and technology transfer received from OAD projects. However, after the project ends, inappropriate management mechanism has led to limited assessment activities (World Bank, 2012).

As reported by the Natural Disaster Mitigation Partnership (NDMP, 2008), the current DRM data systems in Vietnam mainly collect information on people and property damages. The basics of the disaster information management system in Vietnam are summarized below:

a. Types of information

- Statistical information system for disaster damage focusing on disasters such as floods, storms, flash floods, landslides, tornados, hailstone.
- The information stored in the system focuses on the direct lossess and damages such as property lossess; Information such as risk of disease or lack of clean water and sanitation is not fully mentioned.
- No template for collecting data on the post-disaster recovery needs, leading to incomplete and inaccurate statistical information.
- The statistics on disaster damage and risk has not been segragated into different target groups affected by the disasters.

b. Data Collection and Processing

Currently, the CCFSC Steering Office have been done by the DANA (Damage and Needs Assessment System) software for the collection, management and processing of disaster data and information, which can no longer be upgraded (UNDP, 2006).

On February 24th 2012, the CCFSC Steering Office issued a template for collecting information on losses and damages, and need assessment under the Decision No. 31/QD/CCFSC (CCFSC, 2012).
The system is installed from commune to central level with a multi-sectoral structure. Information will be collected for the purpose of on-site response and reporting to the higher levels.

c. Collection Methods

The main data are mostly statistical reports.

Frequency of collection and reporting depends on the severity of the disaster. The reports are updated daily for a duration of 1 to 2 weeks, until the most accurate data are collected.

d. Feedback and Evaluation of the Disaster Information Systems

The disaster information collection network is widely spread with the participation from many sectors, at various levels, which is an advantage in collecting and reporting data.

The collected data mainly focuses on direct damages related to people and property, and overlooks other target groups or indirect risks caused by disasters.

The damage index is mainly the damage caused by storms, floods. The indices for other types of disaster are not collected.

There is no template for collecting indicators on relief, recovery and reconstruction demands. This may affect the accuracy of the statistics due to subjective omissions, such as the damage index and relief needs of vulnerable groups including children, except for few relevant indicators such as the number of out-of-school children or damage to school facilities.

Indicators for the implementation of relief, rehabilitation and reconstruction have not been mentioned in the monitoring tables. Currently in Vietnam, disaster prevention and reduction depend on two database management systems, DANA and DesInventar. However, there are still many issues related to the link between these two systems:

- Data is insufficient, scattered, discontinuous and disorganized
- Data collection is not representative and in details
- Data is aggregated at the national level, and deficit and dispersal at the provincial, district and commune levels
- Data collection tables are too complicated

Some provinces have paid insufficient attention to the collection and storage of information and data on damage. To overcome the limitations, there is a need to:
- Reconsutrct appropriate data collection tables for each level, reconsider the indicators and mechanisms to share and exploit data in accordance with the conditions of Vietnam
- Evaluate the capability of the two systems for building or upgrading a common system for managing data

- Strengthen the exchange with the regional and global database
- Strengthen human resources training at all levels, first at central and provincial levels

e. Risk Mapping

Currently, only a few provinces in the Northern and Central areas including Thanh Hoa, Quang Tri, Quang Nam and Quang Ngai provinces have constructed flood maps with funding support of the WB4 project (World Bank, 2006) and Disaster Mitigation project funded by the Australian Government (AusAID, 2003). The disaster risk map is only static, hence can only be used as reference. Community safety maps in the beneficirary communes of WB4 project have been implemented but the results are limited because due to the lack of updated data.

f. Recommendations to Improve Risk Assessment and Maintain Disaster Information Systems in Viet Nam

Disaster information system, in addition to the collection of statistical data on disaster damage and post- disaster relief needs, information on disaster risks should be better considered and invested. In particular, there should be a detailed risk assessment for different types of disasters by regions.

Currently, the vulnerability of different target groups needs better assessment, especially the highly vulnerable groups such as the elderly, children, women, ethnic minorities and the poor.

Modernizing the collection and analysis of disaster data, and information sharing within communities require more attention to improve efficiency in updating disaster data.

The coordination and consistency between disaster information system for flood prevention and the data of the General Statistics Office of Viet Nam (GSO) is an important improvement.

6.6.1.2. Preparedness for Response: Risk Awareness, Training, Early Warning Systems

1) Disaster Risk Perception

Perception of disaster risk is an important issue, in which community-based DRM approach has been applied in many countries around the world as well as in Vietnam.

Community-based DRM has been implementation in Vietnam since early 2000s. Most of community-based DRM (CBDRM) programmes are internationally funded and implemented through non-governmental organizations (NGOs) in the country. Government agencies at all levels are partners or co-coordinating the implementation such project programme.

Thua Thien Hue and Quang Tri provinces are the first two to perform community-based DRM in 2001. By 2003, the activity expanded to nine (9) central provinces including: Nghe An, Ha Tinh, Quang Binh, Quang Tri Da Nang, Quang Ngai, Binh Dinh, Ninh Thuan, Binh Thua provinces; By 2008, 23 provinces have implemented community-based DRM, including Thanh Hoa, Yen Bai, Nghe An, Ha Tinh, Quang Binh, Ninh Thuan, Binh Thuan, Son La, Ha Giang, Hue, Lao Cai, Kon Tum, Da Nang, Binh Dinh, Quang Ninh, Hai Phong, Thai Binh, Ninh Binh, Nam Dinh, Tien Giang, Ben Tre and Quang Ngai provinces.

So far, 17 organizations including donors, bilateral and multilateral cooperation, such as UNDP, WB, GIZ, AusAID, JICA and non-governmental organizations such as IFRC International, Oxfam, Care, World Vision, Save the Chirldren, PLAN have been implementing projects based on community-based DRM in 23 provinces/cities, mostly concentrating in provinces frequently affected by natural disasters.

The implementation of Decision No.1002/QD-TTg (Government of Vietnam, 2009) on improvement of community awareness and community-based DRM by the end of 2012 has achieved the following results: 718 trained officers for 63 provinces on provincial community-based DRM; pilot training for 108 teachers in Kien Giang province; technical support teams established to guide the implementation of the project in a number of provinces. The project is currently developing communication materials on DRR and community-based DRM. There are 39 provinces and cities which made plans to implement the project (DMC 2013).

Implementation Plan for period 2013-2015 has been developed and approved by the Government on February 18th 2013. However, the implementation is facing difficulties such as: no mechanism or financial guidance; no uniform set of criteria for selecting 6,000 priority communes; no clearly defined focal point organization at local level and specialized staff; lack of training and communication staff; lack of communication materials at provincial, district and commune levels.

2) Training

Vietnam has been enhanced DRM capabilities through the development of a country standard training curriculum on DRM. The main objective of the training programme includes:
• Standardize training programme for DRM in order to establish national standards among implementing organizations and create favorable conditions for more effective DRM issues.
• Establish regional Training Agencies/Organizations in association with the operation of the Center for Disaster, which is being established in each region.
• Propose training programme, establish network of trainers at national, regions, provinces and districts levels.
• Develop a certified training programme for DRM at national level.

3) System for Disaster Forecasting and Warning in Viet Nam

Nowadays, in Vietnam, the system for forecasting and warning storms and floods has been the focus of investment. The Government is investing in Tsunami and flash flood warning system for pilot testing and subsequent implementation.

As soon as storms and tropical depressions form or approach the East Sea, NCHMF monitors and sends forecasts every 2 hours. Forecasting, monitoring and providing early warning of extreme weather events are implemented by the NCHMF.

NCHMF has a system to receive weather satellite images with high resolution to serve for forecasting of weather and storm. Besides, the NCHMF has other 7 weather radar stations.

Table 6-3. List of hydrometeorology stations in Vietnam (as of 2014)

No.	Description	Number of Station
1	Earth-based meteorological observation station	176
2	Rain Gauge	764
3	Hydrological Station	245
4	Oceanographic stations	17
5	Weather radar station	7

Source: Project "Strengthening weather forecasting and early warning system" under the project "Disaster Management-WB5"

4) Disaster Warning

Provincial Committee for Flood and Storm Control, through its Department of dyke management and flood control is the focal unit to implement forecasting, warning and controlling of natural disasters in Vietnam. Flood and storm warning systems are operated in a systematic manner from central to local levels and to each hamlet via radio and television system.

Although communication system for disaster warning is considered relatively good, especially the broadcasting system in lowland villages works effectively in disaster warning, this system is not sustainable when the disaster occurs. During and after heavy storms and floods, most of the information systems at local level are damaged resulting in difficulties in steering and operating.

According to Article 24 of Law on Natural Disaster Prevention and Control (National Assembly of Vietnam, 2013), disaster forecasting and warning information will be delivered in minor ethnic languages if necessary.

Main content of the disaster forecasting and warning bulletins:
a) Meteorological, hydrological and oceanographic forecasting and warning bulletins must ensure to provide the following information: type of disaster, intensity, level of disaster risk, location, current coordinates and progress predictions;
b) The earthquakes and tsunami forecasting and warning bulletins must ensure the following information: location, intensity, level of risk and level of impact of the earthquake; forecast of initiating location, potential, height of tsunami wave, level of risk, moving direction and affected area.

Responsibility for forecasting and warning of natural disasters are defined as follows:
a) The Ministry of Natural Resources and Environment is responsible for issuing forecasts and warnings of disasters related to meteorological, hydrological and oceanographic;
b) The Vietnam Academy of Science and Technology is responsible for issuing bulletins of earthquake forecastings and tsunami warnings.

Responsibility for the communication of forecasts and warnings of natural disasters are defined as follows: the agency responsible for forecasting and warning shall send disaster forecasts and warnings to Vietnam Television, the Voice of Vietnam and other mass media; Vietnam Television, the Voice of Vietnam are responsible for the transmission and distribution of forecasts and warnings of disaster provided by competent authorities.

6.6.2. Reduction of Disaster Risks Caused by Climate Change

6.6.2.1. Application of Technology and Infrastructure Development Approach

Climate change has direct or indirect impacts to the safety of the constructions and cause changes to their technical operation and maintaince procedures. Extreme weather phenomena that exceed thresholds of the design parameters of the constructions will increase the potential of damage and may lead to critical disruption or damage on the whole system and catastrophe. For example, in the central region, when large reservoirs encounter flood that exceeds the design safety level, water from such reservoirs must be released resulting in "artificial" double flood effects that cause serious damage to the coastal deltas located downstream of the reservoir.

In Vietnam, the impact of climate change on the constructions has been considered in many sectors. Many technical standards and technical guidances for traffic, irrigation and infrastructure constructions integrate the impact of climate change into the calculation of the technical specifications of each construction. Action Plan Framework for Adaptation and Mitigation of Climate Change of the Agriculture and Rural Development Sector Period 2008-2020 (MARD, 2008a, section 2.5, page 6) has considered a plan to build National Standards (TCVN) and National Technical Regulations (NTR) for planning, designing and building rural and agriculture infrastructure systems that help increase adaptive capacity to climate change of the system. In 2012, the Ministry of Agriculture and Rural Development issued the design standard for sea dyke (MARD, 2012a, section 6.1, page 10,11), which considered the impact of sea level rise when designing water level and sea dyke.

The development and rapid expansion of cities and municipalities may lead to the lack of control and long term planning. As a result, infrastructures will be at high risk of being affected by climate change and current extreme climate events. Therefore, the development and planning of infrastructure and essential social services need to be reviewed and evaluated in the context of climate change.

Models of storm shelter and flood have been proposed and implemented in the central coastal provinces, Mekong Delta which has contributed to minimize the damage caused by natural disasters.

6.6.2.2. Human Resources Development and Vulnerability Mitigation

Development of human resources is crucial in reducing vulnerability. Vulnerability to disasters related to climate and options for alleviating vulnerability are different among regions, depending on factors such as poverty, geographical location, gender, age, class, ethnicity, social structure, decision making process of community and political institutions. Poor areas are usually characterized by vulnerability of houses, weak support services in emergency situations and the deterioration of infrastructure, which depend mainly on agriculture and other natural resources.

Vietnam has been implementing a programme to develop human resources on national scale through activities of community-based DRM, primarily focusing on vulnerable communities to prevent and DRR: propaganda on disaster risk, health promotion, disease prevention and disaster risk reduction.

Box 6-2. The Status of mangroves in Viet Nam

Viet Nam implemented the programme "Development and Restoration of Mangrove, Period 2008- 2020". According to statistical data of the Ministry of Agriculture and Rural Development, in 2008 (Ministry of Agriculture and Rural Development, 2008b), the total planning mangrove area in Viet Nam was 323,712 ha. More than 60% of the country's mangrove is in the Mekong Delta, 20% is in the Southeast and the remaining 20% is in the North coast and the Red River Delta. In many places, mangrove forms a narrow belt along coastal line with large waves and strong currents. The mangrove belt protects and reduces the effect of wind, waves and storms and contributes to erosion control and alluvial deposits polders.

Since risks posed by climate change could affect the investment and development, the integration or mainstreaming DRM and climate change adaptation into development activities is an indispensable requirement to reduce vulnerable situation. Therefore it is necessary to integrate public awareness raising and community-based DRM programmes into raising climate change awareness in order to produce a synthesis programme. Based on the result of risk assessment of natural disaster impacts on climate change, community will propose appropriate adaptive measures for each region and each type of disaster.

6.2.3. Investment for Environment Reserve Fund and Ecosystem-based Adaptation

Ecosystem-based adaptation is integrated into an overall adaptation strategy, which may be cost-effective to respond to adverse impacts of weather and climate extremes. Investment for sustainable management of ecosystem and environment also shows potential to improve the livelihoods and enhance biodiversity conservation.

Investment in management of natural ecosystems has long been applied to reduce the risk of natural disasters, such as the investment for mangroves, which is also a natural ecosystem service, plays an important role in minimizing the impact of big waves and storm surges, since it can dissipate from 70 up to 90% of wave energy in coastal areas, reduce the size of the coastal protection works and bring opportunity for people's livelihood.

In Vietnam, Red Cross and non-governmental organizations started a campaign to replant mangroves since 1994 (Do Dinh Sam and Vu Tan Phuong, 2005). As of 2002, there are approximately 12,000 hectares of mangroves being replanted at a cost of 1.1 million dollars. Mangrove system helps saving costs for maintenance of sea dyke systems annually which is up to 7.3 million dollars, protecting coastal areas from the big storm (Mazda et al, 1997), and restoring the livelihoods of coastal residents in terms of cultivation and exploitation of fisheries resources brought by mangroves (MARD, 2008b).

Strategic environmental assessment has been applied in Vietnam for projects on landuse planning and hydropower development in Vu Gia - Thu Bon river basin. The risk of natural disasters caused by climate was taken into account in the assessment.

The ecosystem-based adaptive strategy can be more effective technical solutions in compared with construction measures, to bring multiple benefits and more accessible for those poor people in rural areas compared to other technical solutions. To achieve success in increasing investment in solutions based on the ecosystem, the country needs to overcome many of the challenges related to cognitive mechanisms, including:

The ecosystem-based adaptation strategies can be more effective than technical solutions. They bring multiple benefits and are more easily accessible for the poor in rural areas compared to other technical solutions. In order to achieve success in increasing investment in ecosystem-based solutions, countries needs to overcome challenges related to institution or awareness, including:

- Inability to identify the socio-economic benefits and the ability to issue decisions for complex and dynamic systems
- Lack of capacity to conduct the detailed cost-benefit analysis of strategic plans in order to make decision
- Lack of data and information or inaccessible data sources at provincial or central levels when it is needed to make decisions on landuse planning

6.6.3. Risk-sharing

Not all risks can be mitigated and resolved, thus risk-sharing mechanisms are an essential approach.

Box 6-3. Agricultural insurance

According to Decision No. 315/QD-TTg (Government of Vietnam, 2011a) on implementing pilot of agricultural insurance during 2011- 2013, the Government supports 100% of insurance premiums for farmer and poor households; 80% of insurance premiums for farmer households and farmers living just above the poverty line; 60% of insurance premium to other farmer households and others that participate in agricultural insurant and 20% of insurance premiums for agricultural organizations that participate in agricultural insurance.

Insured targets include rice paddies in Nam Dinh, Thai Binh, Nghe An, Ha Tinh, Binh Thuan, An Giang, Dong Thap; buffalos, cows, pigs and poultry in Bac Ninh, Nghe An, Dong Nai, Vinh Phuc, Hai Phong, Thanh Hoa, Binh Dinh, Binh Duong and Hanoi; “Tra” and “Basa” catfish, black- tiger and white-legged shrimp in Ben Tre, Soc Trang, Tra Vinh, Bac Lieu and Ca Mau.

The MoF reported that as of 30th April 2013, the pilot agricultural insurance has been implemented in all provinces and cities, with 234235 households signing insurance contracts, of which 80.8% are poor households, and total insurance value for crops, livestock and fisheries of over VND 5437 billion. Total gross insurance premiums is more than VND 303 billion (VNPlusOL, 2013)

Among current risk-sharing methods, the most common are property, possessions and crop insurances. Currently in Vietnam, property damage insurance has not been developed, and retains a very small proportion.

Box 6-4. Disaster Risk Insurance Fund

According to Swiss Re, disaster risk insurance funds have been applied in many countries and regions. For example, Mexico applied the Multicat insurance for risks related to earthquakes and typhoons, with participation of stakeholders such as the World Bank (WB), Swiss Re. In Asia-Pacific region, the PDRIF funded by WB, ADB and Japan MoF provided pilot disaster insurances for 5 islands (including the Marshall, Samoa, Solomon, Tonga, and Vanuatu). In addition, insurance model has been adopted in many other countries such as Turkey, Indonesia, Thailand, Taiwan, etc.

The aforementioned insurance funds are operated as parametric insurance and differ from other traditional insurances which is usually compensated on the basis of determining the actual damage.

Source: Workshop on "The choice of financial solutions for disaster risk in Vietnam" March 20th, 2013 (Vinare, 2013)

Box 6-5. Disaster Insurance for businesses

According to Mr. Nguyen Dien - Deputy Director of Department of Viet Nam Chamber of Commerce and Industry (VCCI) in Da Nang, 81% of companies are not active in disaster risk prevention and control and depend on the Government support, especially financial support.

In addition, 95% of interviewed companies said that the Government are supporting businesses to recover and rebuild after disasters and 91% of interviewed companies said this responsibility belongs to Government agencies.

In fact, damages to enterprises/businesses caused by natural disasters are significant. Statistics by the Asia Foundation in three central provinces showed that 85% of enterprises was affected by storms, 45% was affected by floods, and 12% was affected by tornados in 2012. 60% of businesses/enterprises were damaged, of which 5% was severely damaged and, 30% was heavily damaged, which are mainly on facilities, equipments and goods. For example, Danapha Pharmaceutical Joint Stoke Company lost more than VND 40 billion due to the impact of the Typhoon No. 6 (Xangsane) on October 3rd 2006.

Mr. Nguyen Tri Thanh from the Representative Offices of the Asia Foundation in Vietnam said that most of the enterprises are concernd about disaster prevention but they lack of necessary and effective preparation to prevent and mitigate the impact of disaster. 46% of businesses/enterprises are concerned about disasters prevention and control but do not have disaster prevention plans, 33% have plans but do not have enough capacity and resources to implement.

The statistics in Da Nang show that only 10% of businesses/enterprises participating in insurance, which are mainly foreign businesses/enterprises. This suggests that businesses/enterprises, especially small and medium ones hardly insured against disaster risks.

Source: Seminar on Vietnam business readiness to respond to disasters, May 3/2013 (VCCI, 2013)

Currently, MoF and MARD are piloting the agricultural insurance in Viet Nam under the Decision No. 315/QD-TTg (Government of Vietnam, 2011a) on pilot provision of agricultural insurance during 2011- 2013.

In developed countries, disaster risk insurance and reinsurance are required for specific types of natural disasters such as hurricanes, earthquakes. However, in Viet Nam there is no provision for compulsory insurance against natural disasters. The Law on Disaster Control and Prevention only added the provisions of Clause 5, Article 5 of preferential policies to encourage insurance companies to provide disaster risk insurance. At present, it is also impossible to specify the proportion of Government budget for disaster insurance.

According to the report on the implementation of disaster risk insurance in Viet Nam (Vinare, 2013), the majority of businesses do not actively prevent and control natural disaster risks and still rely on the support of the Government. On the other hand, the majority of key policies aim at communities and not the enterprises.

In March 2013, the Viet Nam National Reinsurance Corporation (Vinare) worked with the Swiss Re to conduct a research on establishing disaster risk insurance fund in Viet Nam. This is a joint property fund to which many insurance companies contribute. The fund is used to provide insurance for high risks that beyond the affordability of a single insurance company. In 2013, Vinare also collaborated with MoF, domestic and foreign insurance companies to construct and expand legal framework solutions as well as share experience of the insurance markets in the region to develop scenarios of disaster insurance for Vietnam (Vinare, 2013).

6.6.4. Impact Management

In many cases, although necessary efforts have been implemented, disaster risks could not be completely eliminated, hence there is a neede to invest in capacity to manage the potential impacts of natural disasters (IPCC, 2012, page 313). The scope of the impact of the disaster will determine the extent and scope of the disaster response, which could be within households or at national or international levels. The responses at the international level will pose challenges for the government in terms of management due to the diversity of response activities and the complexity of the different resources.

Vietnam has a consistent DRM model from the central to local levels (Figure 6-1). At the central level, CCFSC undertakes two main tasks of drafting legal documents and providing information to provinces. The highest level is CCFSC, of which the President is the Minister of Agriculture and Rural Development and members are representatives of ministries and sectors.

CCFSC is responsible for formulating and implementing national plan for disaster reduction; developing policies and guidelines; promoting international cooperation; coordinating activities among provinces, organizations and relief activities.

6.7. Aligning Disaster Risk Management Systerms in Viet Nam with Climate Change Challenges e

The effectiveness of national systems for managing disaster risks in a changing climate will be improved if they integrate assessments of changing climate extremes and disasters into current investments, strategies, and socio-economic activities, and recognize climate change as one the underlying causes of vulnerability and poverty (IPCC, 2012).

In practice, this requires: (i) cooprations between organizations, governments and countries; (ii) participation of relevant actors in the national system; (iii) new cross-sectoral collaborations; (iv) re-allocation of functions, responsibilities, and resources across different levels; and (v) new implementing procedures (IPCC, 2012).

Recognizing the link between CC adaptation and disaster prevention and control, Viet Nam has developed the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, to continuously study the impact of global CC, sea-level rise and other unusual climate phenomena for prevention planning. At the same time, Viet Nam has also developed the National Strategy on Climate Change with the primary strategy to actively respond to disasters and monitor climate. This shows proper attention to linking the two important components of disasters prevention and climate change response. In order to implement the objectives of the strategy, the Government has issued the National Action Plan on Climate Change 2012-2020 to implement activities related to CC adaptation and DRM.

6.7.1. Assessing the Effectiveness of Disaster Risk Management in the context of Climate Change

In order to align disaster risk management with the challenges associated with climate change, it is necessary to assess the effectiveness and efficiency of management options in a changing climate based on the best available information. Through adopting a common assessment framework, different approaches have been used to assess the effectiveness or efficiency of adaptation solutions. Many studies on climate change adaptation have focused on national allocated funds for adaptation measures rather than comparison between costs and benefits (Nordhaus, 2006; EEA, 2007; UNFCCC, 2007a; Agrawala and Fankhauser, 2008; World Bank, 2008; ECA, 2009; Parry et al., 2009).

Currently in Vietnam, there are two independent management systems including national DRM system under MARD and the national system for managing activities related to CC under MoNRE.

At the provincial level, there are different models of disaster management systems, which are managed by various agencies, which results in the ineffective administration of disaster prevention and reduction.

Many studies on climate change adaptation have focused on national allocated funds for adaptation measures rather than comparison between costs and benefits. Other approaches include focuse on the effectiveness of risk assessment at the core, or on economic efficiency of response management (Benson and Twigg, 2004; Mechler, 2004).

It is, however, difficult to fully assess the effectiveness of disaster risk management context of climate change, since all the evidence-base for determining economic efficiency – that is, benefits net of costs – remains limited and fragmented.

Recently, a number of studies have been conducted to evaluate the effectiveness of DRM systems in Viet Nam in the context of climate change. The study focused on assessing the effectiveness of DRM systems through economic, social and environmental indicators (World Bank, 2010), evaluating the economic aspects of climate change adaptation measures through quantifying the impact of climate change; and comparing damages between the cases with and without adaptation measures, for example if no adaptation measures are implemented, 0.7% reduction in GDP will incure, while 0.7% increase in GDP will incur if adaptation measures are implemented, thus the total profits brought upon the implementation of adaptation measures will be 1.4% of GDP. As for agriculture, the total yields can be reduced by 5.8% or increased by 5.4% for the cases with and without adaptation measures, respectively, thus the total benefit of implementing adaptation measures is 11, 2%.

6.7.2. Managing Uncertainties and Adaptive Management in National Systems

Disasters associated with climate extremes have become increasingly complex, involving socio-economic as well as environmental and meteorological uncertainties. Population, social, economic, and environmental changes all influence disaster risk, through the impact on levels of exposure and on human vulnerability to hazards (IPCC 2012).

The uncertainty and limitations of the data and predictive models resulted in the uncertainties of projections. Enhanced scientific modeling and interdisciplinary approaches to early warning systems can address some of these uncertainties and provide better baseline and time series data. Adaptive management, defined as a structural process of improving policies and implementing management practices through systemic learning from the outcomes of implemented strategies, and by taking into account changes in external factors in a proactive way (Pahl-Wosrt et al., 2009; Pahl-Wosrt, 2009). This also means bringing together interdisciplinary sciences, sectors, experience, and traditional knowledge into decision-making through the 'learning by doing' process by individuals and organizations (IPCC, 2012).

In most cases, adaptive management has been implemented at the local or regional levels and only a few at the national level. There are many examples of adaptive management in ecosystem management and in disaster risk management (IPCC, 2012). One of the existing issues in adaptive management is to ensure that scientists and engineers tasked with researching disaster risk management and adaptative management processes learn from each other and from practical experience, and aggregate lessons learned to inform policy-making and management practices. The ineffectiveness of management was partly due to the unwillingness of some social groups to accept short-term losses for longer-term sustainability of ecosystem services (Kyker et al., 2001). Hurricane Katrina, which was not taken into consideration during disaster risk planning and decision-making, is considered a valuable lesson (Laska, 2004; Congleton, 2006). The hurricane management in Cayman Islands, on the other hand, demonstrates a successful story of flexible disaster management based on practical experience, and essentially "learning by doing" process.

The 'Learning by doing' model in disaster risk management can only be undertaken effectively if the management organizations are at the appropriate scale, where in some cases it is necessary at the local level, or in others at multiple scales with effective interaction (Gunderson and Holling, 2002; Eriksen et al., 2011).

Climate resilience (IPCC, 2012 page 34) as a development goal is, however, difficult to implement, particularly when it is unclear as to what resilience means. Unless resilience is clearly defined and broadly understood, with measurable indicators designed to fit different local contexts and to illustrate success, the potential losses may go unnoticed, causing problems with policy implementation and legitimacy (Eakin et al., 2009)

6.7.3. Tackling the Underlying Casuse of Vulnerability

Reducing vulnerability and addressing the underlying causes of vulnerability are considered an important aspect to overcome shortcomings in DRM (UNISDR, 2009, 2011).

Aligning national disaster risk management systems with the challenges posed by climate change and other drivers of disaster risks places considerable importance on addressing the underlying cause of vulnerability as one of the most effective measures (Tanner and Mitchell, 2008; Davies et al., 2008; CCCD, 2009; UNISDR, 2009c; Mitchell et al., 2010). The secondary factors underlying vulnerability include gender equality, poverty, declining ecosystems, lack of access to and use of energer, basic services, land, and weak governance (Wisner et al., 2004; Schipper 2009; UNISDR 2009c, 2011).

To date, strategies for tackling the risks of climate extremes and disasters, in practice, tend to focus on dealing with the symptoms and consequences of vulnerability and risk, rather than considering the underlying causes. This is partly because disaster risk management is still not perceived as a core component of sustainable development (Schipper, 2009). The impacts of climate change are seen as a potential motivation that will help to forge a stronger connection between disaster risk reduction measures and poverty and vulnerability reduction measures (Soussan and Burton, 2002; Schipper, 2009; Mitchell et al., 2010).

6.7.4. Disaster Risks Approach, Adaptation, and Development

Climate change poses diverse and complex challenges for authorities in the national disaster risk management systems, for disaster risk management policies and for implementing disaster risk management practices more broadly. The national disaster risk management systems and national strategies need to take into account the impacts of CC, realigned to maintain and improve their effectiveness.

Flexible and adaptive national systems for disaster risk management based on the principle of “learning by doing” are more suitable (IPCC, 2012). Where such assessments generate uncertainty for decision-makers, tools such as multi-criteria analysis, scenario planning, and guidelines offer ways of supporting information. There is strong evidence to demonstrate that integratingdisaster risk management processes into development planning and practices leads to more resilient development pathways. (NDMP, 2007). This suggests an ideal national system for managing the risks from climate extremes and disasters would be designed to be fully integrated with social, economic and environmental development, poverty reduction, and humanitarian actions to create a holistic approach (IPCC, 2012).

Viet Nam has begun considering the integration of climate change factors into disaster risk assessment and management, some studies have adopted a comprehensive approach. For example, aggregate risk assessments during the implementation of DRM take into consideration factors related to climate change into assessing the threat, vulnerability and exposure to risk

(Nguyen Mai Post, 2010; Nguyen Tung Phong et al., 2011). However, Viet Nam is also facing common problems existing in many countries that need to be improved, for example:

- Lack of initiative in planning for DRM capacity building at all levels, limiting people and organizations' readiness for the challenges posed by climate change.
- Poor and inaccurate information on climate change, and associated uncertainties presented by climate change, as well as and requirements for response capacity.
- Unclear division of functions, roles, and responsibilities of different actors working within national disaster risk management systems at the national and sub-national level.
- Lack of flexibility, practical lessons and adaptive management in the national disaster risk management systems of different governance levels.
- Limited contextual information prevents decision-making in disaster risk management interventions at different scales level.
- Difficulty in identifying the costs and benefits of disaster risk management if the impacts of climate change and other changing factors are considered.

6.8. Conclusions and Recommendations

In general, laws and regulations on DRR in Viet Nam are quite comprehensice, from Laws, Decrees, Decisions at the national and local levels. However, the approachs are sill separated by types of disasters and by sectors, and mainly focus on the management responsibility of each sector. Therefore, legislation systems on DRM are often cumbersome, overlapping; implementation guidelines are slow and inconsistent. There is a lack of mechanism to deal with non-compliant cases; lack of policy to encourage participation in disaster insurances and encourage the private sector to participate in DRM. No legal document on either integrating DRM into or coordinating between DRM and socio-economic development is available.

During the implementation of DRM, Viet Nam has made remarkable success; lessons learned have been highly appreciated with regard to mitigating damages caused by disasters; some experience of DRM implementation have been published as guidelines/manuals for dissemination. Disaster prevention activities in Viet Nam mainly focus on response and recovery stages while overlooking other stages in the DRM cycle including forecast, warning and prevention, which are significantly limited. The importance of disaster warning, monitoring and prevention have been taken lightly by most people. Comprehensive training systems in both management and technique from central to local levels are not available. The organizational structure relating to disaster management (mainly storms, floods) at the local level are not in harmony.

Coordination in implementing DRM among ministries, sectors and provinces is limited, lacking harmonious planning or timely adjustments in resource mobilization policies for disaster prevention and reduction. Coordination among strategic agencies in proposing contents and programmes related to disaster management is slow and unrealistic; the coordination, evaluation and reporting at natinal and sub-national levels are not very effective.

The disaster information across the DRM cycle in Viet Nam has been made available on time and contributed positively to DRM, however, there has been inconsistence in evaluating cases, thus affecting the efficiency of the DRM cycle.

DRM in Vietnam is mainly implemented by the Government from budgeting to all stages of warning, forecasting, infrastructure development and disaster recovery. Therefore, people and the private sector have not been proactive, and lack awareness of their roles and responsibilities in the disaster prevention process. Insurance companies in Viet Nam have not actively involved in disaster insurance, but still heavily depend on subsidies of the Government.

The Law on Disaster Prevention and Control No. 33/2013/QH13 adopted by the National Assembly of the Socialist Republic of Viet Nam on 19th June 2013 and the President's Order No. 07/2013/L-CTN dated 28th June 2013 and the bylaws would create homogeneous comprehensive and effective legal frameworks for disaster management in Viet Nam. However, based on the current situation of DRM system, there remains a need to improve in the following issues:

- Reviewing, improving and completing DRM legislations in order to create a sufficient, consistent and unoverlapping system that is sizable, robust, strict and feasible. IT is important to enhance the training system on DRM that is consistent across sectors and levels, including awareness of the community and private sector to promote their initiatives and responsibilities throughout the DRM cycle.
- Strengthening the effectiveness of DRM in Viet Nam, through increasing investment in both human capacities and infrastructure for the prior-disaster period, including warning and forecasting at increasing level of accuracy and warning duration to mitigate the damage caused by natural disasters. Mobilizing the whole society to participate in disaster management in an effective and proper way.
- Human resources is one of the determinants of effective disaster prevention, as a result, in addition to awareness raising, there is a need for setting up trainning systems in management and techniques at different levels for different sectors.
- Strengthening the coordination between ministries, sectors and provinces, from formulating policies, legal documents, and socio-economic development plans to the implementation of activities, monitoring and evaluation of disaster-related information and data. Enhancing expertise in disaster prevention based on "integrated management approach in disaster prevention" in the context of climate change in Vietnam.
- Updating and moving towards the appropriate management model that is effective for all levels and sectors and ensures sustainability and feasibility within the communities; selecting advanced technologies to meet the "emergency" requirements in disaster prevention and reduction, for example, assessing relevant models to be replicated across provinces such as the "Center for disaster prevention and reduction" model in Quang Ngai province; or the "Multi-hazard Early Warning System for River Basin" model.

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Chapter 7

Managing the Risks: International level and Integration across scales

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Summary

Natural disasters and climate change often occur on a large scale, and can affect society, economy, environment and security of many countries. Therefore, disaster risk management (DRM) and climate change adaptation at national level have a close relationship with the activities at international level. The close cooperation between countries and regions will contribute to reduce the risk of natural disasters and climate change. For effective implementation of DRM and climate change adaptation, it is necessary to understand the current situation at the international level and consider how it is relevant to national level, how international actions can affect a country and vice versa (Section 7.2).

There are two principal mechanisms for international cooperation at the global level on DRM and climate change adaptation, which are the United Nations Strategy for Disaster Risk Reduction (UNISDR) and the United Nations Framework Convention on Climate Change (UNFCCC). In addition, there are other international and regional organizations and mechanisms contributing to DRM and climate change adaptation actions, such as: the ASEAN's Agreement on Disaster Management and Emergency Response, World Meteorological Organization, Global Network for Disaster Risk Reduction (GNDR), ASEAN Working Group on Climate Change, Asia-Pacific Typhoon Committee, etc. Viet Nam has actively participated in these organizations and mechanisms. Besides, Viet Nam has already developed policies and relevant organizations to implement the country's commitments (Section 7.3).

Despite support and opportunities from international and regional mechanisms and policies, the implementation of DRM and climate change adaptation in Viet Nam still faces a number of barriers related to legal and financial issues, technology transfer, disaster risk sharing, and dissemination of knowledge. Review of the opportunities, constraints and challenges that the international policy and finance framework may bring, as well as other important issues will help to provide an overview of the barriers, opportunities and options for DRM and climate change adaptation globally and in Viet Nam (Section 7.4).

DRM and climate change adaptation are currently managed by different agencies. The cooperation and coordination among DRM and climate change adaptation agencies is critical, in order to formulate suitable policies, strategies and integrate them into development programs and plans. These policies should be consistent with laws and policies on DRM and climate change adaptation of other countries, in order to be widely accepted (Section 7.5).

In Viet Nam, DRM and climate change adaptation activities are also managed by different agencies. DRM is coordinated by the Central Committee for Flood and Storm Control, with a permanent coordination agency in the Ministry of Agriculture and Rural Development. Meanwhile, the leading agency and focal point for responses to climate change is in the Ministry of Natural Resources and Environment. This leads to differences in financial resources, institutional setup and policies. Over the coming period, DRM and climate change adaptation will be integrated into development policies and plans of Viet Nam and it is necessary to do further research in order to better harmonize the international, national, sectoral and local interests based on national and international experience (Section 7.5.2).

7.1. Introduction

Climate extreme events are often related to large-scale disasters. Climate change may cause change in frequency and intensity of the extreme events, and for this reason climate change adaptation is one of the important aspects of the United Nations Framework Convention on Climate Change (UNFCCC), getting substantial attention of the parties to the Convention. Climate change adaptation can be implemented based on the experience from disaster risk management (DRM). The Hyogo Framework for Action (2005-2015), adopted by 168 Governments in Kobe, Japan in 2005, as well as agreements of the Parties to the UNFCCC enable climate change adaptation and DRM integration to a certain degree (IPCC, 2012).

Chapter 7 focuses on DRM and climate change adaptation activities at the international level; introduces the integration of climate change adaptation and DRM at international, regional and national levels; and the possibility to link climate change adaptation and DRM activities in Viet Nam with activities at international and Southeast Asia levels. This chapter will address the following issues: concepts of DRM and climate change adaptation (Section 7.2); International organizations and institutional frameworks on DRM and climate change adaptation (Section 7.3); Legal, financial and technological barriers and cooperation opportunities for DRM and climate change adaptation at international level (Section 7.4); and it provides policy recommendations related to DRM and climate change adaptation (Section 7.5).

7.2. Some principles in disaster risk management and climate change adaptation

Section 7.2 gives a brief overview of the concepts and principles related to DRM and climate change adaptation, including: finance and international support, other related regulations and policies. This section will also discuss the relevance of **DRM and climate change adaptation activities at international** level to national level in Viet Nam, how to link with international activities, these activities can affect Viet Nam and vice versa.

7.2.1. Systematic Risks and International Security

Systematic Risks refer to risks that are characterized by linkages and interdependencies of many entities, hence, impact on one or some entities can cause direct impact on the other entities. Because of close linkage and international interdependency, disasters occurring in one country can potentially impact other countries or regions in the world. For example, ice/permafrost melting not only increases level of risk in the directly affected areas, but also causes systematic impacts such as sea level rise, affecting coastal areas and island states, creating loss of habitat of many species, etc.

Environmental issues or economic development activities in one country can have direct impacts, sometime slowly and not be noticed immediately, to other countries. For example, in Mekong river basin, there is a plan on building 12 dams in the mainstream of the lower part of the basin in Thailand, Laos, Cambodia and Viet Nam and 14 dams in the upper mainstream in China. Beside the possible benefits from the hydroelectric dams, there are potential adverse impacts to the downstream countries, including Viet Nam. The construction of dams can change the flow and natural characteristics of the Mekong River and have serious adverse impacts on fisheries and food security (ICEM, 2010).

International systematic risk is also reflected in the related fields of society and economy such as international migration, finance and international trade. These problems have not only impact within one country but also have transboundary impacts (IPCC, 2012, page 399). The causes of migration are very complicated, hence there are still objections to the recognition of reasons for "environmental refugees" or "climate change refugees".

Recent reports estimated that over 20 million people were displaced due to natural hazards, A middle-range estimate has put the figure at 200 million by 2050 (IPCC, 2012, page 399). A typical example is the increasing climate related stress in the Lower Mekong River Basin (Cambodia, Viet Nam), people in the Mekong Delta may migrate to adjacent areas of Viet Nam and/or neighbouring countries due to their livelihoods being affected (Padilla, 2011).

International security is a necessary condition for regulated and orderly living and existence of human. International security can be understood in many aspects such as economic security, environmental security and social security issue has been and will be an important issue.

Food security is closely related to international security. Natural disasters have caused substantial damage to the economy and affected food security in the world. According to the report of Food and Agriculture Organization, currently there are about 1 billion people suffering from chronic undernourishment. The global number of hungry people was nearly 870 million (12.5 percent of the world's population) in 2010-2012, most of them, 852 million lived in developing countries (FAO, WFP and IFAD, 2012).

Viet Nam is one of the largest rice export countries in the world, but climate change and natural disasters have been and are affecting food production. Therefore, crop failure in Viet Nam due to the impact of climate extremes is likely to increase the risk for the global food market.

7.2.2. Economic impact

Natural disasters cause huge economic and human losses. After a natural disaster, the affected countries and regions apply measures to overcome the consequences. The results of these measures depend on economic and financial ability, as well as policy system of each country, region and the international support.

From 1994-2013, there were more than 530.000 deaths caused by about 15.000 extreme weather events, as well as nearly 2.2 trillion US-Dollars in damages worldwide (Kreft S. et al, 2014, page 4). According to the report of the United Nations International Strategy for Disaster Reduction, in 2012, 357 natural disasters were registered with 9,655 people killed and the economic damages were estimated about 143 billion USD (Guha-Sapir et al, 2013). Although the number of natural disasters in 2012 and the number of deaths caused by these disasters were less than the average number of the decade, the economic damage increased. In three consecutive years, the economic damages caused by natural disasters have always exceeded $ 100 billion. Due to the earthquake and tsunami in Japan, the damage caused by natural disasters worldwide has reached a record of 366 billion USD. According to the statistics of UN, the damages caused by natural disasters in 2012 were as follow: in Japan: 15,854 people were dead and more than 200 billion USD lost by the tsunami (NOAA, 2012); in US: losses from natural disasters in 2012 were more than 40 billion USD; New Zealand and Thailand had the same situation. The annual report on climate and global disaster revealed that, in 2013, there were 296 natural disasters worldwide, approximately 21.250 people were dead and economic losses were 192 billion USD (Impact Forecasting, 2014).

In Viet Nam, over the last 65 years, natural disasters have occurred in most of the country's regions, causing great loss of human lives, damage of properties, infrastructure and economic, social and environmental negative impacts. In addition, under climate change influence, the natural disasters became more complicated, increased in intensity and frequency, along with other unpredictable changes (Nguyen Tien Dung et al, 2013). Annually in Viet Nam, natural disasters cause more than 500 people dead and missing, thousands of people injured and economic damage counted for about 1.0-1.5% of GDP. In particular, during the period 2000-2010, the number of people killed by natural disasters were 5045 people, 617 people were missing, the total socio-economic losses were up to 91,275 billion (MARD, 2012).

The experiences of the past decade showed that, the close and efficient cooperation between countries and regions will reduce the risk, economic and human losses by natural disasters. Early forecasting and warning of natural disasters will provide more preparation time for response and more efficient prevention.

7.2.3. Shared responsibility and international support

The international community much concern about shared responsibility in DRM and climate change adaptation. In low-income countries, the average fatalities caused by natural disasters are 40 times higher and the direct asset loss ratios to average gross national income are three times greater than in high-income countries. In low-income countries, damages caused by natural disasters can be beyond risk management capacity. Shared responsibility can contribute to reduce vulnerability and poverty in these countries (IPCC, 2012, page 400).

Climate change, manifested by an increase in extreme events, has been, is and will be negatively impacting and threatening human life. This is a global problem that needs international cooperation and sharing. The poor, the elderly, children and women are the most directly affected and vulnerable to climate change. Without significant international assistance the most vulnerable countries will have difficulty in adapting to changes in extreme events and other impacts of climate change (IPCC, 2012, page 400). Effective sharing of responsibilities will reduce losses caused by natural disasters to a minimum.

There are many international organizations providing post-disaster support such as the United Nation (UN), members of International Federation of Red Cross and Red Crescent, Doctors without borders organization (MSF: Médecins Sans Frontières), v.v. . When disaster happens, the UN is one of the first organizations provide relief and support to the victims. World Food Programme provides food for the disaster areas and FAO provides seeds and plants for affected areas. United Nations High Commissioner for Refugees (UNHCR) and International Organization for Migration (IOM) have established the refuge for those who were forced to leave their homes. World Health Organization (WHO) helps with health protection of people displaced by natural disasters. United Nations Children's Fund (UNICEF), with the assistance of international organizations such as Save the Children, provides educational support for children in areas affected by natural disasters (http://www.un.org/en/globalissues/humanitarian/).

Viet Nam is consider as one of the countries most affected by natural disasters and climate change, therefore, participation in sharing responsibility will contribute to better DRM and provide support for disaster recovery in Viet Nam.

In addition, Viet Nam also actively participates in supporting and sharing with countries heavily affected by natural disasters. Viet Nam has jointly provided support to the victims of Hurricane Katrina in Louisiana and Mississippi in the United States. Viet Nam has also granted emergency aid of USD 100,000 to Philippines people affected by Typhoon Haiyan and is considering other assistance within the country's ability.

7.2.4. Legal obligations

7.2.4.1. Scope of international law

International law, according to the authoritative Article 38 of the Statute of the International Court of Justice, emanates from three primary sources: (1) international conventions, which establish "rules expressly recognized by the states," and result from a process of negotiations; (2) international custom; and (3) general principles of law, "recognized by civilized nations".

International Convention is a document clearly indicated the allowances and prohibitions related to a certain subject, agreed and committed by a group of countries. International convention is valid with member States, but also have effects to non-party countries.

In general, the international laws provide a sufficient legal framework related to climate change adaptation and DRM. These may include: obligations to mitigate the effects of drought (United Nations Convention to Combat Desertification); formulate and implement measures to facilitate adaptation (UNFCCC; see Section 7.3.1); exercise precaution measures (Rio Declaration); international cooperation to protect and promote human rights (IPCC, 2012, page 401) and develop national legislation to address DRM (HFA; see Section 7.3.2).

However the international legal instruments are not equipped to fully facilitate climate adaptation and DRM. To illustrate, the international agreements related to legal basis for disaster response, which aim to establish a legal framework for transboundary disaster relief and recovery, have been characterized as "dispersed, with gaps of scope, geographic coverage and precision" (IPCC, 2012, page 401), with states being "hesitant to negotiate and accept far-reaching treaties that impose legally binding responsibilities with respect to disaster preparedness, protection, and response" (IPCC, 2012, page 402). Another example, international refugee law does not recognize environmental factors as grounds for granting refugee status (IPCC, 2012, page 402).

7.2.4.2. Customary law and soft law principles

Unlike international conventions, customary law and soft law principles are applied flexibly. Currently, customary law and soft law principles are being widely applied to meet the States targets.

"Customary law" generally reflects the actual characteristics of each state or location but still follow a certain legal obligations, it comes from the actual situation of the country.

The "soft law principles" are important in shaping the development of international law and negotiations to develop more precise norms" (IPCC, 2012, page 402). In practice, the distinction between rules of customary law and soft law principles is frequently blurred. This is clearly reflected in the commitments related to the environment and climate change, such as in Principle 15 of the Rio Declaration "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities" (UN, 1992a); in Article 3 of the UNFCCC "Consider the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change" (UN, 1992b).

According to the UN Human Rights Commission, ""climate change can only be effectively addressed through cooperation of all members of the international community" (IPCC, 2012). This is reflected in Principles 18 and 19 of the Rio Declaration (UN, 1992a): *Principle 18* "States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted". Or *Principle 19* "States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith".

7.2.4.3. Non-legally binding instrument

Currently, besides the binding legal instruments between countries for international affairs in general or DRM in particular, there are non-legally binding instruments for these issues.

There are many organizations related to these issues such as: International Red Cross, non-governmental organizations and projects related to disaster relief, which focus on the assessment of disaster condition in the world, disaster response ability of most vulnerable countries, and launch the relief movement of voluntary international community for humanitarian reasons which are non-legally binding. The one should be mentioned is Sphere Project and Sphere Handbook. The Sphere Project was initiated in 1997 by a group of NGOs and the Red Cross and Red Crescent Movement to develop a set of universal minimum standards in core areas of humanitarian response. The aim of the Handbook is to improve the quality of humanitarian response in situations of disaster and conflict, and to enhance the accountability of the humanitarian system to disaster-affected people (Sphere project, 2011; http://www.sphereproject.org/).

7.3. International institutions and organizations on disaster risk management and climate change adaptation

Section 7.3 discusses the international institutions and organizations under UN related to DRR and climate change adaptation and other international organizations. Besides, this section also discusses the participation of Viet Nam, policies, guidelines and other relevant organizations of Viet Nam to implement the country's commitments.

7.3.1. The United Nations Framework Convention on Climate Change (UNFCCC)

7.3.1.1. Formation and Evolution

The United Nations Framework Convention on Climate Change (UNFCCC) was signed in 1992 and entered into force in 1994. UNFCCC is the common legal document for countries in the world to cooperate in efforts to respond to climate change. The objective of UNFCCC is: "…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (UN, 1992b).

Kyoto Protocol (KP) was adopted at the 3rd Conference of the Parties to the UNFCCC held in Kyoto, Japan in 1997 and in force from 16 February, 2005. KP set legal obligation for industrialized countries and countries with economy in transition for quantified greenhouse gases (GHG) emission reduction. Viet Nam ratified UNFCCC in 16 November 1994 and KP in 25 September 2002.

A major motivation of the UNFCCC negotiations is climate change mitigation, therefore all policies and measures aimed at reducing the emission or increasing the absorption of GHG. Adaptation to climate change was an important part of UNFCCC, but it was still given little priority despite of strong requirements of developing countries. From climate change adaptation side, the main mechanism to increase understanding and share best practice at international level is Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change (NWP), coordinated and implemented by Subsidiary Body for Scientific and Technological Advice (SBSTA). There is also COP16 Decision related to Cancun Adaptation Framework (CAF), including Loss and Damage (L&D).

NWP aims at assisting all Parties, in particular developing countries, including the least developed countries and small island developing States to: (1) improve their understanding and assessment of impacts, vulnerability and adaptation to climate change; and (2) make informed decisions on adaptation measures on a sound scientific, technical and socio-economic basis, taking into account current and future climate change and climate variability.

NWP is implemented by countries, intergovernmental and non-governmental organizations, private sector, communities and stakeholders. SBSTA encourages the active participation of stakeholders to implement NWP following determined working program and field. NWP disseminates knowledge and information on adaptation and emphasizes the work of the partners as much as possible through a variety of knowledge and publication products. Organizations, institutions, private companies at all levels and in all sectors can participate in the program by becoming a partner and building commitment to action.

Currently NWP focuses only on least developed countries, therefore, Viet Nam has not participated in this program. However, with its own objectives, NWP can help Viet Nam to raise awareness on climate change (including climate change impact assessment, vulnerability and adaptation measures) for community and to address socio–economic, technical and scientific problems in the future, with climate change issues taken into consideration.

The objective of the Cancun Adaptation Framework (CAF) is to enhance action on climate change adaptation, through international cooperation and consider problems related to adaptation under the Convention. Above all, strengthening adaptation activities is to reduce vulnerability and enhance resilience in developing countries, taking into account the urgent needs of most vulnerable developing countries. At COP17 in Durban in 2011, all Parties have promoted the implementation of the Cancun Adaptation Framework.

7.3.1.2. Status of implementation

There is to date no overall and comprehensive assessment of UNFCCC implementation progress. Parties to the UNFCCC are required to submit National Communications on their response to CC (including both mitigation and adaptation activities). The Conference of Parties to the UNFCCC (COP) and Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP) are the annual conferences to review the implementation; and also to discuss, bring out the action solutions to promote the implementation progress of the commitments under the UNFCCC and the Kyoto Protocol.

The Bali Action Plan, agreed at COP 13 in 2007, gave the priority to mitigation and adaptation actions, and identified technology and finance as the key mechanisms for enabling developing countries to respond to CC. There are five priority areas of adaptation actions (IPCC, 2012, page 407).

COP 15 did not achieve many agreements between the Parties, however, the Copenhagen Accord was considered as a key milestone. This is a nonbinding document but has been endorsed by the Parties about quantitative GHG emission reduction after 2012, and finance for climate change mitigation and adaptation actions have been identified for developing countries.

In 2010, the Green Climate Fund (GCF) was established and the Cancun Adaptation Framework was proposed in order create favourable conditions for the planning, prioritization and implementation of adaptation programs and projects, as well as the actions identified in the program, plans, national strategies in poor countries.

COP16 established the working program to consider the approach to solve Loss and Damage (L&D) problems due to negative climate change impacts in the vulnerable developing countries.

COP 18 and CMP8 have important role, marking the end of the first commitment period and starting preparation for the second commitment period (from 2013 – 2020) of Kyoto Protocol and moving to the implementation phase of Bali Action Plan.

COP18 agreed that it is necessary to carry out further studies to enhance understanding of loss and damage and decided the institutional arrangement at COP 19, such as an international mechanism, including the functions and methods, to solve the loss and damage problems in developing countries that are particularly vulnerable by the negative impacts of climate change.

AT COP 19 (2013), Warsaw international mechanism on loss and damage by climate change was considered as a key tool of the UNFCCC to promote the implementation of measures to address the problem of loss and damage in a comprehensive and unified way.

Evolution of adaptation policies within the framework of the UNFCCC showed an increase of adaptation policies in the negotiations, with more detailed level in COP Decisions. At the same time, the adaptation decisions link more and more closely with DRR, namely the Hyogo Framework for Action has been clearly mentioned in the Cancun Agreement.

Viet Nam established the Steering Committee for the implementation of UNFCCC and Kyoto Protocol on 04 July 2007, with 15 members from 14 Ministries and sectors, the Committee was completed with 18 members in 2009. MONRE is the focal point of the Government on the implementation of UNFCCC and KP.

As a Non-Annex I country, Viet Nam has fully implemented commitments to the Convention, such as: developing the National Communication, implementing GHG inventory, developing and evaluating GHG mitigation options and action plan on climate change adaptation. Viet Nam has submitted 02 National Communication to the UNFCCC in 2003 and 2010 and the first Biennial Update Report in 2014. These communications and reports included the overall assessment of climate change impacts and adaptation measures, however, the action plan to respond to climate change has not brought out in these two reports. In term of policy, Viet Nam has actively set out the targets and nationally appropriate response policies (see more detailed in Chapter 6). Although the Cancun Agreement encourages all countries to develop National Adaptation Plans (NAPs), Viet Nam has not submitted the national action plan to UNFCCC. In 2012, Viet Nam developed the National Action Plan on Climate change, this is the most detailed legal document on adaptation measures, with the same meaning as NAPs. These adaptation plans might be submitted to the UNFCCC within the framework of Intended Nationally Determined Contributions (INDCs) in 2015.

Climate change adaptation actions have been clearly stated in the National Strategy on Climate Change issued in 2011: "Simultaneously adapt to climate change and reduce greenhouse gas emission, focusing on adaptation in the early stage" (Government of Viet Nam, 2011). In the National Action Plan on Climate Change period 2012 - 2020 (2012), in addition to the objectives of strengthening capacity and institution for climate change adaptation and mitigation, the other key objectives also include "capacity building on climate monitoring and disasters early warning" and "actively respond to natural disasters" (Government of Viet Nam, 2012a).

In Resolution 24-NQ/TW, the viewpoint of the Communist Party of Viet Nam in response to climate change is "Simultaneously conducting adaptation and mitigation, particularly the adaptation to climate change, focusing on active prevention of natural disasters" (Communist Party of Viet Nam, 2013). It can be seen that, the policies on climate change in Viet Nam have always focused on climate change adaptation which mainstreamed disaster risk reduction. However, the policies and action plans on climate change in Viet Nam have not yet been submitted to the UNFCCC. Currently, Viet Nam is mainly focusing on strengthening the policy document, raising climate change awareness and mainstreaming climate change issues into socio – economic development planning and strategies.

7.3.2. United Nations International Strategy for Disaster Reduction (UNISDR)

7.3.2.1. Formation and Evolution

In 1989, the United Nations General Assembly designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR). About 120 National Committees were established in this period.

In 1994, at the first World Conference on Natural Disaster Reduction held in Yokohama, Japan, "Yokohama Strategy and Plan of Action" was produced to provide policy guidance with a technical and scientific focus.

In 1999, IDNDR was followed by the United Nations International Strategy for Disaster Reduction (UNISDR), which broadened the scope to include increased social action, public commitment and linkages to sustainable development. The UNISDR plays a role as a focal point in the UN system to ensure the coordination and integration of DRR activities into the development and other issues of the UN. The UNISDR encourages the mainstreaming of DRR and climate change adaptation.

In January 2005, the second World Conference on Natural Disaster Reduction was held in Kobe, Japan. 168 governments adopted the Hyogo Framework for Action (HFA) 2005-2015 with the main objective to build the resilience of nations and communities to disasters (ASEAN Secretariat, 2011). The HFA is not a binding agreement, it is a recommendation which the governments agreed and implement voluntarily. Some regarded the voluntary nature of the HFA as a useful flexible commitment, largely based on self-regulation and trust, while others regarded this as its inherent weakness (IPCC, 2012, page 404).

Since 2012, the UN General Assembly requested UNISDR to develop a post 2015 framework for DRR called the Hyogo Framework for Action 2 or “HFA2”. By 2025, the vision of the UNISDR is economic, social and political actions which should make DRR having impact all over the world.

7.3.2.2. Status of implementation

UNISDR mobilizes and coordinates the international efforts in DRR through a network of nations, intergovernmental and nongovernmental organizations, financial organizations, technical agencies, companies, scientific partners, members of the national assembly and local governmental officials, UN agencies and social organizations.

The main task of UNISDR is enabling countries to implement HFA. UNISDR established the Global and Regional Platforms on DRR – coordination between governmental and nongovernmental organization to create the diversity of stakeholders in field of disaster prevention and risk reduction. UNISDR convenes, informs and mobilizes countries to mainstream DRR into national policies and programs. These platforms are considered as a valuable opportunity to develop the partnership and network, to share the necessary knowledge and experience in order to turn global and regional commitments into actions. UNISDR also supports nations in the establishment and management of National platform.

To monitor the implementation of the Hyogo Framework for Action, UNISDR has created an online national self-assessment tool – *Hyogo Framework for Action Monitor (HFAM)* – which allows countries to report their HFA implementation progress. At the same time, UNISDR also develops the local self-assessment tools, allowing reports to be done at local level.

For the development and dissemination, as well as technical support for the tools application, UNISDR has published the biennial Global Assessment Reports (GAR) and the Regional Assessment Reports (RAR). Starting from 2009 to 2013, UNISDR has developed 03 GAR (GAR09, GAR11 and GAR13). Until 2013, there were 137 countries used HFAM to self-assess their implementation progress. 88 of those countries fully set up coordinating bodies for DRR (National Platforms) and 66 countries established national disaster damage and loss databases. Especially, at least 850 municipalities in 62 countries now have a dedicated institutional point of responsibility for DRR, backed with budget allocation (UNISDR, 2013, page 8).

Viet Nam held the National Platforms for DRR and climate change adaptation in 2011, 2012 and 2013. MARD and MONRE were assigned to promote and manage the Platform activities. UNISDR in collaboration with UNDP and other partners have supported sharing experiences and lessons learned in the development of Law on Disaster prevention and control in Viet Nam (Viet Nam's National Assembly, 2013).

Intergovernmental organizations play a supporting role, including, for example, promotion of DRR programs and integration into development planning, and capacity building (UNISDR, 2005b). In fact, the national governments play the primary roles in planning and implementation, while the UNISDR Secretariat and international organizations play supporting, advice and information sharing roles at the regional and global levels.

In 2010, the UN Special Representative of the Secretary General for DRR and the main donors to UNISDR requested an independent evaluation of the performance of the secretariat (IPCC, 2012, page 408). This assessment reviewed the overall effectiveness of UNISDR, especially in policy advocacy, awareness raising and establishing global and regional platforms. The assessment specifically highlighted the strong contribution of UNISDR in mainstreaming DRR into climate change policy. The difficulties and limitation of UNISDR are lack of definition of comparative advantage in climate change adaptation or the need to balance the focus and resources spent on DRR and climate change adaptation versus broader DRR activities.

HFA is just a strategic legal framework guiding the countries and territories to build their actions on disaster mitigation and post-disaster recovery. In 2008, UNISDR published guidance notes to provide the template for self-assessment of countries. The main instrument to guide and encourage HFA application is the HFA Monitoring Service on PreventionWeb (www.preventionweb.net/). In addition to the Global Assessment Reports on DRR (GAR), UNISDR has also published a mid-term review of the HFA implementation. World Bank (WB) and the United Nations Development Programme (UNDP) also use the HFA to guide their support to national and local programs on DRR and climate change adaptation.

The Global Assessment Reports show that since the adoption of the HFA, progress toward DRR is varied across scales and the global effort in DRR becomes more systematized. This variation is based on national government agencies self-assessment against the indicators defined by the UNISDR (UNISDR, 2008).

Viet Nam adopted HFA in 2005, since then the legal framework for DRR has been completed, governance and response activities have also been professionalized. Measures for disaster prevention, control and risk reduction is strengthened, early warning system is focused, improved and implemented via new means (television, radio, communication systems and local warning). Steering Committee for Flood and Storm Central (SCFSC) applied the *4 on-the-spot* motto in order to standardize the prevention and response as well as encourage the participation of the community. The “National strategy for natural disaster prevention, response and mitigation up to 2020” with specific actions, harmonious combination between non-structural and structural measures is considered as a foundation for strong and consistent guide at all levels and communities (Government of Viet Nam, 2007). The Program “Community awareness raising and community-based disaster risk management”, approved by the Decision No. 1002/QĐ-TTg dated 13 July 2009, has been implemented during 12 years in 6.000 communes and small villages frequently affected by natural disasters with main focus on education and community awareness raising (Government of Viet Nam, 2009). Law on Disaster prevention and control was approved by the National Assembly and came into force from 1 May 2014.

However, the DRR activities in Viet Nam still have certain limitations such as: lack of details in planning; DRR and climate change adaptation are not fully mainstreamed into socio–economic development process; limited and incomplete awareness on natural disasters and climate change amongst people and local authorities. “National Platform for DRR and climate change adaptation” in Viet Nam is quite new and not really associated with disaster prevention, control and risk reduction and climate change adaptation actions. Risk assessment from local to central level has been done gradually, however, the results were still not comprehensive due to the lack of unity of policies and supporting instruments. It can be said that, the biggest gap of Viet Nam in response and DRR are capacities and resources, so in the near future, resources strengthening should be promoted (MARD, 2012).

7.3.3. ASEAN Agreement on Disaster Management and Emergency (AADMER)

7.3.3.1. The process of formation and development

ASEAN Agreement on Disaster Management and Emergency Response (AADMER) was signed in July 2005, ratified by the 10 ASEAN member states and entered into force on 24 December 2009. This agreement aims to strengthen regional policy on disaster management, thereby enabling a regional framework with more active cooperation, coordination, technical support and mobilization of resources in all areas related to DRM (ASEAN Secretariat, 2011).

AADMER emphasizes the active participation of all stakeholders, such as non-governmental organization, the private sector and the local community, which is considered critical for disaster management. AADMER strongly affirmed the commitment of ASEAN to HFA. To concretize this commitment and to implement AADMER, the AADMER work program for the period 2010-2015 is designed to support national action programs and support the capacity of member states in disaster management in order to achieve the vision towards 2015 that the member countries should have the ability to respond to natural disasters and develop safe communities in the region.

7.3.3.2. The implementation status

The AADMER Work Programme for the period 2010-2015 (ASEAN Secretariat, 2011) includes a detailed roadmap for four strategic components: (1) Risk assessment, early warning and monitoring; (2) Prevention and mitigation; (3) Readiness and response; and (4) Restoration.

Some organizations in ASEAN are also involved in the process of implementing and monitoring the work program. ASEAN Coordinating Centre for Humanitarian Assistance in Disaster Management (AHA Centre) has been appointed as the main agency for implementing the activities of the Work Programme. ASEAN Committee on Disaster Management (ACDM) is responsible for overseeing policies and monitoring the implementation process. ASEAN Secretariat is supporting the policy coordination of ACDM and the Working Groups, at the same time will serve as the AADMER’s Secretariat and monitor the implementation of the AADMER work program.

The overall objective of the work program is to significantly reduce the human loss and socio-economic and environmental damage due to natural and human-induced disasters in the ASEAN member countries. The guiding principle of the AADMER Work Programme is to develop safety culture and natural disaster self-coping awareness in order to improve the ability to respond to natural disasters and cross-border cooperation between member countries.

Viet Nam is the member country responsible for early warning activities of the AADMER Work Programme (2010-2015). Viet Nam cooperates with the ASEAN Committee on Science and Technology to implement activities aiming at: (1) ensuring that Member States have the capacity to establish, maintain and periodically evaluate the agreement on disaster early warning; and (2) enhancing the early warning capacity for the region based on the existing capacity and system of the ASEAN.

7.3.4. International organizations

Worldwide, there are many agencies and international organizations involved in DRR and climate change adaptation activities. However, this section only introduces and analyses the strengths and weaknesses in implementation as well as the role of some key agencies/organizations

7.3.4.1. World Meteorological Organization (WMO)

World Meteorological Organization (WMO) is a specialized agency of the United Nations with the participation of 191 member countries and territories. This organization was formerly known as International Meteorological Organization established in January 1873. In October 1947, at the 12th World Meteorological Conference in Washington it was decided to rename the International Meteorological Organization to the World Meteorological Organization (WMO) and since 23 March 1950, the WMO official regulations have entered into force. Since then, the 23 March was selected as the annual World Meteorological Day. On 20th December 1951 WMO signed an agreement with the United Nations and officially became a specialized agency of the United Nations.

WMO provides a framework for international cooperation in the development and operation of activities related to meteorology, hydrology and apply it in practice. Within the framework of the WMO program, the National Hydro-meteorological Agency has contributed significantly to protect people and property from natural disasters, protect the environment and improve the socio-economic welfare.

In order to meet the demand for a comprehensive approach to climate change information, the 3rd World Climate Conference agreed to develop a Global Framework for Climate Services (GFSC) in 2009, with the goal of “developing and providing climate-related information and forecasts based on the scientific basis serving DRM and climate change adaptation in the world”. In 2011, the 16th Congress of the WMO has committed to “support and create favourable conditions for the implementation of GFCS as a priority of the WMO” (IPCC, 2012, page 409).

In Viet Nam, National Centre for Hydro-Meteorology (TT KTTVQG; http://kttvqg.gov.vn/) is the agency responsible for meteorological monitoring and forecasting, providing data used in disaster risk management and climate change adaptation. TT KTTVQG cooperates with similar agencies in other countries, which are closely linked together by the WMO.

7.3.4.2. Intergovernmental Panel on Climate Change (IPCC)

Intergovernmental Panel on Climate Change (IPCC) is a scientific organization sponsored by the United Nations, established in 1988 by the United Nations Environment Programme and the World Meteorological Organization. Currently, the IPCC has 195 participating countries (http://www.ipcc.ch/index.htm).

The IPCC does not conduct research or monitoring of climate-related phenomena. One of the main activities of the IPCC is review, analysis and publishing the special reports on topics related to the implementation of the United Nations Framework Convention on Climate Change (UNFCCC). From inception time to date, the IPCC has developed five Assessment Reports (ARs). The AR5 has been completed and officially published in 2014. The reports are often being prepared by 3 working groups (WG) related to physical science of climate change, climate change impacts, adaptation and vulnerability, and climate change mitigation. IPCC also includes a Task Force on National GHG Inventory. In addition, the IPCC also publishes special reports on a specific topic. The IPCC report is the source of scientific information for climate change policy makers. Vietnamese scientists are also involved in the development of and providing feedbacks for IPCC reports.

7.3.4.3. Typhoon Committee of Asia Pacific

Typhoon Committee of Asia Pacific (ESCAP Typhoon Committee/WMO) is an intergovernmental organization established in 1968 within the cooperation program of the United Nations, to promote and coordinate the planning and implementation of necessary measures to minimize the damage caused by the storm in the region. Since 1974, the Committee has operated more independently with the support of ESCAP (The United Nations Economic and Social Commission for Asia and the Pacific) and WMO. Typhoon Committee ESCAP / WMO consists of 14 members: Cambodia, China, North Korea, Hong Kong (China), Japan, the People's Democratic Republic of Laos, Macao (China), Malaysia, the Philippines, South Korea, Singapore, Thailand, Viet Nam and the United States (http://www.typhooncommittee.org/). Viet Nam officially joined the Typhoon Committee since 1979, the National Centre for Hydro-Meteorology (former National Hydro-Met Service) is the focal point of the Viet Nam to participate in the Typhoon Committee in cooperation with Standing Office of the Central Committee for Flood and Storm Control.

At the 46th session held at Bangkok in February 2014, the Typhoon Committee discussed various technical issues and carried out the mid-term review of the strategic plan for period 2012-2016 (ESCAP/WMO Typhoon Committee, 2012b). The activities of the Committee aim at minimizing the damage caused by storms and floods through coordinating the efforts of the Member States, as well as recommendations how to improve the prevention capacity of community and improve the methods of hydro-meteorology projection. The Typhoon Committee also assesses climate change impacts on the intensity and frequency of tropical storms in Asia and the Pacific (ESCAP/WMO Typhoon Committee, 2012a).

7.3.4.4. ASEAN Working Group on Climate Change (AWGCC)

ASEAN Working Group on Climate Change was established in 2009 to oversee the implementation of the related activities in the ASEAN Socio-Cultural Community Blueprint (2009-2015) (ASCC Blueprint) with six key elements: (1) Human Development; (2) Welfare and social security; (3) Rights and social equality; (4) Ensure environmental sustainability; (5) Create ASEAN identity; and (6) Narrow the gap between countries.

In 2012, the “ASEAN Action Plan on Join Response to Climate Change” was developed to provide a more detailed reference to the implementation of the ASCC Blueprint. Due to the interdisciplinary nature of climate change, climate change is concerned not only by AWGCC but also other relevant working groups in the areas of environment, agriculture, forestry, energy, transport, science and technology (http://environment.asean.org/). Viet Nam is the leading country in supporting long-term cooperation in the region to strengthen the climate change negotiation capacity (ASEAN, 2012).

Since 2014, Viet Nam has been selected as head of the ASEAN Working Group on Climate Change and the mission was officially assigned to the Department of Meteorology, Hydrology and Climate Change (DMHCC) from January 2015.

7.3.4.5. International organizations' technical assistance and support in implementation of disaster risk reduction and climate change adaptation

In 2007, at the first meeting of the Global Platform for Disaster Risk Reduction in Geneva, the Global Network for Disaster Risk Reduction (GNDR) was formally established. This is an international network of non-governmental and non-profit organizations aiming at improving the lives of people affected by disaster worldwide. The network currently has more than 300 organizations in more than 90 countries and has made the clearer linkage between DRR and climate change adaptation. GNDR poses a lot of initiative which emphasizes the development of linkages between DRR, climate change adaptation and poverty reduction. However, at present there is no formal assessment of the effectiveness of these activities.

Several social organizations related to disaster risk management and humanitarian aid integrated climate change adaptation activities into the activities of the organization. Typically the International Federation of Red Cross and Red Crescent has established the Climate Centre to assist in reducing climate change impacts and climate extremes to the vulnerable people (http : //www.climatecentre.org/). In Viet Nam, the Red Cross has many activities related to DRM, including: (1) Emergency and humanitarian assistance; (2) Search for relatives lost by war and natural disasters; and (3) Participation in natural disasters prevention and response. The Viet Nam Women Union also cooperates with international organizations and actively participates in preventing and responding to natural disasters across the country, particularly focusing on the field of child protection.

There are many international non-governmental organizations operating in the field of disaster risk reduction and climate change adaptation in Viet Nam. These organizations have many projects to be benefited from the professional and international experience, such as:

- Projects on community-based disaster risk management and climate change adaptation, including projects on assessment, planning, and enhancing the community capacity and "hard" measures at the small scale in order to enhance the community resilience to natural disasters and climate change;
- Planting mangroves in the coastal areas to protect the community;
- Education, hunger eradication, poverty reduction and promotion of gender balance, focusing on climate change adaptation and DDR integrated programs;
- Provide food, water and other essential items before and after the disaster.

Many bilateral and multilateral projects provide technical support including research, capacity building, and the construction of small and medium-scale infrastructure which are climate-resilient. For programs on larger infrastructure, the support sometimes is soft loan. The development agencies and international non-governmental organizations support capacity building for government agencies at the central level, including the Standing Office of Central Committee for Flood and Storm Control (http: //www.ccfsc. gov.vn/) as well as CCFSC offices at provincial and sectoral levels and other agencies related to DRM. In some provinces and cities, climate change coordinating offices have also been established with international support, for example in Can Tho (http://biendoikhihau.cantho.gov.vn/) and Da Nang (http://ccco.danang.gov.vn/).

7.4. Barriers and opportunities in disaster risk management and adaptation to climate change

Section 7.4 introduces and discusses the barriers and opportunities for legal, financial, technology transfer, disaster risk sharing, and knowledge of DRR and climate change adaptation in the world and in Viet Nam. The example of Viet Nam was analysed in the international context at present and in the future in order to give a general overview of the barriers, opportunities and options for the DRR and climate change adaptation activities of the country.

7.4.1. International law

7.4.1.1. Restrictions and limitations of international law

International law and negotiation treaties depend on the consensus of the countries. For example, the Tampere Convention on the prevention of telecommunication resources for DRR and the relief operations are only enrolled by 04 of the 25 countries which are often affected by natural disasters, thus limiting the influence of the convention on the beneficial countries (IPCC, 2012, page 411).

Some of the scope of international law can be applied to DRR and/or climate change adaptation, but may be limited by the application and the situation in the country. In the 1949 Geneva Conventions, International Humanitarian Law (IHL) is considered applicable and widely compliant, but is limited in situations of military conflict. In contrast, the International Disaster Reduction Law (IDRL) is seen as a copy of IHL in peacetime, it lacks a central regulation and the linkage with Geneva Convention, and there are difficulties in coordinating and monitoring IDRL (IPCC, 2012, page 411).

7.4.1.2. Opportunities to the application of international law

In addition to the provisions of existing international law related to DRR and climate change adaptation, more new provisions and contents are formed by countries and gradually improved in the process of their application and practice. The expansion of interpretation and application of existing international laws, as well as the introduction of new laws for DRR and prevention and climate change adaptation in the future is very promising.

The Conference of the Parties 21 (COP 21) taking place in France in 2015 is expected to be able to make a new agreement on climate change, including global adaptation objectives and new international commitments on finance and technology transfer. This agreement will provide opportunities for new international cooperation in climate change adaptation activities, and will affect the laws and regulations in the countries.

Although there is controversy about the international refugee law including expanding the definition of refugees, many countries oppose the use of refugee law to address international migration issues related to climate and climate change. However, according to analysis by the International Organization for Migration (IOM), migration may be a new strategy for climate change adaptation, although this method is considered as worse scenario to adapt to the severe change of the environment (IPCC, 2012, page 412). Therefore, in the future migration will be considered more in the laws related to DRR and climate change adaptation. The new legal concept of "protection responsibility" are also been proposed to use in DRR. Meanwhile, the law on human rights will promote and support this concept, which means that the climate migrants will be protected better.

7.4.2. International finance

7.4.2.1. Financial needs for adaptation activities

UNFCCC recognized that the developed countries in addition to reducing their GHG emissions and implementing climate change adaptation, also have the responsibility to support developing countries in the implementation of mitigation and adaptation activities. The necessary budget for adaptation activities worldwide is estimated at about US$ 48-171 billion in 2030 (or $ 60 to 193 billion in case of considering the investment for ecosystem adaptation) (UNFCCC, 2007b). Of these, about $ 28-67 billion annually is needed for developing countries (IPCC, 2012). Financial needs for adaptation for the infrastructure ranges from $ 8 to 130 billion in 2030, of which one third will be used for developing countries. Approximately $ 41 billion is needed for agriculture, water, health and protection of coastal areas and most of this investment was spent for developing countries (UNFCCC, 2007b).

In addition to the global estimate, the total financial needs for adaptation were also assessed at national level. The National Adaptation Programmes of Action (NAPAs) have been developed in most of the Least Developed Countries (LDCs), it is seen as attempts to assess the priorities and funding for adaptation needs. As of September 2009, the cost of the prioritized projects to meet urgent adaptation needs was about 1,660 million for the 43 LDCs which have completed NAPAs (IPCC, 2012 page 413).

Table 7-1. Estimate of annual costs for adaptation activities in developing countries

Organization	Year of assessment	Cost (billion USD)	Milestone
World Bank	2006	9-41	Present
Stern	2006	4-37	Present
Oxfam	2007	>50	Present
UNDP	2007	86-109	2015
UNFCCC	2007	28-67	2030
World Bank	2010	70-100	2010-2050

(*Source:* IPCC, 2012)

In Viet Nam, the results of some recent studies showed that climate change imposes significant impacts on Viet Nam's macro-economy. According to the World Bank's assessment on the economics of adaptation in Viet Nam, it is concluded that the impact of climate change on agriculture can reduce GDP in 2050 by 0.7%-2.4% depending on the scenario of GHG emissions and selected climate change models; the benefits of adaptation measures can be up to 1.3 to 1.6% of GDP, which can be higher than the adaptation cost (World Bank, 2010). In Viet Nam, the financial resource to cope with climate change is mainly from the national budget, loans of government, ODA projects and the programs, research, technical assistance and global funds.

7.4.2.2. Financial options

The international finance for climate change adaptation and disaster risk reduction (DRR) can come from different sources. Information on funding sources is integrated on the website Climate Finance Options (CFO) (http://www.climatefinanceoptions.org/). A CFO web-page is being developed exclusively for Viet Nam (Vo Thanh Son, 2012).

Other funds under the UNFCCC such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF) play an important role in climate change adaptation. Meanwhile, the Global Facility for Disaster Reduction and Recovery (GFDRR) plays a critical role in DRR. Climate change is a major obstacle to development, hence the World Bank has set aside 2% of the total funds for rehabilitation and reconstruction after disasters (IPCC, 2012, page 417).

7.4.2.3. UNFCCC's finance for climate change adaptation

A challenge to the international community is how to meet the financial needs for climate change adaptation. At COP 15 in Copenhagen (2009), developed countries agreed to contribute $30 billion to the "fast-track" finance over the period 2010-2012. This fund can help balance between climate change adaptation and mitigation activities. In the future, until 2020, the fund aims to leverage $100 billion/year from various sources in order to maintain the regular operation of the fund.

At COP 16, the member states agreed that "scaled-up, new and additional, predictable and adequate funding shall be provided to developing country Parties, taking into account the urgent and immediate needs of developing countries that are particularly vulnerable to the adverse effects of climate change"(UNFCCC, 2011; Section 97 of the UNFCCC Decision 1/CP.16).

(i) Global Environment Facility (GEF)

GEF was established in 1991. From 1991 to 2014, the GEF has sponsored 12.5 billion USD and co-financed $58 billion for 3690 projects in 165 developing countries (http://www.thegef.org/GEF/whatisgef). Additionally, through the GEF Small Grants Programme (GEF-SGP), the Fund has supported more than 18,000 projects with the highest level of $50,000 per project, which are mostly implemented by NGOs and community organizations.

GEF also manages the Special Climate Change Fund (SCCF; http://www.thegef.org/gef/SCCF) to support climate change adaptation and technology transfer in developing countries. In 2003, the GEF has established Strategic Priorities Fund for Adaptation (SPA), which spent $50 million from the trust fund for pilot and demonstration projects and to support countries in reducing their vulnerability and enhancing resilience to the adverse impacts of climate change. According to data as of 30th June 2010, SPA has spent $5.5 million to the program on Community-Based Adaptation (CBA) implemented by UNDP in the following countries: Bangladesh, Bolivia, Guatemala, Jamaica, Kazakhstan, Morocco, Namibia, Niger, Samoa, and Viet Nam (GEF, 2010).

In Viet Nam, the Ministry of Natural Resources and Environment is the focal point in cooperation with GEF and other related funds. Since 1998, Viet Nam has received 17 projects from GEF for GHG inventories and national communications with a total amount of $50 million (http://www.thegef.org/gef/gef_projects_funding). In addition, more than 25 projects under the GEF-SGP on climate change adaptation and mitigation at community level were implemented (https://sgp.undp.org/). Viet Nam does not receive subsidies from SPA or the Least Developed

Countries Fund (LDCF). Only one project "Climate change-resilient infrastructure in the northern mountainous provinces in Viet Nam" received a grant of 3.4 million dollars from the SCCF.

(ii) Green Climate Fund (GCF)
Green Climate Fund (GCF; http://www.gcfund.org/home.html) is a new UNFCCC financial facility which was established to support projects, programs, policies and other activities on climate change mitigation and adaptation in developing countries. The fund is one of the main financial instruments to allocate $100 billion/year to developing countries since 2020 as the commitment at COP 16 (UNFCCC, 2011). However, the current financial commitment to the fund remains very limited (by December 2014 it only reached about $10 billion). Simultaneously, the method of disbursement/support has yet to be agreed amongst related Parties. In Viet Nam, the Fund will be coordinated by the Ministry of Planning and Investment and distributed evenly for climate change mitigation and adaptation. GCF started operation since 2014 after reaching agreement on the GCF operation (GCF, 2014).

7.4.2.4. Other bilateral and multilateral financial resources

In addition to funding activities under the UNFCCC framework, adaptation finance is also provided through a number of other sources. Despite the increase of funds, the finance for adaptation needs has not yet been adequately prioritized.

A question is raised on how to link the climate finance with other international financial flows although the integration of adaptation will increase the efficiency of financial resources. However, the developing countries are concerned that, if the donor search for integration between adaptation and development, the funding for adaptation will not be added. Integration can also redirect the new and additional adaptation finance to development activities, thus limiting opportunities related to climate change. In addition, there are concerns that the ODA donor suppose that mainstreaming adaptation activities may impose conditions on the national direction. (IPCC, 2012, page 414).

(i) Global Facility for Disaster Reduction and Recovery (GFDRR)
The Global Facility for Disaster Reduction and Recovery (GFDRR) (https://www.gfdrr.org/) with the participation of 41 countries and 8 international organizations to assist developing countries including Viet Nam in DRR and climate change adaptation activities. The mission of GFDRR is to integrate DRR and climate change adaptation into national development strategies in developing countries by supporting the implementation of the HFA. At national level, GFDRR provides technical and financial assistance and infrastructure for climate change adaptation and DRR for a number of programs and projects. As of 5th June 2014, GFDRR has mobilized $395.5 million. GFDRR has a role in knowledge transfer, policies and practice in mainstreaming DRR with climate change. GFDRR has also been recognized for effective implementation of programs (IPCC, 2012, page 411). However, the resource mobilized through the GFDRR is still much lower than required. The integration of policies and monitoring of results is uneven across the countries. Despite these limitations, GFDRR has been rated as already implemented the necessary steps to enhance its function and implementation scale (IPCC, 2012).

One of the programs supported by GFDRR in Viet Nam is the Support Program to Respond to Climate Change (SP-RCC). GFDRR supports 03 projects in Viet Nam with the total amount of approximately $4.5 million (GFDRR, 2013), through giving loans to small-scaled infrastructure to reduce their vulnerability due to disaster. In addition, GFDRR provides information about climate catastrophes and climate change adaptation and DRR adaptation activities supported by many donors and this information is posted on DFDRR website.

(ii) Support Program to Respond to Climate Change National (SP-RCC)
In 2009, the international partners have supported Viet Nam in developing the SP-RCC to attract the investment into climate change response activities in Viet Nam. The program is being implemented and aims to supporting climate change response activities in Viet Nam, developing and implementing climate change policies and institutional framework, and ensuring that climate change be integrated in the policy-making process.

Initially, the SP-RCC program has have 02 donors, namely Japan International Cooperation Agency (JICA) and the French Development Agency (AFD). To date, the SP-RCC has more donors, such as the World Bank (WB), Canadian International Development Agency (CIDA), Australian Agency for International Development (AusAID) and Korea Eximbank (K.Eximbank). So far Viet Nam has received $1 billion through the SP-RCC program. Currently, a number of other donors are discussing with the Ministry of Natural Resources and Environment to consider their participation in the program.

(iii) Financial assistance program for the National Target Program to Respond to Climate Change
In December 2008, the Government of Viet Nam has approved the National Target Program to Respond to Climate Change (NTP-RCC), with the total budget of 1,965 billion (nearly $94 million) over the period 2009-2015 (Government of Viet Nam, 2008). The financial sources to implement the NTP-RCC include the state budget and international supports from the Government of Denmark, Canada and Australia (Government of Viet Nam, 2012b).

The finance for implementation of NTP-RCC is allocated over the years as following: 2010: VND141.7 billion (2010), VND166 billion (2011), VND340 billion (2012), VND248.3 billion (2013) and VND242 billion (2014). In addition to the NTP-RCC, the SP-RCC has about 200 climate change-related policy actions in the last 4 years (including three pillars: adaptation, mitigation and institutional and cross-cutting issues) with 14 objective-groups already developed and being implemented. Currently, in Viet Nam a forum has been established for policy dialogue on climate change amongst ministries, donors, non-governmental organizations and the business community. In parallel, the coordination and cooperation mechanisms between central and local agencies and between government agencies and donors have also been developed.

(iv) Other bilateral and multilateral financial sources
Other bilateral and multilateral donors, UN organizations and NGOs also supported a variety of climate change adaptation and DRM activities in Viet Nam. Key sources and mechanisms include:

- **Bilateral Aid:** includes direct activities with key ministries and some provincial agencies. Amongst donors, Australia, Denmark, Germany and Japan are the main sponsors. For example, Germany and Australia provided funds for coastal ecosystems-based adaptation programs in the Mekong Delta. Netherlands supported Ho Chi Minh City in planning for climate change adaptation, and worked with line ministries on the overall planning for the Mekong Delta.

- **Multilateral technical assistance**: provided by the development banks and UN organizations on DRR and climate change adaptation, the technical assistance activities include mainstreaming climate change into sectoral activities.
- **NGO activities**, including sponsored activities. NGOs are also supporting climate change adaptation and DRR activities, especially at the local level, most of the activities are concentrated on capacity building. This support is likely to be one of the few financial channels that can be accessed by the civil society groups.

(v) Domestic/national financial resources for climate change adaptation and DRR

- **The domestic or national funds.** Viet Nam Environment Protection Fund (VEPF) supports environmental projects, mainly in the form of concessional loans. Current regulations require all CDM credits supported by ODA will be transferred to this fund, not to the project owner. Some stakeholders are concerned that this mechanism may limit the development of carbon finance and Viet Nam can lose significant funding opportunities in the future. However, in addition to lending environmental projects and activities, one of the priority tasks of the Fund is to finance environmental restoration activities after disaster in the disaster area.
- **Government budget allocation:** In general, the detailed information on actual expenditure for climate programs in Viet Nam is inadequate (Chitra Priambodo et al, 2013).
- **The involvement of civil society:** The participation of CSOs in climate change programs and projects, including finance, and their access to related information is still limited and difficult.

7.4.2.5. The barriers to the international climate change adaptation and DRR finance

a) Barriers to DRR finance

According to Kellett and Caravani (2013) in the financial report on DRR to be submitted to GFDRR, within the past two decades, the international finance for DRR often encounter the following barriers and limitations:

- The finance for DRR has not really received adequate attention. According to the GFDRR, within the past two decades the international community has contributed a total amount of $3,000 billion, of which was only $106.7 billion for disaster and approximately $13.5 billion for DRR measures.
- The financial resources are not allocated appropriately, focused only on some type of disasters/projects and mainly in middle-income countries. In developing countries, finance for DRR fluctuates. For example, the aid for DRR occupy relatively large portion in the total aid for disaster in some countries such as Colombia (39.6%), China (40.9%) and the Philippines (55.7%); while in other countries this ratio is quite low such as Tajikistan (9% of $40.3 million), Mozambique (3.7% of $1.1 billion), Kenya (7.7% of $1.6 billion) and Haiti (3.6% of $2.7 billion). Funding for drought has not really been focused as the current funding primarily focus on floods and catastrophes such as earthquakes and tsunami.
- Low capacity of countries in allocation of finance for DRR. For example, the low-income countries with limited state budget for disaster management could hardly get financial support for DRR, e.g. countries affected by drought in the Sahara (Africa). In contrast, the countries with more available funds for disaster often attract more financial aid for DRR.

b) Barriers to climate change adaptation finance

The information on climate change projects is still highly fragmented. The government agency responsible for managing the climate finance has no common set of criteria to identify climate change projects or systems to track and monitor the expenditure on climate finance. Therefore, it causes difficulties to tracking climate finance, especially for the development projects which do not consider climate change as the focus, but also have content related to climate change. Most donors do not have a specific definition for climate finance, which is often, be considered part of the ODA budget, leading to difficulties in tracking climate finance. The lack of detailed information also halt comprehensive analysis. From that perspective, the development of a transparent auditing system is necessary (CARE and Oxfam, 2013).

Besides, the level of investment, especially for adaptation projects, is relatively low. However, the technical assistance or demonstration projects are still essential, especially in the short-term, in order to encourage innovation in the different areas.

In the long term, climate change adaptation and DRR finance should not be dependent on aid from the developed countries but need to be mobilized from other sources such as the state budget and the private sector. But above all, it is necessary to have a better coordinated and integrated financial mechanism with appropriate objectives.

7.4.2.6. The opportunity to apply for international finance for climate change adaptation and disaster risk reduction

a) For Disaster Risk Management:
As reported by Kellett and Caravani (2013), the opportunity for DRR finance includes:

- Finance from donors for DRM is stabilized in recent years, and is moving from international finance for projects on large infrastructure to that of adaptation funds;
- Several countries have positive move in DRR, such as Indonesia and the Philippines, which have considerably invested into DRR activities in their home countries, even more than the international financial support.

b) For climate change adaptation:
According Bapna and McGray (2008), the opportunity to adaptation finance includes:

- Developed countries have certain responsibilities in financial support for adaptation activities in developing countries through international funds for adaptation;
- The domestic investment for adaptation activities in developing countries is increasing and likely to increase over time. For example, Bangladesh has allocated $40 million from the state budget to develop the Climate Change Trust Fund.
- The cooperation amongst developing countries will be increasingly promoted. The emerging economies (e.g. China and India) is likely to provide financial support for adaptation activities for low-income countries to help these countries to cope with climate change. For example, one of such funds is the Insurance Fund for Disaster Risk in the Caribbean area.

7.4.3. Technology transfer and cooperation

7.4.3.1. Introduction to technology transfer

According to the IPCC, "technology transfer" is the process including the transfer of experience and equipment on DRM and climate change adaptation amongst governments, private sectors, financial institutions, NGOs and research/education institutions (IPCC, 2000). The IPCC used the word "transfer" which includes the technology sharing and cooperation amongst countries.

Technology transfer has received much attention in climate change adaptation and DRR. The operation and maintenance of the technology will be the challenge to developing countries due to lack of resources, human capacity and cultural differences. On the other hand, technology transfer can be complex, requiring capacity building and need to focus on the user rather than the technology designers (IPCC, 2012, page 414).

The institutional, political, technological, economical, information, financial, cultural and legal problems can be barriers to the transfer of climate change adaptation and DRR technologies, which countries should attempt to overcome. Public-private partnership as a policy tool may be a necessary mechanism for technology transfer for adaptation projects (IPCC, 2012, page 414).

Intellectual property rights are rarely seen as a problem for the transfer of adaptation technologies. However, when the intellectual property rights is an issue, it is necessary to take measures to promote the application of new and more affordable technologies but still encourage technological developers (IPCC, 2012, page 414).

In Viet Nam, the government has enacted the Law on technology transfer at Decision No. 80/2006/QH11 dated 29/11/2006 (National Assembly of Viet Nam, 2006), Law on Intellectual Property at Decision No. 50/2005/QH11 dated 29/11/2005 (National Assembly of Viet Nam, 2005) and the amendment of number of articles of the Law on Intellectual Property at Decision No. 36/2009/QH12 dated 19/06/2009 (National Assembly of Viet Nam, 2009), which can be considered as legal basis supporting the receipt of climate change adaptation and DRR technologies.

7.4.3.2. Technology for disaster risk reduction and prevention

In general, DRR and prevention include many different contents, and hence the technology can be applied separately for each content. The contents include: (1) Early warning; (2) Search and rescue; (3) Provide logistics, environmental clean-up and sanitation before, during and after disasters; (4) Infrastructure on disaster prevention.

Another important issue to reduce the damage caused by natural disasters is the ability to forecast and provide early warning messages. Satellite and remote sensing, the climate models, computer tools including geographic information systems (GIS) and other local and regional information systems are major components of the early-warning system. The application of GIS technology in support of emergency operations play an important role. With GIS technology, it is possible to provide information and support decision-makers to make the right decisions, and help to locate and rescue victims effectively.

Space technologies (such as earth observation, satellite images, real-time applications of space sensor, mapping techniques) have a very critical role in DRR activities. Currently, a number of developing countries such as India, Bangladesh, China, Philippines and Viet Nam have developed remote-sensing systems for the purpose of DRR and prevention.

Currently, information on the scale and nature of the disasters is provided by the ground technology. However, this information can be provided more efficiently by using input from a space sensor system. Micro satellites (with small weight and size, less than 500kg) are also regarded as the important technology for the detection of weather-related hazards. Some Asian countries have cooperated with the countries of the Organisation for Economic Co-operation and Development (OECD) to developed micro satellites for earth observation, such as Daichi and WINDS equipped with both optical and microwave sensors.

One more important thing in the early-warning technology is to take advantage of the advances in communication technologies such as broadband wireless access, Global Positioning System (GPS) and GIS technology to improve the relevance and effectiveness of the warning.

Viet Nam is located in the tropical monsoon area, one of the five storm-prone regions of the Asia - Pacific, often faced with many types of disasters. The severe consequences of past natural disasters requires the attention and efforts to strengthening DRR and prevention measures and applying science and technology.

In many locations, the DRR and prevention is based on practical experience of local people. However, it is clear that the experience-based measures are passive and damage is inevitable. For proactive DRR and prevention, it is necessary to have more effective strategies. The National Strategy for disaster reduction and prevention until 2020 focuses on the application of advanced technologies in forecasting storms, floods, droughts, salinity intrusion, earthquakes; early warning of tsunami and other hydro-meteorological hazards, focusing on extending the lead time in storm and tropical depression forecast up to 72 hours before the event; promoting communication; enhancing research capacity and capacity to monitor the global, regional and territorial natural fluctuations.

Currently, a variety of scientific works have been carried out for the purpose of DRR and prevention. The application of GIS technology in predicting and preventing floods is one example. In some projects GIS technology was integrated into flood-forecasting software. For example, in the project: “Application of GIS maps for flood mapping in Quang Nam province”, GIS technology was studied and applied together with hydrological models for flood forecast and prevention in Quang Nam province. Based on these parameters, decisions can be made to help evacuate people from dangerous areas (Dinh Phung Bao et al., 2012).

The technology using numerical models to predict the meteorological and hydrological factors also receives great attention from many scientific organizations in Viet Nam. Currently, in addition to the traditional meteorological and hydrological forecasting methods, the application of a system of models are also widely used in Viet Nam to provide early, timely and more accurate reports to help mitigate the damage caused by natural disasters.

7.4.3.3. Technology for climate change adaptation

In order to effectively adapt to climate change, different measures shall be applied. Adaptation measures include adjusting of infrastructure design, increasing flexibility of management system, enhancing adaptability of natural system, reducing vulnerability, improving capability and awareness of communities.

The key issue is to identify the appropriate technology to enhance the capacity to respond to disasters and climate change. For example, applications in coastal adaptation systems include different types of GIS technologies such as mapping, surveying, satellite images, videography, remote sensing, global positioning system…These technologies help formulate adaptation strategies, implementing strategies and provide early warning system (UNFCCC, 2006b). There are several examples on adaptation measures to protect against sea level rise such as dikes, levees, floodwalls, seawalls, revetments, bulkheads, groynes, detached breakwaters, floodgates, tidal barriers, and saltwater intrusion barriers among the hard structural options, and

periodic beach nourishment, dune restoration and creation, and wetland restoration and creation as examples of soft structural options (IPCC, 2012, p.415).
Measure selection process should consider local conditions and not affect sustainable development of the area in order to achieve high efficiency in responding to disasters.
Structural measures would be selected based on local conditions such as environmental impacts and hydrological and meteorological regimes.
Various types of technologies should be used to respond to climate extremes such as improved drainage system, emergency plans, raising buildings and protecting against sea level rise…Many of these technologies could be considered meeting both DRM and climate change adaptation objectives such as risk reduction for ecological system and society. Adaptation technologies have been used over generations in coping with floods such as building floating houses or floating cultivated lands. Some technologies were developed based on new invention such as advanced materials and satellite remote sensing. An example of a successful technology transfer is the typhoon proof house project in Danang which was funded by Rockefeller foundation and Asian Cities Climate Change Resilient Network. The project provided technical assistance and loans for 244 households in Danang to build their typhoon proof houses. The project achievements were confirmed after Nasri typhoon in 2013 (Tran Van Giai Phong, 2013). After the project, the Danang Women's Union proposed to People's Committee of Da Nang to develop policy to integrate typhoon against standards into construction procedures in Danang.

7.4.3.4. Financing technology transfer

Recent financing mechanisms have mainly focused on climate change mitigation. There are lack of financing mechanisms for climate change adaptation due to insufficient incentives, increased risks and high transaction cost (Klein và nnk, 2005). However, lesson learned from the mitigation technology transfers could be good references for climate change adaptation. In Viet Nam, Support Program to Respond to Climate Change Program (SP-RCC) operate as a bilateral and multilateral fund to support the implementation of National Target Programme to Respond to Climate Change (NTP-RCC and also serves as a policy dialogue platform on climate change between Viet Nam and the international development partners in order to achieve the ultimate goal of enhancing institutional environment for climate change response in Viet Nam. Projects funded by SPRCC remains their priorities on adaptation targets, for example, dyke building or strengthening projects, mangrove planting projects…
Cost is one of the main barriers of technology transfer. Therefore, innovative financing ideas are needed. Financing potentials for technology transfer could come from bilateral, multilateral sources and the private sector for example, World Bank, regional banks, GEF (SCCF, LDCF), financial flow generated from CDM and private sectors.
Estimated budget demanded for mitigation technologies varies from 70 to 165 billion USD per year and only 10-20% of that would be delivered to developing countries. Current budget for financing adaptation projects in developing countries is estimated around 1 billion USD (UNFCCC, 2009a). The literature shows that technology transfer for adaptation is lag behind that for mitigation. It's necessary to have more support on finance for technology transfer in adaptation area.

7.4.4. Risk sharing

7.4.4.1. International risk sharing

At present, there are many mechanisms to support countries to share disaster and climate change risks. These mechanisms could help vulnerable countries to reduce losses caused by disasters and climate change. Applying these mechanisms at national and global scales could bring challenges and also opportunities to countries.

Risk sharing is a part of climate change adaptation and DRR. Hyogo framework (2005) called for promoting financial mechanism for risk sharing, particularly insurance and reinsurance against disasters (UNISDR, 2005a). In 2007, Bali Action Plan calls for consideration of risk sharing mechanisms as an instrument to enhancing climate change adaptation (UNFCCC, 2007a). The Plan considers the insurance as set out by Article 4.8 of the UNFCCC and Article 3.14 of the Kyoto Protocol.

7.4.4.2. International risk sharing mechanisms

International risk sharing mechanisms include: i. Remittances; (ii) Post disaster loan; (iii) Insurance and reinsurance; (iv) Alternative insurance instruments; và (v) Regional risk funds.

a. Remittances

Remittances are money transfers from expatriate individual or communities to their home countries creating huge financial sources as informal risk sharing, even huger than the formal sources. In 2010, the total recorded global remittance were estimated around 325 billion US dollars and the unrecorded could be around 50% of that amount. In some countries, remittances could contribute one third of their GDP (IPCC, 2012, p. 418). Although, concept of remittance is very simple, transfer fees could make it more complicated. These transfer fees vary from 2.5% - 40% (IPCC, 2012, p. 418). International communities are active in reducing the fees and barriers for post disaster remittances.

Recently, remittances in Viet Nam have been substantially increased. In 2010, the official flow of remittances in Viet Nam was estimated around 8 billion dollars, 25.6% more compared to that of 2009. In 2012, the remittance flows in Viet Nam in 2010 and 2011 were 10 and 11 billion dollars, respectively, which were ranked 9^{th} globally.

To encourage and create favourable environment for Vietnamese living overseas and foreigners to transfer money to Viet Nam Decision 170/1999/QĐ-TTg dated 19/9/1999 on encouraging Vietnamese living overseas to transfer money to their home country. This is an opportunity to promote the channel of remittances to future risk sharing in order to adapt to climate change and reduce disaster risk.

Box 7-1. Catastrophe Deferred Drawdown Option

Catastrophe Deferred Drawdown Option (Cat DDO) of World Bank is a credit line providing liquidity for International Bank for Reconstruction and Development (IBRD) member countries for post disaster. Viet Nam is one of 188 IBRD member countries.

CAT DDO guarantee member countries the ability to access financial sources before disaster occurs. Each country could access a loan of up to 500 million USD or 0.25% of its GDP (IPCC, 2012). The money could be delivered right after a country declares its emergency situation. In order to access CAT DDO, the loaner would need to implement a disaster risk management programme and the programme would be periodically examined by World Bank.

As of December 2010, three countries have approached Cat DDO loan. Costa Rica had received 24 million dollar loan from Cat DDO after a 6.2-magnitude earthquake on May 01, 2009. Guatemala had accessed to 85 million USD for reconstruction and other costs after two huge disasters occurred in 2010. Colombia has borrowed $150 million to resolve the crisis caused by the worst monsoon season over decades in this country (IPCC, 2012).

b. Post disaster loan

One of the most important financial mechanisms for post disaster is loans for governments and individuals. Since 1980, World Bank have loaned more than 500 loans for post disaster recovery and reconstruction with total budget of more than 40 billion dollars (World Bank, 2006). Asian Development Bank also reported huge loans spent for post disaster. (IPCC, 2012, p. 419). Awareness of increased important role of pre-disaster preparedness, some international organizations provide pre-disaster loan options – for example, the World Bank's catastrophe deferred drawdown option would deliver money right after a government declares the emergency (IPCC, 2012, p. 419).

At present, Viet Nam has many financial providers. Financial organizations face with the risks that loaners always want to lose the contingent of financial provision or to clear the debt for them. These risks are more serious at more vulnerable areas.

c. Insurance and Reinsurance

Insurance is the risk sharing mechanism which is most recognized by international community. The portion of damaged property due to climate extremes which have been insured increased from negligible level in 1950 to 20% in 2007 (IPCC, 2012, p. 419).

Insurance and reinsurance markets attract capital from international investors making insurance as an instrument to share disaster risks globally. Insurance market development is unequal from a country to another country at global scale. From 1980 to 2003, 4% of total losses was insured from developing country, approximately 1 billion USD, while this number from developed country was 40% (IPCC, 2012, p. 419).

There are 3 popular types of climate change insurance products which are:

❖ New insurances created in the context of climate change:

- Agriculture insurance (for such risks as drought, flood, insects, or weather, which can cause losses): Agriculture insurance was operated since early decades of the 19th century and have proved the role of adaptation to new risks. At initial stage, the products of this insurance were only applied in developed countries such as the US, Japan, United Kingdom and France… Later on, the application of this product reached agricultural countries such as Indonesia and Philippines;
- Flood insurance started in 1990's. At present, products of flood insurance were widely applied to countries which suffer huge losses from natural disasters (Tsunami, flood) such as Thailand and India;

❖ Insurance products developed from existing (adding new climate change related terms);

❖ Consulting service/loss reduction.

Among above insurances, Viet Nam has applied agricultural insurance at pilot scale (see details in chapter 9). Disaster insurance was mentioned and elaborated in Disaster preparedness law (National Assembly of Viet Nam: clause 5, article 5).

d. Alternative insurance instruments

Alternative insurance instruments include: (i) Catastrophe bonds(CAT), (ii) industrial loss insurance (iii) Reinsurance (a company purchases a portion or all of an insurance contract from an insurance company to share profits and risks) and (iv) Right to sell natural disaster bonds Those mechanisms play an important role for providing finance when huge losses happen.

CAT is the most prominent instrument among those mentioned above. Over 90% CAT bonds were issued by insurance and reinsurance companies in developing countries. Although, this is still pilot market, values of CAT bond were doubled from 2005 to 2006 and reached peak at 4.7 billion USD in 2006 but decreased to 3.4 billion USD in 2009 (IPCC, 2012, p. 420).

e. Regional risk pool

Regional risk pool is an initiative which support vulnerable countries, especially small countries, to have more opportunities in international risk sharing by integrating regional risks or national risks and integrating national reservation over time. Regional risk sharing could reduce insurance cost, thus reduce the variety of reinsurance pricing cycle and ensure insurance cost for insured governments (IPCC, 2012, p.420). For example, Caribbean Catastrophe Risk Insurance Facility (CCRIF) was established in 2007 to provide insurance for Caribbean countries with significant lower cost (approximately 50% reduction) compared to cost that if they have to buy in the financial markets.

7.4.5. Knowledge Sharing

The processes of integrating DRR and climate change adaptation and integrating climate change adaptation and DRR into development planning, strategies require different types of knowledge sharing at different scales. It’s necessary to have the collaboration from scientists in different areas, planners, decision makers and public sectors (IPCC, 2012, p. 421).

The establishment of risk sharing mechanism is to exchange experiences, tools and information to support DRR and climate change adaptation activities at different scales and the integration of DRR and climate change adaptation into development plans (IPCC, 2012, p. 421).

International Council for Science (ICSU, www.icsu.org) is a key international organization which encourages and supports information sharing on global environment changes, including DRR and climate change adaptation. ICSU is a NGO focusing on scientific research. At present, ICSU has been supporting 4 programmes on Global Environment Change (GEC). These programmes play key roles on developing and providing background science for DRR and climate change adaptation (IPCC, 2012, p. 422). The link between science knowledge and policy on climate change adaptation was included in IPCC’s activities, meanwhile the link for DRR was included in UNISDR’s activities. The ultimate goal is to provide information to each region to solve environment issues toward sustainable development (IPCC, 2012, p. 422).

Currently, the approach for climate change information dissemination is top down, based on global models which provide information at larger scale, not details at local level and with high uncertainty level giving challenges for policy makers in decision making process. Moreover, climate change happens in a long term, possibly 50-100 years, while a policy only lasts 5-20 years. Besides, other factors could affect decision making processes, thus climate information at differential scales are necessary. In future, annual climate information and a decade climate projection should be integrated in DRR and climate change adaptation (IPCC, 2012, p. 422).

Although weather forecasting and meteorological WMO networks are being improved, number of meteorology stations are quite small and some stations are not sufficiently equipped. (IPCC, 2012, p. 422).

The integration of cross-sectoral information is a huge challenge for DRR and climate change adaptation. Integrated Research on Disaster Risks (IRDR) - cosponsored by ICSU, International Social Science Council (ISSC) and UNISDR – was established to apply integrated approach in studies on natural and human induced disasters (IPCC, 2012, p. 422). Information sharing and dissemination are improved through the establishment of websites such ReliefWeb (www.reliefweb.int) which is operated by UN office for Coordination of Humanitarian Affairs (OCHA) in 1996 and recently, PreventionWeb (www.preventionweb.net).

In Viet Nam, MONRE is a focal point of providing information and knowledge on climate change. Institute of Meteorology Hydrology and Climate Change (Under MONRE; http://www.imh.ac.vn/) developed climate change scenarios and sea level rise for 7 climatological areas in Viet Nam in 2009. In 2012, the scenarios were updated and downscaled to 63 provinces/cities. Based on the scenarios, each Ministry and each province would assess impacts of climate change and sea level rise and then developed their own action plans to respond to climate change and sea level rise. Beside formal information on climate change disseminated by MONRE, other climate change information could be provided by Universities, research institutions, international organizations and NGOs.

Hydro-meteorological monitoring data and forecast are provided by the National Hydro-meteorological Service, local and provincial Hydro-meteorological services. Central committee for flood and storm control (CCFSC) and Provincial/city People's committees use weather forecast information to prepare for DRM. All information related to disasters are published on CCFSC website (http://www.ccfsc.gov.vn/KW6F2B34/Disaster-Database.aspx).

Information technology and mass media play important roles in sharing and disseminating disaster news as well as climate change information. At present, Viet Nam national television (VTV) and local televisions also have important roles for providing and sharing information and knowledge to support communities to effectively prepare and respond to natural disasters. However, more efforts on identifying and disseminating news on vulnerabilities and natural disasters should be made in order to contribute effectively to DRR.

In addition, application of electronic devices such as mobile phones, websites, online blog or forum with interactive function, linkable to other websites could help disseminate information on disasters, preparedness methodologies and other DRR important messages effectively to multiple people at once (IPCC, 2012). In Viet Nam, July 2012, Ho Chi Minh City People's committee gave permission for sending disaster warning messages to mobile phones. In 48 hours before landing of a storm/hurricane, preparedness and related organizations have to send warning messages to residents' mobile phones frequently. At present, this technique has been applied widely in provinces in Viet Nam. For example, in 2013, timely information on Haiyan hurricane was disseminated and updated to the residents.

Knowledge dissemination and sharing on DRR and climate change adaptation are implemented by DRM organizations such as UNISDR, International Federation of Red Cross and Red Crescent… Natural disasters and climate change related issues are also studied at universities, research institutes. However, the studies sometime are quite academic. Therefore, these studies should be translated into applicable languages for general public in order to enhance DRR and climate change adaptation activities at different levels. Information technology also contributes to enhancing interactions among individuals, from national to regional and to international level, forming networks for global DRR.

Establishment of national, regional and international communication networks is encouraged in order to enhance knowledge dissemination and sharing. Some international disaster database networks could be listed as Centre for Research on the Epidemiology of Disasters (CRED), NatCatSERVICE or DesInventar (IPCC, 2012, p. 423). Currently, 18 Asian countries including Viet Nam, are members of DesInventar network and the focal organization in Viet Nam is MARD. Disaster database of Viet Nam and other member countries are published in DesInventar website (http://www.desinventar.net).

Another initiative of DRR and climate change adaptation is RANET. The RANET network always gets strong community engagement in information dissemination from global data bank combined with local and regional database, provides input and forecast results to serve food security, agriculture and health in rural areas (IPCC, 2012, p. 423). Establishment of other websites, for example Prevention Web sponsored by UNISDR, ProVention Consortium (www.proventionconsortium.org) and UN adaptation mechanism (www.adaptation learning.net) is to enhance DRR and climate change adaptation activities.

In the process of applying information technology (IT) for DRR and climate change adaptation, it is necessary to recognize two roles of IT. First, IT plays an important role in exchanging knowledge on disaster risks and hazards. Second, IT plays a role in dissemination of information. These two roles should be recognized separately because knowledge is what can be received from information analysis while information can be obtained by gathering multiple data. Hence, enhancement of information provision and dissemination does not necessarily mean that information would be well analysed and integrated into DRR and climate change adaptation. It depends on the capacity of each region/ country, technological and development level and existing policies. Therefore, sufficient information doesn't guarantee the effectiveness of DRR. Websites only provide information but the analysis and integration of those information into DRR and climate change adaptation policies/plans depend on each country and local capacity (IPCC, 2012, p 423).

Another challenge in DRM is the lack of cooperation between financial/development organizations and DRR/climate change adaptation organizations. For example, urban planners rarely cooperate with DRR and climate change adaptation people for a building's construction resulting in increasing the vulnerability of the building if disasters happen in future. Therefore, facilitating collaboration in research, information sharing and practices among DRR organizations and other organizations should be considered as activity supporting global security (IPCC, 2012, p. 423).

The difference in languages and terminologies between DRR and climate change adaptation people is another challenge. Currently, countries move toward establishment of DRR organizations which have similar organizational structures with related regional and international organizations. Such establishment may help in strengthening the communication globally and linkages between DRR and climate change adaptation.

7.5. Institutional and policy recommendations to integrate DRR and climate change adaptation

DRR and climate change adaptation have many things in common in terms of definition and objectives but there are still differences between them. DRR and climate change adaptation haven't been integrated closely into/with each other due to some major challenges and limitations. In future, in order to effectively manage disaster risks and climate change adaptation implementation, it is very important to overcome the barriers and challenges in integration DRR and climate change adaptation into each other and into development plans, strategies and policies.

7.5.1. Policy framework

At global and national scales, there are many studies and policies related to DRR and climate change adaptation. The UNFCCC and UNISDR are international legal basis to guide and adjust the DRR and climate change adaptation activities at both national and international scales. However, the different scales for application and implementation of UNISDR and UNFCCC make the integration of DRR into climate change adaptation and vice versa more challenging (IPCC, 2012, p. 424).

Viet Nam has appropriate policies to implement these international commitments such as: National Strategy on Climate Change (Government of Viet Nam, 2011); National Action Plan on Climate Change, period 2012-2020 (Government of Viet Nam, 2012a); National Target Programme to Respond to Climate Change (Government of Viet Nam, 2008); research projects, studies and policies of the line Ministries and provinces or municipalities for climate change adaptation and mitigation.

Viet Nam has ratified HFA and used HFA as guidance to manage and coordinate the DRR activities. Viet Nam has also put great efforts for institutionalization of DRR at national level by ratifying the Law on Natural Disaster Prevention and Control (National Assembly of Viet Nam, 2013), National Strategy on Natural Disaster Prevention, Response and Mitigation to 2020 (Government of Viet Nam, 2007) and Action Plans of Ministries and provinces to implement the Strategy as well as Project "Enhancing community awareness and community based DRR" (Government of Viet Nam, 2009) etc.

Besides, the integration/combination of agencies responsible for DRR and climate change adaptation is necessary to formulate effective strategies and policies in order to integrate DRR and climate change adaptation into development planning at national scale. These policies and strategies will only be accepted and up-scaled widely if they are aligned with existing laws and policy framework on climate change adaptation and DRR. These policies also need to show the consistence between DRR and climate change adaptation.

So far in Viet Nam and globally, climate change adaptation and DRR are not so well integrated with each other and into development plans and policies. The main reason is the differences in temporal and spatial scales as well as institutional structures of DRR and climate change adaptation at both international and national levels. For example: in Viet Nam the National Strategy on Climate Change sets targets and tasks at national level until 2050 and is managed by the MONRE. On the other hand, the DRR programmes and projects are usually managed by MARD and implemented mainly at community level, such as Project “Enhancing community awareness and community based DRM” implemented in 6000 villages frequently affected by disasters (Government of Viet Nam, 2009).

7.5.2. Institutional setting

International organizations involved in DRR and climate change adaptation include both governmental and non-governmental organizations. However, within these organizations DRR and climate change adaptation are managed by separate units/divisions, and located in different places in the world. Some international organizations integrate DRR and climate change adaptation together into one unit. However, there are still some debates regarding the integration of DRR and climate change adaptation between and within organizations due to possible effects of the integration on DRR policies and activities.
At present, in most countries DRR and climate change adaptation are managed by different organizations. Usually climate change adaptation is managed by Ministry of Environment (e.g. MONRE in Viet Nam) while DDR is usually managed by Ministry of Home Affair (in Viet Nam, DRR is managed by MARD). The integration of different organizations/units responsible for the two mechanisms into one might bring some benefits for climate change adaptation and DRR activities.

7.5.3. Mechanism and financial sources

At international level, climate change adaptation and DRR activities receive finance through different channels and sources. Countries could possibly receive DRR finances if their DRR policies meet requirements of HFA and UNISDR, while finance for climate change adaptation comes from Global Environment Facility (GEF), Adaptation Fund (AF) or Green Climate Fund (GCF). Each fund has different financial mechanism and procedures. These are barriers not only for DRR projects to apply for fund but also for integrating DRR and climate change adaptation.

In Viet Nam, to implement the National Strategy on Natural Disaster Prevention, Response and Mitigation to 2020, MARD proposed a budget of 18 billion USD (GFDRR, 2009). The action plan to implement this Strategy (2009-2010) includes 36 projects with total budget of 242.76 thousand billion VND (approx.13.12 billion USD).

7.5.4. Integration of DRR and climate change adaptation

Generally, DDR and climate change adaptation are different in terms of institutional structures and functions at 3 levels: local, national and international. At international level, the integration between DRR organizations and climate change adaptation organization is very limited. The reason for this is that climate change adaptation started to receive attention only since the scientists discovered the GHG emission as major reason causing climate change. Initial target of responding to climate change is GHG emission, and thus related to Ministry of Environment at national level. In the meantime, DRR activities focus more on preparedness, recovery and aids when a natural disaster happens. These activities are normally implemented by disaster preparedness organization or aid-relief organizations at national level.

The approach of DRR is different from that of climate change adaptation. Normally, DDR applies bottom up approach (i.e. from local to national then to international level). Vice versa, climate change adaptation is recognized as a global issue, so initially climate change adaptation applies top down approach. This difference could be opportunity for DRR and climate change adaptation to complement each other when integrated. Climate change adaptation could lift up the level and support DRR activities at global level while DRR could support climate change adaptation at local level.

In Viet Nam, as mentioned, DRR and climate change adaptation are managed by different agencies (Section 7.3) The management of these two important subjects by two different ministries could make certain challenges to implement both DRR and climate change adaptation, especially at local level because of:

- Human resources at local level: The management of DRR and climate change adaptation by different agencies could result in lack of human resources in implementing either of them at local level.
- Finance: Normally, financial demands for implementing DRR and climate change adaptation are very large (See 7.5.3). Therefore, budgets managed by different organizations could make financial amount for DRR and climate change adaptation be divided into smaller portion or overlapped, resulting in reducing effectiveness of DRR and climate change adaptation activities. Separation of DRR and climate change adaptation could limit the potential of attracting international funding for each mechanism. Moreover, at present, Viet Nam is lack of policy which could attract financial sources, particularly financial source of private sector for climate change adaptation and DRR activities and doesn't have proper policy to attract more international finance.
- Policy: DRR and climate change adaptation have the same target of disaster and climate risk reduction. However, again, climate change adaptation and DRR are managed by different agencies resulting in different policies and rules for each mechanism, causing barriers to implement or manage related activities.

Although, integration of climate change adaptation and DRR concept is relatively new and facing many challenges, it has attracted a lot of attention from the Government of Viet Nam. However, similar to international level, the integration at national level faces many challenges and barriers. The barriers could be listed as follows:

- Institution: The integration of DRR and climate change adaptation agencies/ministries at national level or departments (at local level) is not feasible at present because the integration should require new units/offices resulting in extra budgets for operation and management of these new units and changes in workforce of related organizations. Besides, the integration and institutional arrangement of international organizations are still on debate causing barriers and challenges for domestic institutional arrangement.
- Policy: Institutional re-arrangement for DRR and climate change adaptation requires proper policy.
- Capacity: The capacity of DRR and climate change adaptation is still insufficient and far from adequate, particularly at local level.
- Information, data: Climate change scenarios and sea level rises developed by MONRE and downscaled only to provincial/city level, thus it would be very difficult to apply the scenarios for DRR at commune and district level.

Conducting studies for identifying measures to overcome these barriers is a key factor to integrate successfully DRR and climate change adaptation.

7.5.5. Integration of DRR and climate change adaptation into development plans

Aware of adverse impacts of climate change and natural disaster on socio-economic development, the Government of Viet Nam have been putting great efforts on integrating DRR and climate change adaptation into policy and development plans. The Government of Viet Nam approved National Strategy on Climate Change, National Strategy on Disaster Prevention and Control, action plans, programmes, projects and proposals for implementation of these Strategies. One important task of these Strategies is to integrate DRR and climate change adaptation into strategies, planning and socio-economic development plans of sectors and municipalities. However, the integration concept is relatively new, policy makers and planners are facing many challenges in this task of integration. Some existing and ongoing studies and projects to prepare for integration of DRR and climate change adaptation into strategies, planning and development plans could be listed as follows:

- "Guidance for integration of climate change issues into strategies, planning and socio-economic development plans at national/sectoral and local levels" developed by IMHEN and released in 2012 (Tran Thuc et al., 2012).
- "Guiding framework for prioritization of climate change adaptation activities in socio-economic development planning" issued by MPI in 2013 (MPI, 2013).

In the upcoming period, the Government of Viet Nam will keep focusing on studies of policies for integration of climate change adaptation into DRR and vice versa as well as integration of climate change adaptation and DRR into development planning and policies.

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Chapter 8

Toward a Sustainable and Resilient Future

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Table of Contents

Executive Summary

Based on the results achieved in Chapters 3, 4, 5, 6, 7, Chapter 8 is considered to be an orientation toward a sustainable development future which is resistant to the effects of climate change extremes in Vietnam.

With this purpose, this chapter presents the research on "Relationship between Disaster Risk Management and Sustainable Development", "Integration of Short- and Long-term Responses to Extreme Events", and "Relationship between Disaster Risk Management, Adaptation to Climate Extremes, and Mitigation of Greenhouse Gas Emissions". These issues are the theoretical and practical basis to help policy makers in Vietnam define a more specific vision for future development.

Remarks drawn from these studies are:

- Conservation of natural capitals such as biodiversity and ecosystem services, applied science and technology play an important role in directing and harmonizing the nation's socio-economic development goals;
- Integrating disaster risk reduction and climate change adaptation is an important issue in adjusting socio-economic policies and developing sectoral strategies, including connecting short and long-term activities through a synchronous implementation process, in order to bring about the highest efficiency for the present and future;
- Enabling economic and social development as well as maintaining environmental security are essential to the implementation of sustainable development goals while Viet Nam is facing challenges of water shortage, degradation of land resources and biodiversity;
- In Viet Nam, the impact of disaster risk and climate change are considered to be at the tolerant threshold, particularly concerning the vulnerability of affected populations, such as the poor, women, children and ethnic minorities as well as the most heavily affected industries such as agriculture and aquaculture, transportation and infrastructure; and
- The role and awareness of leaders at all levels, as well as the adoption of appropriate approaches, such as adaptive management, will contribute to promote social change in order to adapt more effectively to climate change and and disaster risk reduction.

Based on the aforementioned findings, Chapter 8 provides directions for "Planning for Proactive, Long-term Resilience to Future Climate Extremes" and "Synergy between Disaster Risk Management and Climate Change Adaptation for a Resilient and Sustainable Future".
From the practical disaster risk management and climate change adaptation in Vietnam, three lessons were summarized, namely: 1) Strong commitment of the Government towards disaster risk reduction and climate extremes in order to proactively adapt to climate change; 2) Awareness raising, capacity development associated with the mobilization of community participation in disaster risk reduction, extreme events and climate change adaptation; and 3) Coordinating and promoting national capacity and international cooperation.

8.1. Introduction

Based upon Vietnam's practical conditions, this chapter reviews the major contents on "Toward a Sustainable and Resilient Future" of the Special Report on *"Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation"* (SREX) by the InterGovernmental Panel on Climate Change (IPCC, 2012). The structure of this chapter is as follows: Starting with reviewing the relationship between Disaster Risk Management and Sustainable Development (Section 8.2), reviewing the interactions over time between the present and the future (Section 8.3), assessing natural resources, environmental and social aspects related to sustainable development (Section 8.4), as well as analyzing the relationship between disaster risk management, climate change adaptation and emission reduction. (Section 8.5), in order to establish grounds for response measures and plans towards future climate extremes (Section 8.6), and concluding by emphasizing the synergy between disaster risk management and climate change adaptation, aiming at building a sustainable society (Section 8.7).

Section 8.2. discusses the relationship between disaster risk management and sustainable development, starting by clarifying the concepts (Section 8.2.1), reviewing the roles of ecosystems and biodiversity (Section 8.2.2), emphasizing the importance of awareness (Section 8.2.3), the role of technology (Section 8.2.4) and concluding by considering the challenges in decision-making (Section 8.2 .5).

By concentrating on the time factor, Section 8.3 considers the integration of short-term and long-term objectives through the evaluation of efficiency of present operations resulting in future benefits (Section 8.3.1), reviewing barriers in combining short-term and long–term goals (Section 8.3.2), and recommendation of connecting short-term and long-term actions (Section 8.3.3).

Section 8.4 assesses natural resources, environmental and social aspects towards sustainable development, by analyzing available capacities and resources as well as limitations (Section 8.4.1), considering those who benefit and are affected at all levels (Section 8.4.2), and the possibility of affecting human security aspects (Section 8.4.3), and referring to the implementation of relevant international goals (Section 8.4.4).

Section 8.5 concentrates on the relationship between disaster risk management, climate change adaptation, and greenhouse gas emissions reduction, in which the limitations of resilient capacity are considered (Section 8.5.1), and considers the synergy and conflict between mitigation, adaptation and disaster risk management in urban and rural areas (Section 8.5.2).

Section 8.6 identifies the tools and plans to promote resilience to climate extremes and combine the adaptation, disaster risk management, and other policy goals, of which scenarios are established (Section 8.6.1), then emphasizing short-term and long-term implementation plans using analysis tools and models to improve disaster risk management and adaptation (Section 8.6.2), and finally making recommendations on promoting change (Section 8.6.3).

Finally, (Section 8.7), the chapter concludes by emphasizing the synchronous collaboration between disaster risk management and climate change adaptation in order to build a sustainable society.

8.2. Relationship between Disaster Risk Management and Sustainable Development

8.2.1. Concepts of Adaptation, Disaster Risk Reduction, and Sustainable Development and How They are Related

Sustainable Development is a concept that defines development in all aspects in the present while maintaining the ability to ensure continuous development of long-term future. In Vietnam, sustainable development has become the strategy, view and goal of development, and was manifested through the implementation of the "National Plan for Environment and Sustainable Development 1991-2000" (President of the Ministers'Council, 1991). The viewpoints regarding sustainable development was confirmed in Directive No. 36-CT/TW of June 25, 1998 of the Political Bureau on "Strengthening environmental protection during the period of industrialization and modernization of the country", and was re-affirmed at the 9th National Congress of the Communist Party of Vietnam and on Strategy for Socio-Economic Development 2001-2010, of which "Rapid, effective, and sustainable development, economic growth accompanied by the implementation of social progress and equality, and environmental protection".

More specifically, the sustainable development progress in Vietnam has been clearly reflected in the Strategic Orientation for Sustainable Development, in which "*The overall objective of sustainable development is to achieve full material life, spiritual and cultural richness, equality among citizens, the consensus of society and the harmony between human and nature; development should promote a strong, reasonable and harmonious combination of three aspects: economic growth, social advancement and environmental protection*" (Government of Viet Nam, 2004).

Disaster risks are losses of human life, properties, environment, living conditions and socio-economic activities caused by natural disasters, pursuant to Article 3 of the Law on Natural Disaster Prevention and Control (the National Assembly, 2013), this concept is also discussed in Chapter 1 and Chapter 2 (IPCC, 2012 page 32). Disaster risk management and disaster risk reduction are defined in this chapter as the processes of designing, implementing, and evaluating the strategies, policies, and measures to enhance the understanding of disaster risk, disaster risk reduction, disaster risk insurance, continuous improvement in disaster prevention, response, and recovery practices, with explicit objectives of increasing human security, well-fare, quality of life, and sustainable development (IPCC, 2012 page 34). Adaptation to climate change is reviewed exclusively in human and natural systems (IPCC, 2012 page 36), meanwhile the Ministry of Natural Resources and Environment (MoNRE, 2008) also introduced the concept of climate change adaptation and mitigation, of which the adaptation aspect is defined for both natural and human systems, whereas climate change mitigation are activities to reduce the level or the intensity of greenhouse gases emission.

The concepts of disaster risk reduction and climate change adaptation are also systematically presented in Chapter 1, Section 1.1.2. *Key concepts and definitions*. These concepts and contents are manifested in major policies of Vietnam, in chronological order, starting with climate change mitigation, limiting the detrimental impacts of climate change, natural disasters prevention and control, and consitute one among nine priority areas in the Strategic Orientation for Sustainable Development of Vietnam (Government of Viet Nam, 2004). Disaster prevention and control missions, which consist of prevention, response and recovery in order to mitigate losses caused by disasters, ensure sustainable development are expressively stated in the

National Strategy for Natural Disaster Prevention, Response and Mitigation (Government of Viet Nam, 2007). In the National Strategy for Climate Change (Government of Viet Nam, 2011a), natural disasters are assessed in the context of climate change impacts and climate change adaptation, of which climate change adaptation and greenhouse gases emissions reduction must be integrated in sustainable development, targeting towards a low-carbon economy. Recently, the concepts of natural disasters, natural disaster risk, natural disaster prevention have been reconfirmed and specified in the Law on Natural Disaster Prevention and Control (National Assembly, 2013), and disaster risk management must be implemented by industrial sectors and provinces based on the sustainable development standpoint.

8.2.2. Ecosystem Services in the Context of Disaster Risk Management and Climate Change Adaptation

According to the Millennium Ecosystem Assessment (MEA, 2005), Ecosystem services include direct or indirect benefits which human enjoy from the functions of ecosystems, including: (i) supplying services (food, fresh water, and materials etc.); (ii) regulating services (watershed area protection, flood protection, climate regulation etc.); (iii) cultural services (aesthetic values, recreation and eco-tourism, science and education etc.); and (iv) support services (soil formation, nutrient conditioning etc.).

Reducing human pressures on ecosystems and managing natural resources more sustainably can create favorable conditions for climate change mitigation efforts and reducing vulnerabilities caused by extreme climate phenomenona. The degradation of ecosystems is undermining their capacity to provide products and services upon which human livelihoods and societies depend (MEA, 2005; WWF, 2010), and reducing their ability to respond to diaster risks. The coastal and marine ecosystems play an important role in regulating "the health of the oceans and coastal areas", however they are very vulnerable to the effects of climate change (Nguyen Chu Hoi et al., 2013). If well preserved, ecosystem services will bring many benefits to social and economic development such as those in the Mekong Delta (WWF, 2012).

Ecosystem can act as natural barriers against extreme climate events to reduce natural disaster risks. However, in case of strong impact (shock) of extreme climate events, the ecosystem conditions can be changed and these changes depend on its resilience capacity (IPCC, 2014 page 445). For instance, the role of mangroves is studied with regard to protecting coastal areas, fighting erosion, limiting salinization and promoting alluvial process (Phan Nguyen Hong et al., 2009a), restraining the damage of tsunami (Phan Nguyen Hong et al., 2009b), reducing the impact of waves during typhoons, protecting sea dyke (Phan Nguyen Hong et al, 2008), absorbing wave energy (Nguyen Thi Kim Cuc, 2013) as well as protecting the environment, especially the highly diverse forests with high plants density (Trương Thị Nga, Võ Thị Trúc Hà, 2009).

The rising of sea level will exacerbate the issue of salinization, affect important coastal wetland areas and significantly impact various freshwater species in the sanctuaries ecosystems, including national parks and nature reserves in the Mekong Delta, especially the U Minh Thuong National Park and Bac Lieu Nature Reserve, affect the conservation of wildlife and rare species (Ministry of Agriculture and Rural Development, 2013). Lagoon ecosystems have been severely affected by flooding and the rising of sea level, resulting in changing the salinity of the lagoon, destroying fisheries infrastructure, affecting aquaculture and fishing activities (Cao Lệ Quyên, Nguyễn Chu Hồi, 2009). Coastal ecosystems are also affected by natural disasters, such as degradation and destruction of coral reefs under the effects of tropical storms and bleaching phenomenon in Con Dao (Nguyen Huy Yet, Vo Si Tuan, 2009). Climate change also affects the biodiversity of wetlands and nature reserves in the Mekong Delta (Le Anh Tuan, 2010b).

The impact of climate change on natural ecosystems have been reviewed in details in Chapter 4, Section 4.3.2. The impact on natural ecosystems and practical experiences in biodiversity conservation for the purposes of reducing the risks of extreme climate events impact on society and human are reviewed in Chapter 5, Section 5.3.3. Land use and ecosystem protection.

Ecosystems and ecosystem-based approaches can also facilitate adaptation to the change in climate conditions, reducing the pressures and impacts on water supply, forest conservation of carbon sinks (IPCC, 2012 page 445). In Vietnam, several recent scientific studies have examined the mutual relationship between climate change and ecosystems (CRES, 2013), especially coastal ecosystems (Phan Nguyen Hong and Tran Thuc (Lead author), 2009) as well as wetland ecosystems (CRES, 2011). In Vietnam, scientific basis and the application of ecosystem-based approaches for natural resources management and climate change adaptation has been summarized (Truong Quang Hoc, 2013), especially the application of ecosystem-based approach for wetlands (Shepherd and Ly Minh Dang, 2008). Previously, the ecosystem-based approach was applied for natural resources management at Cuc Phuong National Park and Na Hang Nature Reserve as pilot models by the Center for Natural Resources and Environment Studies (Truong Quang Hoc and Vo Thanh Son, 2008). In recent years, research programmes on climate change adaptation have adopted ecosystem-based approach in improving resilience, adaptation capacity as well as addressing the consequences of climate change in the coastal cities such as Da Nang, Quy Nhon and Can Tho (NISTPASS, 2011), in the planning of biodiversity conservation in Vietnam, and accumulation of experiences in strengthening resilience to adapt to climate change in three urban areas of Vietnam (Hanoi, Dong Hoi and Can Tho) (World Bank, 2012).

Climate change network of non-Governmental organizations (CCWG) is implementing activities to build CCA models applying ecosystem-based approach such as project in Thanh Hoa implemented by CARE (SRD, 2011), studying the adaptation of mangrove ecosystems in coastal areas under the impact of sea level rise in the Red River Delta (Nguyen Thi Kim Cuc, 2011) and other models of climate change adaptation in agriculture and forestry in Nghe An (Nguyen Thi Huong Giang, 2013) and the model of community-based climate change adaptation in Bac Lieu (Tuong Phi Lai, 2013).

The Government of Vietnam has soon developed policies and applied pilot payment model for forest services, by devising a specific plan, including practical research, a review summary and the integration and development of policy through implementating activities and pilots in several provinces. The issuance of Government's Decree No. 99/2010/ND-CP on the payment policy for forest services, which was adopted throughout the country, has been highly commended by international community (Ministry of Science and Training (MoST), 2012b). The development of payment policy for forest services in Vietnam is a positive example of associating the biodiversity conservation policy with the reduction of greenhouse gas emissions policy (IGES, 2011). Mainstreaming ecosystem services into the planning process, especially for wetlands, is being implemented and has achieved initial results in the Mekong Delta (Kim Thi Thuy Ngoc, 2011).

8.2.3. The Role of Awareness-raising in Shaping Responses to Disasters and Extreme Events

Values and perceptions affect actionsin response to climate extremes, and they can be part of sustainable development. Indigenous knowledge, cultures and experience in dealing with natural disasters play a very important role in climate change and disaster risk adaptation, especially at the community level. The development of Vietnam was built on wet rice civilization along the rivers and deltas. To ensure economic development and social welfare, generations of Vietnamese have built a massive system of dykes along major rivers such as the Red River and its tributaries for flood prevention purpose which is a disaster and extreme phenomenon related to climate and climate change.

The World Bank (World Bank, 2011a) evaluated the social aspects of climate change adaptation in Vietnam, and has emphasized poverty, the dependence on climate-sensitive resources, the vulnerability of ethnic minorities, women and children, migration issues, all of which are related to natural disasters and extreme climate events. (Bingxin Yu et al 2012) evaluated Vietnamese farmers' adaptative behavior to climate change through their adjustments of inputs in agricultural production to respond to the changes in rainfall and temperature. Another social aspect such as gender issue has been studied and analyzed regarding the vulnerability of women and children in agricultural activities, which is the sector highly vulnerable to the impact of extreme climate events and natural disasters (Oxfam and UN-Viet Nam, 2009).

Raising awareness of climate change for the leaders, Governments, ministries as well as organizations, unions and local communities about climate change is important. Resolution of the Communist Party (The Central Committee of the Communist Party, 2013) on "Actively respond to climate change, enhance natural resources management and environmental protection" is the highest policy framework to guide, lead, and direct the climate change response, natural resources management and environmental protection in Vietnam. Law on Natural Disaster Prevention and Control (National Assembly, 2013) emphasizes information, communication and education on natural disaster prevention and control through the websites of Ministries, Governmental and local agencies and other means of mass communications, communications materials, especially materials from the ministries such as Ministry of Information and Communication (MIC), Ministry of Education and Training (MoET), Ministry of Agriculture and Rural Development (MARD). The Environmental Law (National Assembly, 2014) also included a chapter on climate change response, which emphasizes mainstreaming response into the strategy and the economic-social development planning.

Many technical guidelines have been compiled such as Disaster Risk Management and Climate Change Adaptation within the framework of the Strengthening Institutional Capacity for Disaster Risk Management project in Viet Nam, particularly the risks related to climate change (UNDP-MARD, 2011), a guide to community-based disaster risk assessment withing the Community Awareness Raising and Community-Based Disaster Risk Management project of the Government (MARD, 2014), and training materials on disaster prevention organized by Vietnam Red Cross (Vietnam Red Cross, 2000).

The training of professional in climate change areas was held at the universities, specifically the Vietnam National University in Hanoi has developmed Master's degree programme in Climate Change since 2011, with knowledge on climate change, its impacts on sectors and industries, and measures to respond to climate change including adaptation and reduction of greenhouse gas emissions. The Vietnam Institute of Meteorology, Hydrology and Environment has developed a PhD. programme on “Climate change and Sustainable Development” since 2014. Many social organizations, international and national non-Governmental organizations have organized programmes and projects on raising awareness for local people in climate change adaptation and disaster risk management such as the “Capacity building on climate change for civil society organizations” project (SRD, 2011). The Government has developed and implemented the “Community awareness raising and community-based disaster risk management” project (Government of Viet Nam, 2009) with the objective to raise community awareness and effectively organize the model of community-based disaster risk management; to minimize fatalities and property loss and contribute to ensure sustainable development.

Many documents have been developed to promote awareness raising and education on climate change. The documents, research results, projects on climate change and the impacts of climate change in Vietnam, technical guidelines serving national, sectoral and local response activities against climate change, such as the Reporter Handbook (Nguyen Duc Ngu and Nguyen Trong Hieu, 2009), basic knowledge of climate change for the community (Truong Quang Hoc and Nguyen Duc Ngu, 2009), training-of-trainer materials on Climate Change (Truong Quang Hoc, 2011; Nguyen Duc Ngu and Truong Quang Hoc, 2009), basic knowledge on climate change (IMHEN and UNDP, 2012).

8.2.4. Technology Choices, Availability, and Access

Science and technology play significant roles in disaster prevention and climate change adaptationand are clearly manifested in the legislation and policy systems of Vietnam. Science and technology are specified in the Strategy for Science and Technology Development 2011-2020 (Government of Viet Nam, 2012b), science and technology to prevent and mitigate disasters are defined in the Law on Natural Disaster Prevention and Control (National Assembly, 2013) and on the National Strategy for Natural Disaster Prevention and Control (Government of Viet Nam, 2007). Certain demands on science and technology in monitoring climate and adapting to climate change have been identified in the National Strategy on Climate Change (Government of Viet Nam, 2011a). Changing towards environment-friendly technologies and reducing greenhouse gas emissions are identified in the National Strategy for Green Growth (Government of Viet Nam, 2012d). Researching new science and technology not only helps reducing greenhouse gas emissions but also provides timely, proactive response to climate change processes, reducing negative impact on socio-economic life, and taking advantage of the favorable opportunities for developming new economic sectors stemming from the environment (National Agency for Science and Technology Information, 2008).

The traditional methods to respond to natural disasters and adapt to climate change such as building dykes, canals, flood regulating and diverging works, etc. actively exploited (Tran Thuc and Le Nguyen Tuong, 2010); conservative technology of crop varieties and indigenous animal breeds, hybrid of crop varieties and animal breeds which have high productivity, high resistant to drought and salinization etc. are also being researched and deployed. Many modern technologies have been successfully applied in climate forecast, constructing climate change scenarios and sea level rise such as detailed statistical method, AGCM/MRI model, PRECIS model and SDSM, SIMCLIM softwares (MoNRE, 2011). This is an important part in the work of natural disasters prevention and climate change adaptation.
The recent climate change adaptation strategies will change the concept of adaptation from passive response to proactive prevention, considering the potential impact of climate change as

an important guide for policymakers (Tran Thuc and Le Nguyen Tuong, 2010). From that perspective, Vietnam has constructed, issued policy documents, normative act, standards, all of which gradually established a legal corridor and policy environment for the prevention and mitigation of natural disasters, response to climate change, in which technology is an important solution among those of social-economic development in general, and adaptation to climate change and extreme events in particular. Various technical standards and technical guidelines in planning, designing, building infrastructure systems of agriculture, rural areas towards enhancing climate change adaptation are being developed and adopted (Chapter 6, Section 6.5.2.1. *Technology Application and Infrastructure-Based Approaches*). The choice of technology to serve economic growth and social services towards "green growth" as part of the policy of sustainable development, are showed in the National Strategy for Green Growth (Government of Viet Nam, 2012d), however the initial barrier of Vietnam is the lack of fund, lack of trained human resources to access and develop advanced technologies.

8.2.5. Trade-offs in Decision-making

There are different definitions of trade-offs within different sectors, cultural and social contexts, however trade-offs can be defined as the exchange/optimal choice/wise use/rational use (CRES, 2007). Trade-off does not merely mean gaining - losing, it is defined as the choice of management to change the diversity, function and services provided by ecosystems over space and time (ACSC, 2007). Trade-offs may also arise through resolving conflicts between economic development and risk management (IPCC, 2012 page 448) or between the conservation of biodiversity and socio-economic development, as in the case studies of conservation policies of Vietnam (Hoang Van Thang et al., 2010). Trade-offs, in a positive way, are linked to the concept of sustainable development, the harmony between conservation and development, or the balance between conservation and development, which are concepts interpreted on the common “mutual benefit”/“win-win” approach .

Other aspects of the trade-offs have been considered, especially regarding the difficulties in decision-making between socio-economic development and environmental protection, agriculture production, water resources management, biodiversity and ecosystem services (Le Dien Duc, 2009), trade offs between economic benefits and environmental protection, especially in the sectors of pollution and human health, immigration issues and impacts on forest resources, between protecting mangroves and shrimp farming (PanNature, 2008) as well as challenges arising from economic growth and degradation of natural resources (Consultative Group for Vietnam , 2010). Thus, the essence of the tradeoff is to achieve harmony between the different objectives, especially when resources (natural, economic, human) are limited, while solving disaster management and climate change adaptation problems have always had conflicts over space and time, between short-term and long-term objectives, between investment for disaster risk management and investment for development.

However, there are currently not many researches conducted on trade-offs related to choosing solutions among disaster risk management, climate change adaptation and socio-economic development in Vietnam; meanwhile the conflict between economic development and environmental protection oobjectives has become more and more exacerbated in the context of climate change. For example, in the Mekong Delta, the increasing air temperature, the seasonal and territory change in precipitation, the abnormal natural disasters and the danger of sea-level rise due to global warming (Le Anh Tuan and Suppakorn Chinvanno, 2011) could affect agriculture production, aquaculture and biodiversity (Le Anh Tuan, 2010a, 2010b, 2013).

8.3. Integration of Short- and Long-Term Responses to Extreme Events

8.3.1. Implication of Present Responses on Future Well-Being

Vietnam is evidently and strongly affected by climate change and the Government is strengthening the implementation of response solutions, which requires integration of short-term and long-term solutions so that it not only ensures the benefits of current development but also strengthens the long-term response capacity to the increasing impact of climate change, especially the extreme events.

Vietnam determines that responses to climate change include activities of climate change adaptation and mitigation, through the integration of climate change into development plans in order to adjust, supplement these plans, including guidelines, policies, mechanisms and institutions involved in mitigating the effects of climate change, short-term and long-term extreme climate events (IMHEN, 2012a). Vietnam has developed and implemented many policies, strategies, and socio-economic development plans towards sustainability, disaster prevention, climate change response. Vietnam Agenda 21 (2004) identified climate change as a factor which should be taken into account for sustainable development, and proposed priority activities to limit harmful effects of climate change, prevent and control disasters.

The Five-year National Project (2001-2005) VIE 01/021 “Supporting the development and implementation of Vietnam National Agenda 21” was led by the Ministry of Planning and Investment (MPI) accompanied by technical assistance and financing of UNDP in sectors such as watershed management, agriculture, forestry, industry, energy, urbanization; the and sustainable development policie have been focused on building long-term visions towards sustainable development goals, provided scientific basis and international experience to design specific actions at different levels of industrial and sectoral development. The comprehensive and clear proposals on climate change response is reflected in the Vietnam Sustainable Development Strategy for 2011 – 2020, especially in the National Strategy for Climate Change and the National Target Programme to respond to climate change.

The results of different studies have confirmed the urgency of the climate change impact assessment and integrated into strategies and development plans for short-term and long-term responses at different levels (countries, industries, sectors, villages, communities) (Tran Thuc, 2009; Dang Kim Chung, 2010; Doan Cong Khanh, 2011; Luu Thi Thu Giang, 2013; Than Thi Hien, 2013). Some studies have gone deeply into the extreme events in specific areas with impact assessment of such events and proposed adaptation solutions (Nguyen Lap Dan et al., 2012). The "Technical guidelines on methods for climate change impact assessment and identifying adaptation solutions” have been developed with the timeframe to assess the impact and vulnerability of 20 years, corresponding to local socio-economic development directions (IMHEN, 2011).

Extreme events and climate change are always linked to poverty issues, since natural disasters often cause greater damage to life, property and livelihoods of the poor and disadvantaged social groups (poor farmers, the elderly, children, women, etc.). Moreover, poverty is a great barrier in climate change adaptation and implementation of sustainable development. The relationship between poverty, social welfare and climate change will continue to be the research topic in Vietnam in the coming years, which has been reflected in the approved long-term research programmes on science and technology at all levels.

In theory, the majority of studies have shown the appreciation for future interests and benefits as sustainable development goals, however, in practice this is not always the case, since not all of climate risks were considered in decision-making. Many medium-term development plans (5 years) only focus on short and medium-term visions, current climate risks, ignoring or not taking long-term vision into account; the approved long-term strategies, sectoral/local socio-economic development plans for 2011 – 2020 were only reviewed and supplemented with climate change factors after the issuance of the National Strategy for Climate Change (2011) and the National Strategy for Green Growth (2012). Even if the content of climate change has been integrated in the strategies and plans, they often lack implementing guidelines (IMHEN, 2012).

Correlation between current and future benefits is one of the problems that contain mixed opinions. Sometimes, the integration of climate change issues into development decisions is considered as creating more complex procedures, increasing investment in the projects. The results of which are immediate benefits often dominate the long-term climate change adaptation (Tran Thuc, 2012).

A question for the research and deployment of sustainable development is the relationship between the beneficiaries and the payers of response activities. In Vietnam, the Government is still the major payer for certain types of goods, public services, price subsidies (electricity, clean water, etc.), and is responsible for allocating annual state budget expenditures (collection, treatment of domestic waste, operation, construction of new landfills...), although the Government has issued mechanisms and policies to mobilize payments from the other stakeholders (so called socialization policy), however their participation is still modest (MONRE/UNDP, 2010). The reason comes from both sides: the capacity of the potential payers and their benefits have not been guaranteed for both short-term and long-term.

8.3.2. Barriers to Combining Short- and Long-term Goals

The studies related to climate change adaptation topics contain evaluations, remarks on the barriers or gaps in the combination of short-term and long-term goals. The main barriers in integrating climate change issues and disaster prevention into development plans in Vietnam have been shown in a recently published study (IMHEN, 2012a), in which a notable issue is the situation of “overloading integration works" (i.e. there are too many aspects to be integrated in the formulation of development plans). The lack of consistency of policy mechanisms, the organizational structure which are the barriers for the implementation of the short-, medium- and long-term goals, have been identified in the strategy, planning and development plans of nationally and locally (MONRE/UNDP, 2010; ISPONRE, 2013a).

Generally, there are four groups of barriers or deficiencies which can be generalized and have been shown in studies, corresponding to five types of adaptation measures for short-term, medium-term and long-term, including: (i) awareness; (ii) legal basis; (iii) resources; (iv) coordination; and (v) technology.

Awareness deficits: In Vietnam this deficit is evaluated as the leading barrier within policies planning and implementation level as well as local and community level resulting in difficulties in allocating investment resources and action coordination (Tran Thuc, 2009; Truong Quang

Hoc, 2009; Nguyen Huu Ninh and Pham Thi Thuy Huong, 2009). There are certain economic activities (hydropower development, tourism) that may exacerbate the effects of climate extreme events caused by lack of knowledge (Le Dien Duc and Han Tuyet Mai, 2009; MONRE/UNDP/DFID, 2009).

The lack of the legal basis: the biggest deficiency is that there are currently no existing regulations of statutory nature but only regulations under the law enacted by the Government. This deficiency results in difficulties, obstacles in assigning, allocating resources for a basic, long-term solution towards climate change response; focuses on the sectoral benefits; poor coordination and overlapping of responsibilities and benefits; complicated and cumbersome administrative procedures (ISPONRE, 2013a).

The lack of resources is considered an important barrier in the implementation and especially in the combination of short-term and long-term objectives regarding climate change response, including adaptation to climate change and disaster prevention (Nguyen Duc Ngu, 2009; IMHEN, 2012a). The lack of resources is common in developing countries (UNISDR, 2009), however if there are good strategies and policies, international cooperation mechanisms, it can help mobilize considerable financial resources, science, technology, communication etc. for climate change response (Nguyen Ngoc Tran, 2009; Nguyen Duc Ngu, 2009). Financial resources for climate change adaptation and disaster prevention and mitigation has not yet met the design requirements, especially financial resources local level have not been built on long-term planning, inefficient use due to integration with other purposeful activities. (Le Thu Hoa et al., 2013).

In general, resources for climate change adaptation and disaster prevention in Vietnam still mainly rely on the state and international support, and yet are poorly mobilized from non-state sources (MONRE/UNDP, 2010). The specific deficiencies are human resources, finance, information, networking organizations, technical facilities (MONRE / UNDP, 2010), especially the large shortage of experts on climate change (Nguyen Ngoc Tran, 2009). Overall evaluation regarding general resources for climate change adaptation and disaster prevention in Vietnam is highly deficient and comprehensively shortage of resources for the present and the next several years, especially human resources, facilities – technology and finance (MONRE/UNDP, 2010).

The lack of coordination is common in Vietnam management development activities. Particularly in climate change adaptation and disaster reduction, the coordination is somewhat even more loose due to both the unfamiliarity and lack of resources – which are important basis for coordination, and there are even more obstacles that cannot be resolved in the near future. This study shows that the main cause is the overlap of responsibilities, lack of clarity about the benefits and lack of legal basis for the coordination of activities (ISPONRE, 2013a). Legal documents or sector plannings are usually developed from the perspective of the sector responsible for drafting or planning and there is no harmonious combination between different sectors and levels (ADB, 2009).

There is a highly appreciated motto in climate change adaptation and disaster prevention which is “think globally, act locally”. Experience shows that the active participation of the community is an important factor in climate change response, especially in dealing with extreme climate events that occur frequently. However, there is still little involvement from the community in Vietnam, which is deemed as “small and unstable” (Nguyen Ngoc Sinh, 2012).

Technology deficiency is also common in poor, developing countries and a barrier to be taken into account in climate change response and extreme events, especially in forecasting and impact assessment. Due to the particularities of climate change and climate extreme events, currently in Vietnam, the technology for climate change adaptation and disaster prevention lies primarily in research and development (R&D) institutes established by the state. Monitoring equipment, scientific research and other necessary technology are evaluated to be of huge shortage (MONRE/UNDP, 2010).

If information is considered an constituent part of science and technology, the lack of information was also rated as large, both on the basis of information resources and management (storage, processing, information providing, etc.) (MONRE/UNDP, 2010). In addition, information sharing mechanisms are unclear and ineffective (Bui Cong Quang, 2009).

8.3.3. Connecting Short- and Long-Term Actions to Promote Resilience

Resistance capacity, according to the most common concept, is the manner in which a system, community or individual copes with turbulence and unexpectation, is the ability of a system to predict and mitigate, respond and recovery from the external impact, more specifically, reducing, responding and overcoming damages caused by climate change since this is the capacity of a foreseeable system, (IPCC, 2012 page 34). Resistance capacity has been recently studied in Vietnam mainly in agricultural system, since it is more vulnerable and is under the direct impact of climate change and extreme events with increasing level of intensity and extent of damage. Research on resilience capacity also often refers to the ability to actively adapt or positive adaptation of social systems, residentl, in which measures to strengthen the capacity to respond flexibly and on-site are usually leading.

The major disaster phenomena, particularly related to climate, occur more and more frequently resulting in enormous consequences for the economy and society, therefore it is necessary to construct synchronization solutions for short-term (1-5 years), medium-term (5-10 years) and long-term (10-30 years), with suitable roadmap to be able to mutually integrated and adjusted according to economy and society fluctuations of the region or country (Le Anh Tuan, 2013).

In Vietnam, the connection between the short-term and long-term activities in climate change adaptation and strengthening resistance capacity is implemented through climate change impact assessment and integrating climate change issues into social - economic development strategies and plans (IMHEN, 2011, 2012a). These policies are planned according to implementation phases (usually 5 years), with specific targets for each phase and overall goals set forth for longer vision (usually 15-20 years). Through the integration and implementation of climate change issues set forth in social - economic development strategy and planning, short-term and long-term activities are connected, which contains the objective of strengthening resilience capacity with leading role belongs to the State in connecting long-term and short-term activities towards climate change response (Nguyen Ngoc Tran, 2009; Nguyen Duc Ngu, 2009).

Realizing the impact of climate change on the sustainable development of the country, there have been studies on the effects, impact assessment and integrating of climate change issues into social - economic development strategies and planning for both short-term and long-term (Nguyen Ngoc Tran, 2009; Nguyen Duc Ngu, 2009; IMHEN, 2011, 2012a; Tran Thuc, 2009). The solutions were identified and decided for different industries, regions, areas and subjects in their vulnerable conditions (IMHEN, 2011).

The approach to the impact assessment and identifying adaptation measures is based on the principle of ensuring systematic, synthetic, interdisciplinary, inter-regional, gender equality, hunger elimination, poverty reduction characteristics. A planning process to cope with climate change and the process of climate change impact assessment with spatial boundaries of administrative units, geographical units, ecosystems, climate regions and impact assessment contents including nature, economy, society conditions are specifically studied and recommende accordingly (IMHEN, 2011).

Studies on integration have been implemented and applied in some ministries, sectors and local regions assisting in policymaking towards climate change response (Nguyen Van Thang, 2010; Dang Kim Chung, 2010; Doan Cong Khanh, 2011), particularly the integration of climate change issues into social - economic development plans have proposed a five-step process: screening; measures selection; measures integration; implementation; monitoring and evaluation (IMHEN, 2012a), as well as the criteria for assessing the integration of climate change issues are referenced from international documents (IPCC, 2014 page 453) and put into the integrated process (monitoring and evaluation stage). Cost benefit analysis (CBA) in impact assessment and climate change integration are also considered (Nguyen Danh Son and Truong Duc Tri, 2009; Nguyen Danh Son, 2013; IMHEN, 2011), since CBA is necessary for the identification, selection and combination of objectives and activities for short- and long-term, which is a step in the process of determining solutions towards climate change adaptation (IMHEN, 2011). In addition, other methods have also been proposed to determine priorities and selection of response measures, such as cost-effective analysis (CEA), multi-criteria analysis (MCA), expert method (IMHEN, 2011).

8.4. Access to Resources, Equality, and Sustainable Development

8.4.1. Capacities and Resources

Major policies usually focused on developing the resources and improving the capacity towards climate change respond, including mitigation of natural disasters and climate change adaptation, which are clearly manifested in the Law on Natural Disaster Prevention and Control (National Assembly, 2013), the Environmental Law (National Assembly, 2014), objectives of the National Strategy for Climate Change (2011), organizational capacity, institutions and policies in the National Target Programme to Response to Climate Change (2008). National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (2007) proposed a high priority for developing human resources and financial resources, science and technology, strengthening the system of dykes and reservoirs.

Within the framework of implementating the National Target Programme to Response to Climate Change, including the field of adaptation, (MoNRE, 2008 page 57) defined four groups of difficulties, challenges, which are: i) The weakness of awareness, both in the scope and extent as well as measures to respond to climate change; ii) Lack of coordination in response to climate change in the construction of policies, planning and programmes in different areas and sectors, iii) Lack of tools and methodologies to guide and consult policymakers and iv) Lack of knowledge.

Financial resources play very important roles in disaster risk management and adaptation to climate change. Law on Natural Disaster Prevention and Control (National Assembly, 2013) Article 8. stipulated Financial sources for natural disaster prevention and control, including state budget, Natural disaster prevention and control funds and voluntary contributions from organizations and individuals. National Target Programme to Respond to Climate Change (MoNRE, 2008) set a 2.374 billion budget for the period 2009-2015, including activities of disaster risk reduction and climate change adaptation (see Chapter 7, Section 7.4.2.4). Construction and implementation of the National Target Programme, National Strategy, National Action Plan to respond to climate change, Vietnam has also attracted technical support and financial resources from bilateral and multilateral sources, mainly for the climate change adaptation and mitigation activities in Vietnam, estimated to be nearly 200 million USD and funded by Denmark, Japan, the Republic of France, World Bank, CIDA and programmes for reducing greenhouse gases emissions through efforts to restrict deforestation and forest degradation (REDD +) funded by Norway which is up to 100 million USD (MPI and UNDP, 2011). Certain international financial resources also prioritize supporting Vietnam in the field of disaster mitigation, adaptation to climate change and areas related to climate change which are summarized on the website on Climate Finance Option (Climate Finance Options, 2014) and constructed by UNDP and World Bank and currently financial resources relating to climate and climate change for Vietnam are introduced by MPI (Climate Finance Options - Vietnam, 2014).

Financial resources for preventing and mitigating natural disasters are primarily laid in the State overall budget and mobilizable social resources, including backup budget and the national reserve to ensure the processing of requirements regarding the response and recovery from disaster consequences (see Chapter 6, Section 6.4.3.1. Finance). For example, the “Raising public awareness and community-based disaster risk management Project" period 2009-2020 owns a total investment amount equivalent to 54 million USD, whereas cost estimates for the implementation of the National strategy for preventing and mitigating natural disasters to 2020 of MoARD are 18 billion USD (see Section 6.4.3.1).

However, the allocation of resources is uneven between central goverment and loca regions, among different ministries, as well as among demographic groups. Financial resources for climate change adaptation and disaster prevention have not always been employed effectively in local level (Le Thu Hoa et al, 2013). The public expenditure related to climate change responses in five ministries during 2010-2013 are significant and equivalent to 0.1% of GDP, focused primarily on the MARD and Ministry of Transport (MoT), for irrigation and road projects, with main purpose of adaptation (MPI, World Bank and UNDP, 2014). So far, financial information related to disaster risk reduction, climate change adaptation is incomplete due to lack of general, long-term and large-scale studies.

At local level, strengthening the capacity of local decision-making, including the promotion of applying community-based approach in disaster risk management, is specially emphasized, in which the People's Committee and other social and political organizations play important roles (see Chapter 5, Section 5.4.2 and Section 5.4.3).

8.4.2. Beneficiaries and Stakeholders at Local, National, and International Levels

Vietnam is one of the few countries strongly affected by climate change and sea-level rise with material damage caused by the impact of natural disasters and climate change estimated to be equivalent to 1-1.5% GDP annually (CIEM and UNU, 2012). The loss of the territories and groups of population is very signigicant. Coastal areas, Red River Delta, Mekong Delta, and certain mountain areas are vulnerable ones against disasters and extreme events related to climate and hydrology (MoNRE, 2008 ; Nguyen Duc Ngu (Chief author), 2008). The most vulnerable population groups include the poor, ethnic minorities, women and children (MoNRE, 2009, 2011). Certain vulnerable industries include agriculture, forestry, fisheries, transport, health (MoNRE, 2008; Nguyen Duc Ngu, 2008).

A study on the impact, responses capacity and policy issues related to climate change in ethnic minorities areas in Northern Mountains (Mai Thanh Son et al., 2011) has proposed that extreme events such as droughts, flash floods, landslides, cyclones, hail often increase in frequency, intensity, and erratic, and have greatly affected in agriculture activities and life of ethnic minorities. These are important causes affecting poverty situations, in which people in rural areas are more strongly affected than urban dwellers (Le Anh Tuan and Tran Thi Kim Hong, 2012).

Vulnerable people are often the poor. The impact of natural disasters and extreme climate on the poor is greater and less predictable for their livelihood (Oxfam, 2008), whereaes the poverty rate in Northern Mountains and Central Highlands is the highest in the country (World Bank, 2012). The livelihood of the people depends on agriculture, therefore when disasters and extreme climatic events occur, agricultural activities are often strongly impacted, and therefore, affecting their livelihood (Oxfam, 2008).

Women are also vulnerable to the impact of natural disasters and climate change (IMHEN, 2011). Although Vietnam has gained remarkable achievements in gender equality, women remain disadvantaged in education, health, information access, employment opportunities and decisionmaking (Oxfam and UN-Vietnam, 2009), especially in the case of natural disasters, they have little opportunity to create new livelihoods (Oxfam, 2008). For those of ethnic minorities, natural disaster is also the cause to their vulnerability and poverty due to social reasons, such as unemployment, illness or natural causes, such as crop failure or loss of property (World Bank, 2012).

Whereas those who are disadvantaged, those who suffer loss due to natural disasters and climatic extreme events are easily determined, the beneficiaries are relatively difficult to determine. The group of beneficiaries may include programmes and projects on hydro power plants upstreams, programmes on water resources exploitation upstream Red River and Mekong River, which reduced water flows downstream Mekong Delta, exacerbating extreme events such as saltwater intrusion, flood-tide and coastal erosion and opposing on people living downstream (Nguyen Huu Ninh, 2007).

Therefore, it is difficult to clearly define between beneficiaries and those who suffer loss at local, national or international level in the battle against natural disaster extremes and climate change. However, when building the relationships for Strategy for climate change adaptation and disaster risk reduction, one should also consider groups of beneficiaries and affected stakeholders for the solutions. Solution for this region can create problems for other regions.

8.4.3. Potential Implications for Security Issues

Climate change and extreme events can impact and exacerbate the problems of environmental security and social safety (Nguyen Dinh Hoe and Nguyen Ngoc Sinh, 2012), especially water security while 60% of water resources of Vietnam have foreign origin, mainly from Red River and Mekong Basins (ADB, 2009). Pollution associated with epidemics after natural disasters (such as typhoons, floods) are becoming pressing issues in Vietnam, and requires Vietnam to devote significant resources for handling. Climate change and extreme events can impact and exacerbate the environmental and social safety issues, which Vietnam is making efforts to implement through social and economic development programmes and projects, in accordance with regulations and technical guidelines agreed between World Bank and Government of Viet Nam (World Bank and MPI, 2004a, 2004b). Many of the community initiatives have been applied to ensure healthy and safety for the community in responding to natural disasters, such as distributing water filters and supplying cleanwater for communes affected by natural disasters (CARE, 2007), the media club model “Living with floods” and swimming training model for women and children in Mekong Delta (CARE, Oxfam and World Vision, 2010) or the experience and typical lessons regarding community based-disaster risk management in the highlands of Vietnam (CECI and Live&Learn, 2011).

The issue of food security due to the impact of climate change and climatic extreme events, as well as agricultural production to ensure food security in the context of climate change have been reviewed in chapter 4, Section 4.3.3.2 (issue of food security) and Section 4.3.3.3 (Agricultural Production to ensure food security in the context of climate change). Mekong Delta is an example case of a food and social insecurity due to potential risks of negative impacts of climate change and sea-level rise, which can reduce cultivation area, productivity and yield of agricultural products. This could lead to food security threat, not only for Vietnam but also partly for the world since the Mekong Delta contributes approximately 20-25% to the world’s rice exports, without reasonable solution and effective support internationally, this could be a factor causing instability in food supply for domestic market and a part of international market (Le Anh Tuan, 2012; ADB, 2011c).

A research of UN Vietnam (UN Vietnam, 2014) suggested that unsustainable development and ever-increasingly dangerous climate change are causing environmental degradation and migration; and resettlement according to Vietnam governance is one important tool for sustainable livelihoods in multi-disasters regions. Another research (Le Anh Tuan, 2010a) also pointed out that climate change and sea-level rise decrease cultivation area resulting in food and habitat shortage, natural resources degradation in Ca Mau peninsula, Cuu Long river delta and vulnerability of many poor in rural areas, coastal areas, remote areas and force them to migrate mechanically from coastal areas to urban areas for living.

8.4.4. Implementing Related International Goals

Government of Viet Nam has joined international conventions such as the United Nation Framework Convention on Climate Change and Kyoto Protocol (Chapter 7, section 7.3.1) and the United Nation Strategy on Disaster Risk Reduction (Section 7.3.2) and other related ones such as the Convention on Combating Desertification, the Vienna Convention for Protection of the Ozone Layer (MoST, 2012a). Climate change and natural disasters will directly and indirectly impact on MDGs (IPCC, 2012 pg.458). Vietnam had gain great achievements reagarding MDGs, especially in eradicating extreme poverty, reducing child mortality, achieving universal primary education, however there is still challenge in ensuring environmental sustainability (MoST, 2010), which will intensify under climate change context.

In 2003, the Government of Vietnam signed a commitment to implement the Sustainable Development Strategy for the East Asian sea periods 2003-2011 and 2012-2016. In 2009, the Government also signed the Manila Declaration on Strengthening the implementation of Integrated coastal management for sustainable development and climate change adaptation with emphasis on the important role of integrated coastal management (ICM) and undertook by 2020 to implement ICM programmes in at least 20% of the country coastline. So far 20/28 provinces have applied IMC at different levels.

In 2009, the Government of Vietnam and 92 countries which own seas and islands in the world signed Manado Ocean Declaration at the First World Ocean Conference in Manado, Indonesia, which emphasized the central role of ocean in solving global, regional and national climate change issues. In that spirit, Vietnam has carried out studies to assess the impact of climate change on coastal areas, small coastal fisheries, the coastal islands and evaluate carbon capture capability of mangroves in Xuan Thuy national park and coastal zone in some provinces of Cuu Long River Delta (Carew-Reid, 2008; Cao Le Quyen, Nguyen Chu Hoi, 2009; Nguyen Quang Hung and Hoang Dinh Chieu, 2009).

Government of Viet Nam also adopted the Hyogo Framework for Action (HFA) and applied this framework as guidelines in the implementation of policies of managing and mitigating disaster risk, simultaneously institutionalized efforts by adopting the Law on Disaster Prevention and Reduction (2013), National Strategy on Disaster Prevention and Reduction (2007) (see Chapter 7). The first priority action of Hyogo which was to ensure disaster risk reduction (DRR) with national and local priority has achieved important progresses, based on evaluated rate of success 4/5 point by MARD with limited financial resources and capacity (MoARD, 2010).

8.5. Relationship between Disaster Risk Management, Adaptation to Climate Extremes, and Mitigation of Greenhouse Gas Emissions

8.5.1. Threshold Limits to Resilience

Climate change may cause change in climatic regime at system-level, large scale that could significantly alter climatic and socioeconomic conditions such as increasing the frequency and intensity of natural disasters lyke cyclones, floods and droughts, the number of people affected.

Tipping point is the point at which a system shifts from one state to another. Each life has a certain threshold point, and all threshold points and their resistant capacity to changes in eco-environmental conditions are completely different.

Although there has been no study on thresholds and tipping points in climate change, the researches related to vulnerability in Vietnam and approached from different areas of the natural-social system, community and coastal resources could also be used as examples (IMHEN and UNDP, 2012).

Threshold analysis is to determine climate change threshold at which exceed resilient capacity of the studied object. For example, if temperature over 35°C lasts for 4 continuous days, shrimps die or if the flooding level is maintained at 50 cm for 7 days, road system in certain locations will be damaged (IMHEN, 2011).

Climate change with changes in temperature and rainfall are leading agents which are capable of altering the ecosystems in large scale and seriously impact on the threshold. This will affect the composition and scale of ecosystems such as coral reefs are invaded by algae or the breakout of Acanthaster planci Starfish in some areas of Nha Trang bay, Nam Yet and Thuyen Chai in the Truong Sa islands (Vo Si Tuan et al., 2005).

Resistance capacity of organisms can also be broken by the impact of change in environmental factors lyke the coral in Ninh Hai, Ninh Thuan coastal areas are bleached resulting in sudden decrease of Acropora coverage at a rate of 10.8% (Nguyen Van Long et al., 2009); which also occured in some reefs in Nha Trang, Phu Quoc and Con Dao (Vo Si Tuan, 2009).

When environment changes exceed ecological adaptation thresholds of species, some disappear or appear in specific places, such as the case of Hoang Lien Van Sam pine, a pine species found only in Hoang Lien Son and listed in the World Red Book, previously available only in 2.200m - 2.400m altitude, however currently can be seen at 2.400m -2.700m altitude. Some other endemic species (found only in Hoang Lien Son) lyke Xi Pan maple, Sa Pa mapple, previously only grew at elevation below 1,700 m currently can be seen at altitudes above 2,000m and many other plants are also "climbing" up and occupy spaces of endemic species of cold areas (Pham Duc Thi et al, 2007). According to calculations, by 2070 Vietnam plants can be found upwards 550 m and northwards 100-200 km compared to their current locations, subtropical species shall decline and agriculture, forestry and fisheries production will be forced to adjust (Pham Ngoc Quy and Nguyen Quoc Luat, 2012). When environmental and climatic factors change unexpectedly beyond the resistant capacity of human and infrastructure systems, the vulnerability and damage caused by these impact are very large as in the case of Hue city of limited infrastructure and policy, disaster prevention solutions (Tran Thuc et al., 2013). Therefore, threshold and tipping point play important roles in disaster risk management and climate change adaptation.

8.5.2. Relationship between Adaptation to Climate Change, Mitigation of Greenhouse Gas Emissions and Disaster Risk Management

Recently many researchers have focused on the relationship between climate change mitigation and adaptation to climate change, reduce greenhouse gas emissions and disaster risk management (IPCC, 2012 page 459), which possesses different features in urban areas and rural areas.

8.5.2.1. Urban

In the context of climate change and rapid urbanization, the global sustainable development depends on the formation and development of sustainable cities and resistance capacity against climate change. Forms of urban space is very important for energy consumption and disaster risk management (IPCC, 2012 pg. 460). Urban planning is a tool for disaster reduction, and climate change adaptation and a part of the development process (IPCC, 2012 pg.460).

Urban type affects spatial and society symmetry and thus affects the vulnerability, ability to cope with extreme events and climate change adaptation of urban areas (IPCC, 2012 pg. 460).

In Vietnam, in the last 20 years, the process of urbanization has been going strong, 731 urbans (2009), including 02 special cities of Hanoi and Ho Chi Minh City, categorised from level 1 to level 5, have formed a chain of national central cities and regional centers while also contributes to the increasing the proportion of the urban population from 19.5% in 1990 to around 30% in 2009 (World Bank, 2011b) and as a result leading to overload in using existing infrastructure system. 96% of the population have access to electricity is a great achievement of Vietnam (WB, 2011b, 2012), but this can be associated with the exploitation of large quantity of fossil fuels in power plants, producing more greenhouse gas emissions according to the plan that 46.8% electricity production in 2020 was due to the use of coal (Government of Viet Nam, 2011b).Therefore, the Prime Minister has approved the Urban Development Scheme to cope with climate change period 2013 - 2020 (Government of Viet Nam, 2013b) and actively respond to climate change and to promote urban development in a sustainable way.

Urban flooding in Vietnam has become a pressing issue and apparently is getting worse under the impact of natural disasters and in the context of climate change, especially for coastal citites (See Chapter 9, Section 9.4.2 *Urban flooding: threats and challenges of urban planning*). The cause was identified as not performing the integration of disaster risk reduction and climate change adaptation in urban planning and in practice individual solutions have proved to be ineffective.

Since 2009, the project "Asian Cities Climate Change Resilience Network (ACCCRN)" funded by Rockefeller Foundation was implemented in three cities in Vietnam: Da Nang, Quy Nhon and Can Tho; through activities of enhancing management capacity of marine ecosystem as a resource, livelihood development, modeling of local communities under the impacts of climate change (ISET, 2009). However, these cities are also facing pressure from the rapid urbanization, including environmental issues, migration, water scarcity and other restrictions on infrastructure, climate-related danger, such as obstructing the flow, increasing depth and speed of flood in Quy Nhon, the impact of storm surges, saline intrusion and sea-level rise in Can Tho and river erosion in Danang (ISET, 2013). Institute of Development Studies in the UK have studied institutional and management aspects of Danang, including structural aspects and functions of local Government, urban planning, decentralization of Disaster Prevention and Mitigation, to provide a basis for the proposal on enhancing capacity to withstand climate change and adaptation strategies for the city (IDS, 2007). In summary, in order to strengthen resilience capcity to climate change and extreme events, urban planning system in Vietnam should reinforce: i) the approach to overall planning based on proven fact - and should present accurate aspects and positions in demand and ii) avoiding fragmentation in the planning system and to integrate and fully coordinate between functional regions or space.

Project "Adaptation to Climate Change through Sustainable Development" in Can Tho has applied advanced methods "integrated management of urban water systems" to improve the service system and aquatic environment, thereby enhancing the ability to adapt to climate change (CSIRO, 2012). As one of 10 cities in the world most affected by climate change (OECD, 2008), Ho Chi Minh City was assessed by Asian Development Bank (ADB, 2010) on its vulnerability in urban development and land use planning, population growth and poverty, transport and transport infrastructure, water supply and sanitation, industrial, agriculture development and natural ecosystems, energy, health care by 2050 and proposed adapting solutions.

8.5.2.2. Rural

Rural areas have to face many disasters and are vulnerable. Vietnam's rural areas are home to nearly 70% of the population of the country (Hoàng Bá Thịnh và Nguyễn Kim Thủy, 2011), agricultural production, forestry and aquaculture production are primarily livelihood of the locals, and are also the sectors most affected by natural disasters in the context of climate change.

Many projects have studied the impact of climate change on provinces, building databases and simultaneously proposing adaptation measures as in case of Ca Mau (ADB, 2011a) and Kien Giang (ADB, 2011b). World Vision Vietnam focused on assessing vulnerability and adaptive capacity of communities in Ca Mau (WVV, 2012). Due to the impact of sea-level rise combined with high tides and low water level of Mekong River in the dry season, sea water intrudes deeply inland causing salination and affects agricultural production (Le Anh Tuan, 2009; WWF, 2012).

The ecosystems services and biodiversity affected by extreme climate phenomena in the Mekong basin (WWF, 2009), in wetlands and nature conservation (Le Anh Tuan, 2010a), and the Ca Mau peninsula (Le Anh Tuan, 2010b; Hoang Van Thang, 2013). Damage or costs incurred in the absence of application of climate change adaptation measures in agriculture and aquaculture from now to 2050 (World Bank, 2010).

Agriculture and forestry production and the livelihoods of mountain communities affected by phenomena such as floods, droughts, landslides and cold spells. The project "Capacity building of coordination and integration of disaster risk reduction and adaptation to climate change in agriculture in the Northern Mountains of Vietnam" has gathered experience to provide guideline for mainstreaming disaster prevention and mitigation and adaptation to climate change in the agricultural development planning for Phu Tho, Yen Bai and Lao Cai (MoARD và FAO, 2012). Non-Governmental organizations also actively participate in the study on impacts, adaptive capacity of ethnic minorities in Northern mountainous areas and some policy issues (CCWG, 2011) as well as review the impact of climate change on sustainable development in Vietnam regions in terms of policymaking (Vo Thanh Son, 2013).

It is difficult to ensure the harmony between the development of rural economy and natural resources preservation. Keeping balance and performing controlled exploitation of natural resources are both regulating tools on capacity-building potential and an important mechanism to ensure long-term sustainability of rural livelihoods and the ecosystem services (IPCC, 2012 page 461). In fact, in Vietnam, the ecosystems services, biological diversity are affected by extreme climate events and climate change, as in the case of Mekong basin (WWF, 2009), impacts of climate change on biological diversity in these wetlands and nature conservation in the Mekong River delta (Le Anh Tuan, 2010a), and the Ca Mau peninsula (Le Anh Tuan, 2010b; Hoang Van Thang, 2013).

REDD + programme, with the goal of reducing emissions from deforestation and forest degradation, conserving and enhancing carbon stocks, linked with sustainable forest management is an example of protection and sustainable management of resources natural resources motivation are driven by activities in greenhouse gas emissions, while creating the ability to share benefits for adaptation and promoting biodiversity conservation, sustainable forest management and strengthening reserves carbon, improving the livelihood of rural people in Vietnam (Nguyen Hang et al, 2011). REDD + in Vietnam is divided into two phases: (i) Phase 1 (2008-2012): Capacity building at all levels and all stakeholders in the implementation of REDD +, simultaneously, conducting pilot projects; and (ii) Stage 2 (after 2012): Implementing REDD + Programme (UN-REDD Vietnam, 2011a, 2011b). A number of studies introducing REDD+ implementation in Vietnam consider REDD + as a solution to sustainable development (Holland and McNally, 2010) and promotion activities, awareness raising, conducting technical guidance, such as forest carbon monitoring manual involving the participation (UN-REDD Vietnam, 2011c), builing and design of benefit-sharing systems (Nguyen Hang et al, 2011). Other studies such as evaluating biodiversity and carbon stocks to build REDD + in Vietnam (Vo Thanh Son et al., 2011) and mapping to assess the potential application of REDD + for conservative work (Mant et al, 2013) have also been implemented.

8.6. Planning for Proactive, Long-term Resilience to Future Climate Extremes

8.6.1. Planning for the Future

Disaster risk management and climate change adaptation are basically making plan for a future with uncertainties, a process related to the combination of subjective will (individual and collective) and vision of what may come (IPCC, 2012 p.g462). Recently, reports of the Development and Climate Knowledge Network (CDKN, 2012) have stressed the importance of disaster risk management and climate change adaptation in Asian region, including Vietnam.

With regard to long-term policies, Vietnam has made great efforts in improving the policy system in response to climate change, including disaster risk reduction and climate change adaptation towards building a sustainable society. The legal system related to the environment and natural resources to address disaster reduction and climate change change has been established, including the revised Law on Environmental Protection (National Assembly, 2014), Law on Forests Protection and Development (National Assembly, 2004), Law on Water Resources (National Assembly, 2012), Law on Biodiversity (National Assembly, 2008), Law on Fisheries (National Assembly, 2003); Law on Disaster Prevention (National Assembly, 2013). At the same time, relevant strategies have also been adopted, most important is the Strategic orientation for sustainable development in Vietnam (Government of Viet Nam, 2004), Sustainable Development Strategy Vietnam 2011-2020 (Government of Viet Nam, 2012a), Environmental Protection Strategy by 2020, with a vision to 2030 (Government of Viet Nam, 2012c), National Strategy for Green Growth (Government of Viet Nam, 2012d), the National Strategy on Water Resources by 2020 (Government of Viet Nam, 2006), National Strategy on Biodiversity (Government of Viet Nam, 2013a), National Strategy on Disaster Prevention and Reduction (Government of Viet Nam, 2007), National Strategy on Climate Change (Government of Viet Nam, 2011a). these policies form an important foundation for Vietnam to actively devise long-term solutions to cope with climate extremes, prevent natural disastersand adaptat to climate change (see Chapter 6, Section 6.4.1. The legal documents and legal compliance mechanisms).

Pursuant to the adopted laws and strategies was, the ministries, sectors and local authorities have actively built their climate change action plans, with emphasis on disaster prevention, response and reduction as well as climate change adaptation. Ministries that have estalibshed climate change adaptation plan include MoNRE (2010), MARD (2011), MIT (2010), MoT (2011) and Ministry of Labour, Invalids and Social Affairs (MoLISA) (2011); particularly, MoNRE also developed an action plan for implementing strategies on disaster prevention and response (2009). Moreover, the National Programme to Respond to Climate Change (MoNRE, 2008) has divided responsibilities among ministries, local authorities and also dvised specific projectsin climate change adaptation and disaster risk reduction.

The Five years Socio-Economic Development Plan 2011-2015 (Government of Viet Nam, 2012h) has reviewed the challenges of natural disasters and extreme events in the context of climate change and the proactiveresponse solutions. Several sectoral plannings consider climate change and sea-level rise an important factor, most notable is the water resource planning in Mekong Delta for 2012 - 2020 and orientations to 2050 in the context of climate change and sea-level rise (Government of Viet Nam, 2012f), and water resource planning in Red River delta for 2012 - 2020 and orientations to 2050 in the context of climate change and sea-level rise (Government of Viet Nam, 2012g).

8.6.2. Approaches, Tools, and Integrating Practices

In Vietnam, the essential tool for policy-makers and planners have been more or less applied in the areas of sustainable development, disaster reduction and climate change adaptation. the tools that have been used a lot revently include climate change and sea-level rise scenarios, five-year socio-economic development scenarios, sectoral strategies, and specific action programmes. These form important foundation for climate change response in Vietnam.

In order to recognize and assess the future potential, scenario development has become a research tool both in the natural sciences and social sciences (IPCC, 2012 page 462). Scenarios can be based on different geography (e.g., globally, nationally, and locally) and on different durations (e.g., from a few years to several decades or century).

Vietnam has developed the climate change and sea-level rise scenarios for the purpose of research and policy-making. Developed first in 2009 (MoNRE, 2009) and updated in 2011, Vietnam climate change and sea-level rise scenario was analyzed in details at the provincial level and for coastal areas, especially added with some climatic extreme elements, for the purpose of designing and planning (MoNRE, 2011).

8.6.2.1. Improving Analysis and Modeling Tools

Various tools can be used to design environmental and climatic policies, among them, integrated economic-energy-environment model can produce long-term projections taking into account population, technological and economic trends, however most models are within limited geography and time frame , which doesnot address specific extreme climate events or disasters.(IPCC, 2012 p.g464). Vietnam has used a number of tools to design environmental and climate policies such as regulations on environmental impact assessment (EIA) for the purpose of proposing mitigation solutions to the adverse effects of environmental activities, which are written in the Law on Environment (National Assembly, 2014). (MPI, 2011b) summarized and developed "Guidelines for the Strategic Environmental Assessmentl (SEA) in setting strategies, for socio-economic development planning", including additional guidance on integrating climate change issues into strategic environmental assessment.

Current status of integrating disaster risk management and climate change adaptation into plans and policies in Vietnam was described in Chapter 6, Section 6.3.1. A range of policy instruments related to sustainable development and climate change are being developed and completed, especially in integrating climate change policy development and guidance of the National Target Programme to Respond to climate change (MoNRE, 2008). Integration techniques are applied with techniques in Strategic Environmental Assessment and Sustainability Assessment (Vu Tuan Anh et al., 2011) in developing national as well as socio-economic development plans(Tran Thuc, 2012).

Several ministries have actively integrated climate change issues into theiractivities, such as the Action Plan on response to climate change in agriculture and rural development for 2011-2015 and Vision to 2050 (MARD, 2011), development of documens on mainstreaming disaster risk reduction and climate change adapation for provinces such as Yen Bai and Lao Cai (MARD and FAO, 2012), and technical guidelines on disaster risk management and climate change adaptation (MARD and FAO, 2012). These integration tools are also applied by development organizations such as Oxfam, Red Cross (CARE, 2009; CCWG, 2010). In addition, technical documents on disaster risk management and climate change adaptation (MARD and UNDP, 2012) and technical guidelines on Forest Carbon Monitoring in the framework of the UN-REDD Vietnam (MARD-REDD, 2011) were also developed.

A series of guidelines are designed to integrate disaster risk reduction into the provincial socio-economic development plan in the Mekong Delta (ADPC, 2010a; ADPC, 2010b). Simultaneously the adaptation strategies for coastal livelihoods, which is most at risk due to climate change impactst in central Vietnam, has also been developed (MoNRE, 2010).

In 2004 when the Orientations for Sustainable Development in Vietnam was issued, several studies on the sustainable development indicators of have been conducted (Le Anh Son and Nguyen Cong My, 2006), mainly based on the research of the Sustainable Development Council of the UN (United Nations, 1996, 2001, 2007). The set of national sustainable development indicators was adopted and issued in the Sustainable Development Strategy of Vietnam for 2011-2020 (Government of Viet Nam, 2012a), and the set of local indicators was issued in the Indicators for Monitoring and Evaluating Local Sustainable Development for 2013-2020 (Government of Viet Nam, 2013d), with emphasis on implementing green growth strategy, ensuring the economic development at low-carbon level, smitigating impact of and adapting to climate change, and disaster prevention. Specifically, the green GDP index (implemented from 2015)to calculate the pollution cost and damage caused by disasters in the national accounts system, and the national green GDP calculation methodology are being designed and tested (CIEM, 2012). At the local level, the local sustainable development indicators are also being proposed, particularly indicator number 26 on "The number of disasters and the extent of damage", to provide additional data for calculating green GDP.

Vietnam has developed and issued the "Evaluation Criteria for Priority Projects under the Support Programme to Respond to Climate Change" (Government of Viet Nam, 2011c). The indicators related to climate change adaptation and disaster risk management policies are often integrated into the socio-economic development indicators or environmental indicators, in particular the following: (i) 30 indicators to monitor and assess Vietnam sustainable development for 2011 - 2020 (2012); (ii) 274 National Statistical Indicatior System (NSIS) divided into 24 groups covering economic, social and environmental sectors (2005); (iii) The Management Information System for Forestry Sector (FORMIS) and Forest Inventory (2006);

(iv) 231 indicators in the Management Information System for Resources and Environment Sector (2007) and other targetsindicators systems. These indices/indicators form an important database to assess the impact of climate change and disaster riskwithin sectors and territories, as well as propose response solutions.

One of the important tools is the construction and maintenance of disaster risk management information systems, including information infrastructure and databases, equipment, management software and suitable human resources (See Chapter 6, Section 6.5.1). This information is particularly useful in mainstreaming disaster risk management into the planning of national, regional and local sustainable development.

8.6.2.2. Institutional Approaches

As a disaster-prone country, Vietnam has drawn extensice experience in prevention, particularly strengthening the institutional system, organization and response measures. The National Strategy on Disaster Prevention and Reduction to 2020 emphasized the role of Government in unifying state management in disaster prevention, response and reductionat the national scale. MARD is the permanent body, coordinating with the relevant authorities in assisting the Government in implementing State management in this area. MARD and the Central Steering Committee for Flood and Storm Prevention and Response are the leading agencies in implementing the National Strategy for Disaster Prevention and Mitigation to 2020.

One of the typical and practical experiences of Vietnam in disaster prevention is the summarization of the ”Four On-sites” motto (on-site leadership; on-site human resources; on-site facilities; and on-site logistics) to cope with and overcome the consequences of floods and storms (JANI, 2011). In fact, the ”Four On-site” motto is applied before, during and after disasters and in prevention and mitigation activities for all types of natural disasters which occur frequently in Vietnam such as typhoon, flood , landslides and sea-level rise, salinization, drought, forest fires, etc.

Tools such as insurance, reinsurance, insurance fund, catastrophe bonds, microinsurance, and other mechanisms, transferring economic risk from one person to another,thereby providing compensation in exchange for a payment, usually a premium (IPCC, 2012 Section 5.6.3, 6.5.3 and 7.4, and case studies 09.02.13). In Vietnam, these new tools have recently been researched and applied to all sectors and industries that are at high risk from natural disasters and climate change. This policy is being piloted to agriculture such as insurance for rice, coffee, some livestock and crops in the context of climate change, throughthe issued Decision on the pilot implementation of agricultural insurance in 2011-2013 (Government of Viet Nam, 2011d) (See chapter 6, Section 6.5.3 Sharing unresolved risks).

The financial instruments applied in the environmental sector in recent years were only limited to establishing the Environment Fund atrelatively small scale (MPI, 2012b). Parallel to this process, the MPI also reviews and assesses the financial resources for climate change, specifically from Official Development Assistance (ODA) and public expenditure (MPI, 2011a). Recently, a study on "Assessment of investment and climate public expenditure of Vietnam" (MPI, World Bank and UNDP, 2014) conducted by the MPI, the World Bank and the United Nations Development Programme analyzed the institutional aspects, policies and public expenditures of 5 ministries, 3 provinces and proposed recommendations and related action plans.

8.6.3. Facilitating Transformational Change

Facing strong, abnormal impacts of climate extreme events and disasters, if there is no positive change in policy and society, it will be difficult to adapt to climate change. Adaption is marked by shifting from recognizable trend projects to the macro strategy and from discrete results to an approach including adaptive management, learning, innovation and leadership.

8.6.3.1. Adaptive Management

In general term, adaptive management can be defined as a process for improving management and operational policies of the system by proactive learning from the outcomes of implemented activities in order to adapt to changes of the environment (IPCC, 2012 pg.467). The principle of adaptive management can contribute to a more process-oriented approach disaster risk management, and promoting sustainable natural resources management under conditions of uncertainty (IPCC, 2012 Page 467). Adaptive management is often associated with "flexible" organizations that are not locked into rigid plans, but instead always evaluating the information and emerging challenges to figure out new methods to operate in accordance with new conditions (IPCC, 2012 page 467).

Adaptive management has been only implemented in some fields such as livelihoods in the context of climate change and disaster risk reduction by non-Governmental organizations such as CARE, Oxfam implemented (CARE, 2007; CARE, Oxfam and World Vision, 2010). Management form can be referenced from models of provincial disaster management, and the establishment of the disaster prevention and mitigation centers in Da Nang, Quang Nam, Quang Ngai and Binh Thuan (See Chapter 5, Section 5.4.5. Initiatives and actions of social-political organizations at local). This is an innovative and effective model of local authorities in disaster prevention activities, which can be replicated in other provinces in the country.

8.6.3.2. The process of learning, awareness raising and resources training

The dynamic notion of adaptation calls for learning as an iterative process in order to build resilience and enhance adaptive capacity now, rather than targeting adaptation in the distant future (IPCC, 2012 page 467) . Adaptive management is an incremental and iterative learning-by-doing process, whereby participants make sense of system changes, engage in actions, and finally reflect on changes and actions. Lessons are learned from theories, including experiential learning. (IPCC, 2012 page 467) (see Chapter 1, Figure 1-3).

Studying here is also understood as awareness raising for people, the guiding of Governmental leaders and local Government departments, and the sharing of information, lessons learned from success and failure . Learning is a key ingredient for living with uncertainty and extreme events and is nurtured by building the right kind of social/institutional space for learning and experimentation, knowledge systems, values and facilitating innovative and creative adaptation (IPCC, 2012 page 467). Learning process in this field often tends to focus on activities to raise awareness about climate change, prevention and mitigation of disaster risk (MoST, 2012b; CARE, 2007; Care, Oxfam and World Vision, 2010) .

One urgent issue is the training for highly professional staff in the fields related to climate change. A number of universities and research institutions have organized training courses and training programmes for their the staff in this area, especially, since 2011, the National University Hanoi has organized interdisciplinary master training programme on climate change, including the knowledge packages on the basic of climate change, impacts of climate change on the sectors, regions and coping with climate change, including disaster risk reduction and climate change adaptation. MARD with the support of the United Nations Development Programme implemented a project to enhance institutional capacity for disaster risk management, particularly the risks related to climate change in Vietnam, and simultaneously prepared technical documentation on disaster risk management and climate change adaptation (UNDP and MARD, 2011).

In the education system, MoET has published the ABC Handbook on Climate Change (MoET, 2012) for highschool students and guidelines for teaching and learning about natural disasters risk mitigation (MoET, 2013) for teachers and students with the aim of raising awareness in the field of disaster prevention and adaptation to climate change. At community level, many civil society organizations and development organizations have also deployed multiple training courses to raise awareness on climate change and disaster prevention (Trương Quang Hoc (Chief editor), 2011) or prepared FAQs documentation on Climate Change (Trương Quang Hoc et al., 2011). (MARD, 2014) has also recently prepared documentation of community-based disaster risk assessment aiming at raising awareness for the community.

8.6.3.3. Innovation

The transformation of society toward sustainablility and resilience capacity involves both social innovation and technological innovation – incremental as well as radical change. Innovation may refer to non-material knowledge lyke cognition, awareness, information or intelligence or it can refer to any kind of material resources. In some cases, a slight adjustment in practices or technologies may create signigicant innovative steps toward sustainability, while in other cases, iradical transformation is necessary (IPCC, 2012, pg 468).

There is no common way or rule for solutions to natural disasters and climate change adaption, particularly at the community level. Scientists, communities, people living in regions, from mountains to deltas, from north to south all have much experience and creativity in production and dealing with unfavorable situations. It can be considered the motto "four on spot" in disaster prevention is an innovation of Vietnam under limited resources condition while continuously batlling against increasingly extreme disasters. This motto has been institutionalized in legal documents, especially in law against disasters (National Assembly, 2013), which has been widely applied from central to local and highly appriciated from community development organizations (JANI, 2011).

Community-based disaster risk management approach (Government of Viet Nam, 2009) in development projects, poverty alleviation or approach towards climate change adaptation based on ecosystems (ISPONRE, 2013b) would be an innovative method of implementation.

According to the National Strategy for Green Growth period 2011-2020 with a vision to 2050 (Government of Viet Nam, 2012d), green growth must rely on biodiversity conservation, development and effective use of natural resources, which was initially embodied in the sustainable development strategy for Vietnam period 2011 - 2020 (Government of Viet Nam, 2012a) and in the National action Plan on sustainable Development 2013-2015 period (Government of Viet Nam, 2013c).

8.6.3.4. Leadership

The leaders play critical roles in disaster risk management and climate change adaptation, particularly in initiating processes and sustaining them over a long time (IPCC, 2012 Page 469).

In Vietnam, there is a unified leadership of the Party and the Government in responding to climate change and disaster prevention missions demonstrated by capturing the era trends, actively building institutional systems, policies, from building structures, developing human resources, to completing legal system, developing strategies and specific action plans. These practices have been summarized in the report of the Government on the implementation of sustainable development in Vietnam, and was presented at the Summit of the United Nations on Sustainable Development (RIO + 20) (MoST, 2012a).

8.7. Synergy between Disaster Risk Management and Climate Change Adaptation for a Resilient and Sustainable Future

The evaluation results of this chapter have shown the opportunities of coordination between disaster risk management and climate change adaptation to contribute to the sustainable development of economy, society and environment and towards a resilient future, although there is not one approach or a unique way that can achieve that. The key elements are: 1) capacity to connect short-term with long-term goals ; 2) The desire connect the diverse manifestations of risks in the context of many threats and pressures; 3) Integrating disaster risk reduction and climate change adaptation into the socioeconomic policy development process; 4) Creative, flexible and innovative leadership,; 5) Adaptive, responsive and accountable management; 6) Supporting the flexibility, innovation, and learning at the local levels and in various sectors.; 7) Ability to identify and address the root cause of vulnerability; 8) Long-term commitment to manage risk and uncertainty and promote risk-coping thinking.

Disasters often requires urgent actions, consistent from top to bottom but this command does not seem to work well in disaster risk reduction as well as adaptive risk management. In such systems, the threat of disaster risks are often overlooked in the policy-making process, proactive response plans are not established, while indigenous knowledge of the communities are not properly considered. During disasters, interests or needs of the people affected are often not fully considered. These could be the most common limitations in order to mobilize local people to get involved in disaster risk reduction as well as integrating them into the planning of local socioeconomic development. Decentralization of responsibilities to relevant authorities to plan for the future through sound decisions is particularly important, including the role of international, national and local organizations (IPCC, 2012 pg.471).

Actions for disaster risk reduction and climate change adaptation always involve tradeoffs with other social goals, as well as conflicts among different values and visions to achieve a harmony (IPCC, 2012 page 471). In Vietnam, the tradeoff, or balancing among various objectives, such as the tradeoff among the objectives of biodiversity conservation, environmental protection and economic growth targets in the context of climate change is a huge challenge that each individual, each organization at different levels have to face and address.

Threats and vulnerability from natural disasters forced the individuals and the whole society to cope and adapt. Although there has been progress in disaster risk management, especially with the early warning systems, vulnerability still remains at a high level, thus we have to make choiese in resolving issues such as justice, rights, and participation at different levels.

At the macro level, climate change adapation and disaster risk management issues must be integrated into the content of sustainable development, particularly in restructuring the economy development in depth, at high pace but ensuring sustainability; and this objective has been shown in the recently published strategy, such as sustainable development, green growth and climate change. At the micro level, many development projects, including poverty reduction, natural resource management and biodiversity conservation, have adopted a community-based approach in climate change response, which has been widely implemented throughout the country, especially in the Mekong delta, Red River delta and several midland mountain areas.

Thus, in recent years, Vietnam has achieved initial results in climate change adaptation and disaster risk reduction, from which many lessons learnt could be drawn.

Lesson one: Strong commitment of the Government in disaster risk reduction and extreme climate events to proactively adapt to climate change. The Government has mobilized all social and political resources for disaster risk reduction, extreme climate events and climate change adaptation linked to the sustainable development of the country. The legal system and the legal documents on natural disaster prevention, extreme climate events and climate change adaptation, with short term and long term visions, are developed synchronously and gradually improved. Relevant policies are coordinated and promoted at both central and local levels, line ministries and significantly contribute to reduce vulnerability and improve resilience of the sectors, communities and individuals.

Lesson two: awareness raising, capacity development associated with the mobilization of community participation in disaster risk reduction, extreme events and climate change adaptation. The society and social organizations are encouraged to participate in activities to raise awareness, share experiences and develop capacities in natural disaster prevention and mitigation , extreme climate events in order to proactively adapt to climate change, maintaining a link to poverty alleviation and local socioeconomic development. The "Bottom-up", "Community-based" approach are initially in the policy-making and planning, creating opportunities for people to be consulted during the design and planning of development programmes, policies and projectsin the context of climate change.

Lesson three: Coordinating, promoting national capacity and international cooperation. Vietnam actively participates in international activities in disaster risk management, extreme climate events, and climate change adaptation. Through this cooperation, Vietnam has also received valuable international, particularly technical support, human and financial resources, which contribute to the development of the country's resources in addressing the challenges caused by climate change in order to move towards a sustainable and resilient society.

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Chapter 9

Case studies

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Summary

Case studies provide concrete and detailed information on the events of natural disasters and climate extremes, the physical characteristics and aspects of the events, data on damages and losses of people and property. The chapter also analyzes the applied measures and actions undertaken, thus assesses effectiveness of the policies, measures and adaptation options, identifies positive aspects of actions for disaster risk reduction (DRR) and climate change adaptation (CCA), at the same time draws lessons learned from practical experiences. The case studies are chosen to complement and be consistent with the information in the other chapters of this document, and to demonstrate the key messages to support policy makers in DRR and CCA activities.

Types of natural disasters, extreme climate phenomena analyzed in this chapter include: typhoon and storm; flood and inundation; flash flood; drought; heat wave, freezing cold events; saline water intrusion; and urban flooding. Vulnerable areas for the case studies are selected depending on the type of disaster: typhoons/storms affect all regions of Viet Nam - the North, Central Vietnam and the South; large-scale droughts also affect all the three regions, however the central coast and Central Highland have faced more severe droughts and damages; floods occur in large river basins and directly affect population in these areas; flash floods occur more frequently in recent years in the high mountain areas; temperature extremes represented by the heatwaves and damaging cold events happen more frequently in many parts of the country; saline water intrusion become more serious and caused much more difficulties for people production and well-being, especially in the coastal areas of Mekong Delta; rapid urbanization with highly concentrated population and large investments into infrastructure pose the large urban areas in increasingly high risk of disaster. This Chapter 9 also analyzes some solutions and measure for DRR and CCA such as disaster early warning system; the Motto “four on-the-spots”; disaster risk sharing mechanism; awareness raising for community.

The case studies analyzed in this Chapter have showed significant improvement of experiences, policies and measures for disaster risk management (DRM) in Vietnam, especially in the early warning and coordination between prevention, protection and response (before and during the disaster) and rescue/relief and rehabilitation works (after the disaster). Along with the advances in DRM works, in recent years there is substantial success of applying DRM experiences in CCA activities, especially the introduction of measures and policies to mobilize the local community participation; the mindset changing and methods of water use and saving; the application of indigenous/traditional knowledge and experiences in adaptive farming practice, selection of more adaptive and suitable crop variaties and sustainable use of natural resources. Although significant improvements have been recognized comparing to the past, the progress and achievements should be replicated and improved in order to attract more investment.

9.1. Introduction

In this chapter, case studies are analyzed in order to provide more information, clearer illustration and to gain a better understanding of the risks and damages posed by extreme diasters and hydro-meteorology related events in Viet Nam. Lessons learned and best pratices have been identified from the past measures and actions to prevent and respond to disasters for more effective disaster risk management and climate change adaptation.

The case studies are grouped into: typhoon/storm; flood; flash flood; urban flooding; drought; heatwave; damaging cold event; and saline water intrusion. The case study is presented in a consistent way to enable better comparison of approaches. After an introduction, authors provide a background description of the events, the impacts, the damage and response measures and finally a summary of lessons learned.

The case studies were chosen based on the following criteria: characteristic, intensity and scale of the events; the level of damage; regional/spatial representativeness; effective and appropriate response actions/measures.

The case study on typhoon and storm (Section 9.2.1) focuses on detailed analysis of the four powerful storms: typhoon Linda (1997) landed on Ca Mau, typhoons Xangsane (2006) and Ketsana (2009) landed on the Central Coast, and typhoon Son-Tinh (2012) directly affected the Northern Delta. Analyses in the case studies not only showed the level of risk and damage caused by the typhoons and storms, but also emphasized the importance of coordinated response measures, including early warning systems, which can be effective only with harmonized coordination from central to local levels, along with appropriate policies, better understanding, preparation and engagement of the local communities.

Flood is the most frequent disaster posing highest damage to the economy in Vietnam. The case study on floods (Section 9.2.2) includes the great floods in 1971 and 1996 in the North,the historical flood in 1999 and a big flood in 2010 in the Central Viet Nam; major floods in 2000, 2001 and 2011 in the Mekong Delta. These cases showed the importance and urgent needs of the early warning system, of a better coordination between prevention and protection works, rescue and post-disaster recovery in flood management. Local people in flood-prone areas should be trained and provided better knowledge on flood prevention and preparedness to protect themselves against the adverse impacts of natural disasters.

In recent years, flash floods occurred frequently, and often comes with landslides in the mountainous areas of Vietnam (Section 9.2.3). Due to the unpredictable characterristics and difficulty to predict, often occurring in remote and inaccessible areas, consequences of flash floods and landslides become more severe and significant. Although some efforts and investments were made in forecasting and warning, in raising awareness of local people and authorities in identifying and responding to flash flood, the results were relatively humble.

The rapid process of urbanization with high population concentration and a great amount of infrastructure investments have placed large urban areas in increasing risk of natural disasters (Section 9.2.4). Cities have been suffering severe consequences of heavy rains (Ha Noi), combined effects of heavy rain and high tides (HCM City) and flood discharged from upstream reservoirs (coastal cities in the Central Viet Nam).

Effective drought management to minimize its adverse effects is analyzed through the reality of drought events in the Central Viet Nam and Central Highland (Section 9.2.5). The erratic weather, the consequences of climate change and socio-economic activities with inappropriate use of water and land resources in some areas have contributed to the worsening of drought situation. Mobilizing the active participation of local people, changing their mindset in using water, applying the local knowledges and experiences in farming, breeding drought-tolerant crops, sustainable use of resources etc.. are the positive lessons learned from the case studies on drought.

With global warming trend, the indication of extreme temperature in Vietnam is occuring in both ways: the highest (heatwaves and very hot weather) and the lowest (damaging cold events) (Section 9.2.6). While severe heatwaves occur more frequently in many areas of the country, the freezing and damazing cold events (or cold spells) occurr in the Northern mountainous provinces with already limited responding capacity and poor conditions of local communities. Although statistics in the past and in the projected climate future indicate that the number of cold days tend to decrease (Chapter 3), the freezing and damaging cold event may still occur, especially in the Northern mountainous region.

Saline water intrusion reaching deeply inland during dry season, especially in the coastal provinces of the Mekong Delta is serious challenge to the local government and people. Saline water intrusion, from a regular event occuring every year becoming obstacle for production and people life, could be considered as an extreme event that requires efforts and relevant solutions, especially in the context of sea level rise. Some typical saline intrusion events in the Mekong Delta in the last months of the dry seasons in 2004, 2010 and 2011 analyzed in Section 9.2.7 showed the need of raising the community awareness in using of water appropriately, changing crop pattern in combination with structural and non-structure measures for a better fresh water utilization and storage, as well as shifting the seasonal and crop calendar to increase the efficiency of land and water resources use. These measures also improve the resilience and adaptation capacity of local people to climate change.

Chapter 9 also analyzes selectively some measures and mechanisms of DRM and climate change adaptation, including: early warning system of natural disasters; the "four on-the-spots" Motto; mechanism for disaster risk sharing and transfer - agricultural insurance; community awareness raising.

The implementation of early warning system (Section 9.2.8) will have a significant support in reducing losses of life and property due to natural disasters. Many studies have confirmed that early investment in disaster risk prevention plans, strategies and adaptation tools will be more effective than actions in response when a disaster occurs. The early investment to improve knowledge, early warning systems, adaptive technologies, tools and measures would reduce cost, damage and also reduce the loss of life in future.

The DRM systems structured with clear hierarchization in responsibilities from central to local levels along with improved adaptive capacity of the local communities via “Four on-the-spot” Motto have shown clear effectiveness in case of natural disasters and extreme climate. The Motto plays an essential role and can be very effective provided that there is good preparation at local level (Section 9.2.9).

In order to share the risk of natural disasters, agricultural insurance mechanism has been piloted in a number of areas. The report analyzed the lessons learned from insurance activities in agriculture and the reasons why this activity is still underdeveloped in Vietnam (Section 9.2.10).

One of the vital factors in natural disasters prevention and climate change adaptation is the local community's understanding and awareness (Section 9.2.11). Awareness raising activities and supporting activities for local people in preparing for and responding to disasters and climate change via communications, training, livelihood etc. play a very important role, especially for vulnerable groups such as the poor, women and children.

The information used in the case studies of Chapter 9 is referred from Chapter 3 to Chapter 8 and is gathered from various sources, such as scientific research reports, evaluation reports on disasters, programs, projects, policies, regulatory documents ... from the scientific research institutions, business units, government and management agencies, donor organizations, non-governmental organizations... The detailed analyses of each case with the measures implemented allow to reassess the response actions undertaken in reality. Disaster risk depends on the intensity and impacts of natural disasters, the exposure and vulnerability of the community. For a developing country like Vietnam, the limitations of resources, including natural resources, human resources and infrastructure are factors contributing to the higher risk of natural disasters.

These case studies are closely related to the key messages manifested throughout the chapters of the report, to highlight the innovative and practical solutions. These studies also show the complexity of natural disasters, the urgent need for appropriate disaster risk management and reduction, especially in the context of increasing extreme events due to climate change. The research results can also be considered as basis for methodology development, and for the analyses and evaluation of policies related to DRM and CCA in Viet Nam. Lessons learned from the case studies can be replicated in other locations or upscaled for applying in a broader scope/scale, be adapted to a new context in order to create new solutions, new tools and initiatives for more efficient and effective DRM and climate change adaptation.

9.2. The case studies

9.2.1. Effective typhoon prevention and response

9.2.1.1. Introduction

Vietnam is located in the region strongly influenced by the Western Pacific typhoons. With a long stretch of coastline, typhoons and tropical depressions often cause lots of damage to people and properties in a large scale, affecting all socio-economic activities and inhabitants living in the affected areas (Nguyen Duc Ngu and Nguyen Trong Hieu, 2004). The formation, development and occurrence of storms and tropical depressions have a strong variation depending on space and time of year (Section 3.4.2).

Changes in the pattern of storms and tropical depressions (tropical cyclones) are discussed in Section 3.4.2. The statistical data over the past 50 years have showed that the number of tropical cyclones affecting Vietnam and landing on Vietnam coastline was unchanged or slightly decreased. However, tropical cyclones tend to increase in the coastal and inland areas of South

Central Coast and South of Vietnam. In other words, the tropical cyclones tend to move southward. Regarding the intensity of tropical cyclones, the total number of average-to-strong storms landing onto Vietnam tends to decrease, but the number of very strong storms tends to increase (Section 3.4.2.). Results of the study on relationship between storm activities and sea surface temperature (SST) have also showed that the number of storms has increased in the recent hottest (with highest SST) years. Thus, the increase in sea surface temperature is likely to affect the trend and behaviour of the storms (Dinh Van Uu, 2010; Phan Van Tan, 2010).

Regarding the future trend of tropical cyclones in 21st century, the studies have not concluded with certainty about the increase or decrease of the number of storms. Regarding intensity, there is medium confidence that under the impacts of climate change, storm intensity will increase in the 21st century. The future sea surface temperature will increase 1-2^{0}C due to global warming, leading to expansion of the storm formation areas. In the East Sea region, the number of strong storms tends to increase, leading to higher risk of storms, especially in the coastal areas of central and southern provinces.

9.2.1.2. Some typical typhoons

During recent years, many strong and abnormal typhoons have landed to all three regions of the country. The Central Coast is the most affected region by typhoons; especially strong and damaging were the two recent typhoons - Xangsane (2006) and Ketsana (2009). The South of Viet Nam has rarely faced typhoons but the Typhoon Linda (Typhoon No.5 in 1997) was considered the historic storm causing very significant losses to the provinces and districts located on the storm pathway, including offshore of the southern provinces. The Son Tinh Typhoon in 2012 was considered the most complex and difficult to predict so far, has caused a lot of damages to properties in the Northern provinces (Table 9-1). These four typhoons are selected as typical case studies because they are the strongest or abnormal typhoons, causing serious damages, typical for all three regions (North, Central and South), and some lessons can be learned from the prevention and response works.

Typhoon Linda (Typhoon No. 5 of 1997) hit the coast of Ca Mau and Bac Lieu provinces on 2/11/1997 with strong wind and whirlwind of level 10 and over (Duong Lien Chau and Tran Gia Khanh, 1997). This was an unusual storm, formed near the coast of Southern provinces, with increasing intensity and rapid movement; hit the coast at night time and long duration (about 18 hours) of strong wind. The damages and losses caused by typhoon Linda were very high, especially to off-shore fishermen, boats, houses and crops (DMC, 2011a).

Typhoon Xangsane (Typhoon No. 6 of 2006) was a very powerful storm formed on the east coast of the Philippines in late September 2006. The typhoon directly hit and seriously affected the coast and other areas of Da Nang, Quang Ngai, Quang Nam and Thua Thien - Hue provinces, causing severe damage to these provinces. After the storm, heavy rain and rapidly rising flood also affected other central provinces (NCHMF, 2007). Typhoon No. 6 with consequent heavy rains and floods have caused numerous economic losses (Table 9-1), with total losses of over 10 trillion VND. In particular, this storm has destroyed more than 24 thousand houses (Central Steering Committee for Flood and Storm Control, 2006).

Typhoon Ketsana (Typhoon No. 9 of 2009) was a very strong storm with rapid movement. On 29/9/2009 it landed on the territories of the provinces of Quang Nam, Quang Ngai with wind intensity of level 11-12 and whirlwind up to level 13-14. The typhoon also caused very strong wind storm and heavy rain for the Central Highlands provinces (NCHMF, 2009). This typhoon was of high intensity and very large area of coverage/influence, from Quang Binh to Binh Dinh and Central Highland provinces, caused heavy rainfall from Nghe An to Binh Dinh and Central Highland, which in turn had caused rapid and intensive flooding in the rivers of Central region. Due to additional rainfall happened before the storm, flood levels in the rivers of Central and Highland regions had almost reached the historical flood level of 1999, in some rivers it was even higher (Central Steering Committee for Flood and Storm Control, 2009a, 2009b; NCHMF, 2009).

Table 9-1. Some typical typhoons

Events	Year	Descriptions	Loss of human lives	Destroyed houses (units)	Total damages in VN Dong
Typhoon LINDA	1997	Rapid movement, increasing intensity, reached level 10 when hit the coast of Ca Mau, Bac Lieu on the night of 2/11/1997.	Dead: 778 Missing: 2.123.	107,819	7,200 billion
Typhoon XANGSANE	2006	High intensity (level 13), rapid movement, hit the Central region on 1/10	Dead: 72 Missing: 4 (during the storm and consequent heavy rain and flooding).	24,066	10,000 billion
Typhoon KETSANA	2009	High intensity (level 13), rapid movement , hit the coast of Quang Nam and Quang Ngai provinces on 29/9.	Dead: 179 Missing: 8 (due to storm surge and flooding).	9,770	14,000 billion (both due to flooding and storm)
Typhoon SƠN TINH	2012	High intensity (level 12, 13), rapid and unpredictable movement, , landed to the Northern coast on 28/10.	Dead: 8 Missing: 3		11,000 billion

(Source: CCFSC, 1997, 2006, 2009a, 2009b, 2012, NCHMF, 2013)

9.2.1.3. Response measures

In the case of Typhoon Linda (1997), the NCHMF announced the warnings and forecasts in accordance with **the "Regulation on storm and flood warnings"** (Duong Lien Chau and Tran Gia Khanh, 1997). Office of the Central Steering Committee for Flood and Storm Control (CCFSC) informed the local authorities and line ministries to monitor and prepare for the storm. Numbers of preventive measures were conducted such as informing and banning fishermen to go offshore, calling back the offshore ships and boats or to go for shelters. When the storm approached, telegrams had been sent requesting to evacuate people from coastal areas; protect sea dikes and other infrastructures; prepare emergency plan, vehicles and rescue forces (DMC, 2011a). The CCSFC had repeatedly provided the warning information and guidances to mass media agencies for dissemination to the people. During the Typhoon Linda, it was very difficult and ineffective to call the offshore ships and boats back or to shelters because the fishing areas were very large, the boats and ships did not have effective communications means and equipments. In the other hand, the typhoon was formed very quickly and with rapid movement, passing through a large and long track. Many ships and boats had been moored but were bumped to each other, broken and sunk due to the lack of storm-responding experience and improper mooring techniques. Besides, the Southern region rarely faced storms therefore the local people and authorities do not have much experience of storm prevention and control like in Central and North regions. Due to the lack of awareness and experiences on storm, even when the forecasting agency gave timely storm warning, the local people and authorities of the Southern provinces were still unprepared and neglected (DMC, 2011a).

Typhoon Xangsane (2006) was a very powerful storm. For the first time in the history of hydro-meteorological forecasting of Vietnam, National Centre for Hydro-Meteorological Forecasting (NCHMF) had used "level 13 and higher" for the warning bulletin of Typhoon Xangsane. Although the local authorities had developed evacuation plan, it was not so effective when the storm hit. No plan to help people to protect their houses, therefore the number of destroyed and damaged houses was very high. Some parts of the communities were off their guards when the storm occured, especially with rain and flooding after the storm. Another reason limiting the effectiveness in the response to Typhoon Xangsane was lack of rescuing facilities. The local Committees for Flood and Storm Control were lack of facilities for timely, effective and efficient coordination.

The coordination between the central and local levels with direct guidance of the Government was a significant contribution in reducing the damage of the storm, which was illustrated in the case of Typhoon Ketsana (2009). Typhoon Ketsana was similar to Typhoon Xangsane (2006), but occurred 3 years later, and then the prevention of storms made significant progress. Before landing of the storm, the on-site Steering Committee was established (based in Danang) by direct guidance of the Deputy Prime Minister to implement the urgent measures to deal with the storm (CCFSC, 2009b). The coordination between the line ministries and agencies from central to local levels has been implemented effectively. The storm forecasts and warnings had been carried out well. The local authorities had organized evacuation of more than 350,000 people in the coastal areas to safety shelters before the storm hit, called upon and guided more than 46,000 ships and boats to move to shelters and storm prevention anchoring (CCFSC, 2009c). During this storm, the “four on-the-spots” Motto was remarkably effective during the preparation, response to and recovery after the storm (CARE, 2011).

After the storm, search and rescue of people offshore was first priority. The Central Committee for Search and Rescue Work in coordination with local authorities has immediately started operation. Number of local ships and boats was mobilized to rescue people and pick up ships and boats.

The Central region often faces storms therefore the awareness and experience of storm prevention of the authorities and people are better. Appropriate preparatory works have been timely conducted in the storm-risk areas such as checking and strengthening houses, monitoring of storm preparation, evacuation of people living along the rivers, coastal and mountainous areas from high-risk areas, etc.

One important lesson learned from Typhoon Linda is that the organization of information dissemination system, storm forecasting and timely communications to people, especially for the offshore boats, is very important (Government of Vietnam, 1997). The storm warning bulletins nowadays provide continuous and frequent information about the path and intensity of storms over the media. Since 2006, NCHMF has increased the lead time of storm forcasting from 48 hours to 72 hours, the frequent information on the direction and intensity of storms has also helped the CCFSC being more proactive in managing storm prevention and response (DMC, 2011a). Information about Typhoon Ketsana (2009) was regularly updated and widely disseminated in the mass media. Advanced media and rescue facilities and measures were effectively used such as aircraft, signal fireworks, communications via radio and TV, the navy and border security forces were mobilized to inform and help people, especially the offshore fishermen about the intensity and path of the storm. Thus, many ships, boats and fishermen were instructed to avoid the storm timely and safely, thousands of people have been evacuated to safe places (CCFSC, 2009b).

Northern region also has many experiences in storm prevention and up to 2012, the storm prevention works were relatively effective. However, the unusual Typhoon Son Tinh (2012) with most unpredictable development and movement ever had caused great difficulties for forecasting, prevention and response work. The incapability of early and accurate prediction of the the storm's intensity and landing locations made it more difficult for the storm prevention and response. In many places, the local people were subjective; thinking that the storm would not directly hit their territory therefore did not prepare properly or conduct thorough evacuation leading to higher damages. In fact, the storm did not land directly on the coast but skirted the Northern coast of the East Sea with strong wind swept through a very large radius and caused a lot of damages, especially Hai Phong city suffered the most (NCHMF, 2013).

Learning from this storm, the NCHMF has added additional information in the storm warning bulletins, not only mentioning the location of the storm eye, but the radius affected by heavy rain and strong winds of the storm. To date, the forecast of the changing of storms pathway and movement remains a challenge to be addressed.

Governments and authorities at all levels, non-governmental organizations have had many activities to support affected local people and communities after the storms. After the Typhoon Ketsana, the support activities were implemented in two phases: emergency relief and recovery assistance. At the emergency relief phase, the Disaster Management Working Group (DMWG) carried out appropriate steps for post-emergency support: from opened and democratic selection of beneficiaries to assessment of the target groups needs (Ngo Cong Chinh and Richard Rastaal, 2010, page 18; Hoang Van Duong and Nguyen Thu Que, 2011 page 18; Dang Phi Lan, 2011 page 24); assessment and monitoring to improve the equitable distribution of support (Nigel Smith, 2010 page 20). The recovery assistance phase focused on improving livelihoods such as allocating monetary support to improve agricultural land, support of seeds and young fish breeds, trainning of agricultural expansion staffs. The public health activities were also implemented such as providing and improving health-care and equipments, clean water and sanitation, awareness raising and trainings on primary health care for local health staff and community groups. Support was provided for rehabilitation of local infrastructure such as houses, canals, bridges and irrigation works (Oxfam, 2006 page 4).

With the increased risk of storm impacts due to climate change, the main approach towards integrated DRM and CCA is to increase the community resilience and sustainability. It includes livelihood projects in agriculture, forestry and non-agriculture sectors such as: production and provision of crop varieties and seeds (Vo Chi Tien et al, 2010 Page 7-8); technical assistance for crop nurseries and cultivation, maintenance and production of mangrove forests, improving community livelihood and income diversification (Buffle et al, 2010, page 6; Tran Tho Dat and Vu Thi Hoai Thu, 2012); reducing risks and supporting poor farmers to improve agriculture practice, community-based mangrove management model (CARE, Oxfam, World Vision, 2010; Buffle et al, 2010 page 5); pilot models supporting integration of DRM and CCA into socio-economic development planning at local level, DRR planning at household level (ADPC, 2010, CARE, Oxfam, World Vision, 2010 page 13, 16, 37). The Project "*Buiding storm and flood resistant houses*" supported by the International Federation of the Red Cross and the French Development Agency focused on construction of storm-resistant houses in 7 provinces, ensuring the following criteria: disaster resistant, appropriate for local culture and beliefs, flexible design, and especially appropriate for household budgets (Development Workshop France, 2010). Pilot project on construction of storm-resistant houses in Danang city has proved its effectivity when the storm No. 11 in 2013 (typhoon Nari) caused much damage to the city's infrastructure, transportation, power lines etc., while about 250 newly constructed storm-resistant houses were not seriously affected (Tran Van Giai Phong, 2013).

9.2.1.4. Lessons learned

The case studies on storms and storm prevention have showed that storm prevention is increasingly concerned and gradually improved. In recent years, thanks to effective storm prevention, storm damages was significantly reduced, especially the casualties. Storm prevention should focus on the following issues: (1) Raise awareness about the storm danger for the community; (2) Promote effective early warning systems, especially forecasting system; Improve information dissemination and warning systems; and (3) Reduce vulnerability of communities in the high-risk areas (relocation from high-risk coastal areas, planting mangroves, building storm-resistant houses...).

In the context of climate change when the storm risk and storm impacts increased, the activities aiming at reducing vulnerability, increasing resilience for the community will contribute to both the short-term disaster risk reduction and the long-term climate change adaptation activities (DMC, 2011b).

Practice showed that the commitment, guidance and actions of the government play very important role in promoting the prevention and control of floods and storms. The important legal bases have been given in recent years such as the *National Strategy on Natural Disaster Prevention, Control and Mitigation upto 2020* (Government of Vietnam, 2007) and the *Law on natural disaster prevention and control* (National Assembly, 2013) have created a comprehensive legal framework to promote effectiveness of prevention and mitigation of natural disasters in Vietnam. With the guidance of the Government, Vietnam has mobilized resources and participation of all the civil society to participate in the storm prevention. The international support and participation of non-governmental organizations have also contributed positively, especially in emergency, post-disaster support, relief and rehabilitation after the storm.

After the emergency relief and recovery assistance, the activities should aim to enhance the capacity to manage the storm risks and adaptability of local communities; improving livelihoods; ensuring safety of people and property. These might include investment in storm-resistant infrastructure at different scopes and scale, such as construction of storm-resistant houses, planting mangrove and protective forests, which can diversify the products and livelihoods for the coastal communities, thus increase their resilience to climate change.

9.2.2. Flood Risk Management

9.2.2.1. Introduction

Flood is one of the most common natural disasters in Vietnam. Damages caused by flood in Vietnam are relatively large in the world. In Vietnam, the annual flood season in different areas occurs differently. Depending on natural geography and annual meteorological characteristics, flood season can come earlier or latter. Flood season in rivers of the northern region occurs from June to October; in rivers from Thanh Hoa to Ha Tinh from July to November; in rivers from Quang Binh to Ninh Thuan from September to December; in rivers of Binh Thuan and provinces of South and Central Highlands, it is from June to November (Government of Vietnam, 2014).

In the Northern region, floods in Red – Thai Binh river system affect the northern delta. Floods on the main rivers pose risk to many towns and low-lying areas along the rivers (Le Bac Huynh, 1999). From 1905 to 1999, in the Red River Delta there were 12 years of big flood breaking the main dikes, causing major damages in large scale. In particular, the historical floods in 1945 and 1971 caused heaviest losses for most of the provinces of the Northern Delta. The flood in 1971 was the largest flood in the last 100 years up to 1999 in the Red River (Tran Thanh Xuan, 2000).

In the Central region, due to natural geographical features of the basins with mostly mountainous, steep terrain and small, narrow plains so floods often occur and rise very quickly. Because there is no dyke system in most of the rivers in Central region, overflowed flooding water and inundation happen regularly when big flood occurs. Serious flood on large scale occurred in 1964, 1998, 1999 in the provinces from Quang Binh to Phu Yen; historical flood broke dikes causing big flooding in Ca and La Rivers in 1978. In 1998, 1999, very big floods happened in Thu Bon, Huong, Tra Khuc and Kon rivers causing serious damages to people and assets in Hue, Quang Nam, Da Nang city, Quang Ngai provinces (Le Bac Huynh, 1999). Recently, the 2010 flood in the La river has caused heavy losses of life and property to the Ha Tinh province.

In the Mekong Delta, in average big floods happen every 4 - 6 years (Tran Thuc, 2001). The main causes of flood in the area are heavy rain from upstream, flood discharge from upstream hydroelectric dams, deforestation, improper planning of irrigation and salinity-prevention system or inappropriate urban development planning. For the last 45 years, big floods happen during the years of 1961, 1978, 1984, 1991, 1994, 1996, 2000, 2001 and 2011 (DMC, 2011a).

The Government of Viet Nam recognizes the importance of flood prevention, control, mitigation and recovery from flood-induced consequences and considers flood prevention and control as responsibility of both the Government, organizations and individuals but the Government must play a key role while organizations, communities and individuals play supportive roles and should help each other (National Assembly, 2013). So far, the government has developed a number of policies, and legal documents relating to the measures and plans to prevent and overcome the consequences caused by floods such as "Sustainable Development Strategy of Vietnam for the period 2011 - 2020", "National Strategy for natural disaster prevention and mitigation by 2020" and "Law on natural disaster prevention and mitigation". Some major projects, studies on flood prevention and mitigation implemented recently are: building and upgrading the dyke system, planning of flood-dentesion areas for the Northern Delta, project on flood release to the West sea in the Mekong Delta (DMC, 2011a; National Assembly, 2013).

The following section will analyze, assess and discuss on several typical floods, their consequences and effectiveness of policies and projects in flood risk management in Vietnam.

9.2.2.2. Some typical floods

Table 9-2 below describes the main characteristics, losses and impacts of the typical floods occurred in Vietnam in the recent years that were selected for this study.

The biggest flood in the Northern delta area was registered in 1971, following heavy rainfall after storms in the basins of Thao, Lo and Da rivers. Floodwater from these rivers has aggreagted causing a historic flood of the Red River Delta. The water level in Red River on August 20 reached upto 14.13 m in Hanoi. This water level was 2.63 m higher than level-III of flood alarming level. Water level in Red River measured was 18.17 m in Viet Tri station (2.32 m higher than level-III alarm) and 16.29 m in Son Tay (1.89 m higher than level-III alarm). At the same time, the water level in Cau, Lo and Thai Binh rivers had reached the highest marks in history. The flood had broken 400 km dikes in three locations, flooded 250,000 hectares of crops, causing 594 deaths and affected 3 million people. The flood has caused damages of 537 million VND (in 1971 price), equal to 5.7% of the total products in the Northern region (Le Bac Huynh, 1999).

In the Northern region, there are number of other big floods such as those happened in 1945, 1969 and 1996.

The flood in 1999 was historical flood in Central region. In just over one month, from November 1st to December 6, due to the effects of strong cold front in combination with the tropical convergence range and another tropical depression, very heavy and continuous rain happened causing big floods in Central region and Central Highlands. This biggest historical flood for Central region had caused enourmous damages to people and property, 718 people have died, the estimated damage was US$300 million, leading to extremely heavy and long-term consequences for soco-economic and environmental aspects in the Central region provinces, especially in Thua Thien Hue, Quang Tri, Quang Nam, Quang Ngai, Binh Dinh, some districts of Da Nang city, Quang Binh, Phu Yen, Khanh Hoa provinces (CCFSC, 1999).

In addition, there was a number of other big floods in Central region such as the flood in 2010 in the provinces from Nghe An to Hue, caused 143 people dead, tens of thousands of houses inundated, tens of thousands of people evacuated, estimated damages were tens of millions USD.

In the area of the Mekong Delta, the flood in 2000 was historical, developed complicatedly with two successive peaks associated with high tide (4.05 – 4.16m) happened in late September, early October, which increased the flood level. Duration the water level at Tan Chau remained at more than 4.5 m (level III alarm) was 56 days, equivalent to the floods in 1961 and 1978. This flood has caused severe consequences with 448 deaths, 5 million people affected. Estimates of flood damage was approximately US$285 million.

In the area of Mekong Delta, in 2001 there was another serious flood, leading to 539 people dead, 219 people injured, millions of people were affected and estimated damage was about US$ 300 million.

Table 9-2. Some typical floods

Year	Influenced areas	Discriptions	Damages
1945	Northern Delta	Second biggest flood in the 20th century in the Northern delta, formed by the combination of the biggest flood in Da River joining with medium-level floods in Lo and Thao rivers.	About 2 million people had died from starvation due to crop loss after the flood.
1971	Northern Delta	Biggest historical flood in the last 100 years in Red River system, formed by combination of highest-level floods in Lo and Thao rivers with big flood in Da river.	594 people died, 400 km broken dike, 250,000 hectares of crops flooded, 3 million people affected. Damage was estimated at 537 million VND (1971 price), equal to 5.7% of the Northern region total product.
1996	Northern Delta	Third biggest flood in the last 100 years in Red River system, formed by combination of highest-level flood in Da River with medium flood in Thao river and big flood in Lo river.	60 people died, main dikes broken in Gua river, most of local dikes of Vinh Phuc, Phu Tho, Ha Noi and Bac Ninh provinces were broken. Estimated losses of up to 730 billion VND.
1999	From Quang Binh, Thua Thien Hue to Khanh Hoa provinces	Took place from the beginning of November and December 1999 with flood level beyond the historical records so far.	718 people dead, the economy, society and environment of the Central coastal provinces were severely affected. Estimated losses of 3,300 billion VND.
2000	Mekong Delta	Biggest historical flood in the last 100 years in Mekong delta. Complicated development with two successive flood peaks.	448 people dead, 5 million people affected. Estimated losses of about 3,140 billion VND.
2001	Mekong Delta	The flood remained for approximately 1 month, causing deep and very serious inundation, significantly impacted the economy and society in many provinces of the Mekong Delta.	539 dead, 219 injured, millions of people affected. Estimated losses of about 3,600 billion VND.
2010	From Nghe An to Hue	Caused by heavy rains in early October 2010 in large scale from Nghe An to Hue.	143 people died, thousands of houses flooded, thousands of people evacuated, estimated losses of hundreds of billions VND.
2011	Mekong Delta	Flood level remained at high level for a long time (almost one month), causing deep inundation.	29 dead, millions of people affected, estimated losses of 1,000 billions VND.

(Source: Le Bac Huynh, 1999; CCFSC, *1999, 2000, 2001;* NCHMF *2010, 2011)*

9.2.2.3. Response measures

a) Northern Delta Area

People living in the Northern Delta have long history and tradition of dike building, flood control planning, flood prevention to protect people and production. In addition, many other measures were applied for flood control such as: clearing and dredging rivers to increase capacity of flood discharge; flow diversion for flood regulation; administrative and legal measures in dike management etc. Through the long historical process of accretion, dike construction and upgrading, the dikes in the Northern Delta have formed a continious and closed dike system throughout the plain to the sea for flood prevention purpose. The historical flood in August 1945 has shown that the dike system in the Northern Delta can not resist the water level of 12m in Hanoi. Recognizing this, works for strengthening, consolidation and development of the dike system was promoted in Red River system in the following years, with a goal of being able to resist the historical flood level like in 1945 (Le Bac Huynh, 1999). After the flood in 1971, the government has launched a number of urgent and essential measures to strengthen the flood prevention and control for the Northern Delta to respond to big floods in the Red River system. This included construction of a system of and large reservoirs upstream to regulate or cut the flood downstream, and construction of flood detention and diversion infrastructure. The security level for flood prevention of the dikes in Hanoi in 1974 had reached +13.40 meters (Le Bac Huynh, 1999).

In 1978, the Hoa Binh hydroelectric plant in Da River was built with one of the purposes to contribute to flood regulation and reduction of downstream flooding of the Red River. Since its completion and operation, although there was no direct flood-regulation work required for the downstream, when there were big floods in other tributaries of the Red River system, the operation of Hoa Binh reservoir in Da River has contributed to limiting to the downstream flood levels. During the flood in 1996, a series of effective intervention measures have been applied resulting in reducing of about 1 meter flood in Red River in Hanoi, limiting the damage to people and property, maintaining the main dike system, ensuring the safety of the important residential and economic areas (DMC, 2011a).

In recent years, a series of hydroelectric reservoirs in the upstream of the Red – Thai Binh River system were built such as Son La, Tuyen Quang, Thac Ba reservoirs etc. These works play an important role in preventing and controlling the floods downstream.

b) Central Region

In the Central region, rainfall is usually very big, concentrating in a short time on small, short and steep watersheds, upstream forest is severely damaged, the downstream plains are narrow, sunken and poorly drained therefore floods usually happen very fast and fiercely. Due to these reasons, the 1-2 days earlier detection as well as monitoring, warning and forecasting of rainfall and flood in the Central region is a very complex and difficult task. With existing equipments and qualification, usually the forecasting lead time was only 12 - 24 hours (e.g. the rainfall and historical flood in 1999 were detected and warned 1 day earlier) (IMHEN, 2013). Besides, there is a serious lack of rescue facilities in the region, leading to ineffective and passive actions. Most of interviewed people at commune level recognized that the response and rescue facilities at local level are crucial and of urgent need, but were very limited at the time being (IMHEN, 2013).

To solve this situation, a series of policies and measures have been conducted to prevent and manage the flood risk in an effective manner. It is crucial to invest in modern equipments and conduct more comprehensiveresearch to understand better about the rainfall, storm and flood in order to have more effective and reliable forecast, efficient monitoring and early warning system. The success and effectiveness of flood warning not only depend on more accurate/reliable forecasts, but also on appropriate and timely communication of flood warning information and proactive flood prevention and control strategies (IPCC, 2012).

After the flood in 1999, the flood forecasting as well as DRR organization and disaster response capacity was strengthened resulting in significant reduction of casualties during the 2009 flood and typhoon Ketsana, however the damage and loss of facilities and infrastructure was much higher. Combination of storm and flood is the most serious disaster therefore in Central region, mainstreaming DRR into the projects and activities is not just a recommendation but must become a compulsory factor to ensure the sustainability of each project, each activity as well as the whole society (Nguyen Ty Nien, 2012).

In 2009, the Government had approved a Project on raising public awareness and community-based DRM with objective to raise disaster awareness for the public and affected communities and to effectively design and conduct models of community-based DRM for all levels and sectors, especially for vulnerable local authorities and communities in order to minimize the lives and property losses. The Project has achieved initial success with successful models being able to effectively respond to flood, such as building of the strong and permanent community houses as shelters for people living in the flood-prone areas in the Central region. Relief work after the floods were implemented through a number of projects to support and strengthen the capacity of local communities in flood-prone areas through provision of essential supplies directly to affected people (Oxfam, 2011).

There are a lot of hydropower projects in the Central region. In fact, the reservoirs built decades ago in here can be effective in providing water for irrigation in dry season and some larger reservoirs can partly regulate flooding in the downstream. However, dozens of small and medium hydropower projects built in recent years in this area do not meet the requirements of multi-functional purpose, including flood regulation for downstream. Besides, there is not yet clear and harmonized operational rules for them which may lead to more difficulties for the flood and storm prevention and control, in some cases even increased the flood damages.

c) The Mekong Delta area

The Mekong Delta has always faced frequent flooding and undergone many big floods in recent years. Due to unique characteristics of flood in the Mekong Delta, although the coverage and affected residential area are very large and very long flood duration (may lasts several months), the impacts and damages caused by flood in the Mekong Delta are usually not as high as in the Central region and Northern Delta. Moreover, being aware of the problem, the Government has have fundamental investment in order to form an effective system of measures towards adaptation, living with floods in an active and positive way and reducing losses. The main motto for flood prevention and control in the Mekong Delta is to partly adapt, avoid as possible and to limit the negative flood impact through structural and non-structural measures (Le Bac Huynh, 1999).

The flood in 2000 came earlier and reached highest level ever since monitored (from 1926) in the Mekong Delta with complicated development with two successive peaks, causing historical flooding in the Mekong River Basin in general and in the Mekong Delta in particular. One of the key reasons of this historical flood was the combination of global climate change's influence and very strong and long period of La Nina phenomenon lasting from 1999 until end of 2000 (Tran Nhu Hoi, 2005). Although the NCHMF had timely issued forecasts for this flood, serious damages still occurred.

During the 2000 flood, people have not seriously recognized that the floods came earlier with high intensity and prolonged duration, therefore they did not actively prepare and plan for the flood, being especially passive in evacuation/relocation to a safer place. The loss of lives was mainly because of neglecting communications and checking, therefore the majority of casualties fell to children due to adults' carelessness. The lessons learned from the flood in 2000 as well as increased awareness of people had helped the communities in prevention and response to the next-year flood (Neefjes, 2002). After the flood of 2001, a number of structural and non-structural measures were conducted such as improvement of transport and irrigation system and rural development in the Mekong Delta towards the motto "living with floods". Up to 2006, in the Mekong Delta has been implemented 15 projects on river dikes and sea dikes with total length of 670 km, about 580 km of rural roads-levees , 28 on-dike bridges, 82 salinity-prevention sluices and more than 1000 meters of coastal embankments were upgraded or newly constructed. These works have shown their effectiveness in flood regulation, water supply, flood release, fresh water conservation and salinity prevention, ensuring the safety of the residential and production areas in the Mekong Delta. The Government had also provided loans for people to strengthen their house foundation and/or construct houses-on-piles to support the people "living with floods". Besides, number of non-structural measures were implemented such as: (1) Shifting of crop calendar, pattern and structure of plants and animals farming, maintaining and planting of protective forests along rivers and coastal areas (mangrove); (2) Improving urban and residential planning, adjusting building codes and standards for construction in the flood- and storm-pronce areas; (3) Integrating DRR into education programs and curricula; (4) Preparing logistics, local forces, means and supply materials under the "four on-the-spots" motto; and (5) Conducting trainings for local staff working on flood prevention at district and commune levels (DMC, 2011a; Neefjes, 2002).

After the flood in 2000, the Mekong River Commission has adopted the Flood Management and Mitigation Strategy in 2001, followed by the Flood Management and Mitigation Programme being implemented since 2004 with overall objective of "Preventing and minimizing losses of life and property caused by floods, but still maintaining the benefits brought by the floods". The program has substantially contributed to the flood prevention. The activity "Capacity building on emergency flood management through skill trainings for officials and communities (swimming classes for children, safety school programs, planning for flood prevention, etc.)" has proven its effectiveness in the flood season in 2011 (MRC, 2011).

In addition, some programs and projects have offered support measures after floods, especially in solving problems of clean water and sanitation; public health initiatives, construction of sanitation facilities, propaganda, trainings and general post-disaster management (ECHO, 2003). There were many specific guidelines aiming to improve the capacity and knowledge to people such as: motto of "four on-the-spots" in natural disasters prevention (CARE, 2011); Manuals on prevention and mitigation of floods and storms effects for the community (CARE, 2008) have been produced.

With the needs to manage and mitigate the flood impacts, especially in the context of climate change and sea level rise, the MRC's Flood Management and Mitigation Programme continues to be implemented in period 2011 - 2015 with the new objective to "manage and develop the Lower Mekong River Basin with the best solutions to minimize the damage caused by flood and maintain beneficial resources brought by the flood". In this phase, the program focuses on the following key areas: (i) To provide products of flood forecasting and warning; (ii)

To continue updating and developing databases, models, methods and tools related to flood as well as technical guidelines on the management and mitigation of flood and solve the problems of transboundary flood; (iii) To study the effects of climate change on flood characteristics and behaviour; and (iv) To support the Drought Management Programme and conduct forecast of dry season flows... (MRC, 2011).

9.2.2.4. Lessons learned

In recent years, the government and provinces have special interest in strengthening the infrastructure for flood control, improving flood control capacity, especially the initiatives for local people and communities living in flood-prone areas to significantly reduce the loss of life, particularly of children. Besides, under the guidance of the Government and the CCSFC, the active implementation of flood control measures by the local authorities and communities have contributed to significant reduction of the damages caused by the floods.

The effectiveness of flood-response measures implemented in the Northern Delta has been proven in practice. The level and structure of the dike system were strengthed continiously therefore the flood damages were decreased remarkably. Previously, in the Northern Delta every 2 to 3 years the dikes were broken due to flood. Now, the dike system of Red and Thai Binh rivers have capacibility to resist against floods with much higher level than those that broke the dikes before, even against the same historical flood level of 1971.

In Central region, the model of community-based DRM has brought real benefits. For example, the flood-resistant houses built in Huong Son, Vu Quang and Duc Tho districts of Ha Tinh province have showed their effectiveness in the 2013 flood (IMHEN, 2013). However, although some reservoirs operated effectively in providing irrigation and flood regulation, the intensive flood discharge from other reservoirs had adversely affected the flood prevention and control works downstream. Example are the historical flood in Ha Tinh in 2010 was exacerbated by discharge from hydropower plant Ho Ho; The big flood in 2013 in Quang Nam and Quang Ngai provinces happened when all 15 hydropower reservoirs in the area simultaneously discharged flood water. The Government already took actions to find solutions and to avoid repeating such a problem. Specifically, the MONRE is developing procedures for operation of cascade of reservoirs in the Central region to ensure both the reservoirs safety and the reduction of damage to downstream. Under climate change context, heavy rainfall and storms will likely to increase and be more unpredictable, therefore special attention should be paid to avoid similar incidents threatening reservoirs safety and increasing flood risk in the Central region and Central Highlands (MONRE, 2011).

The floods in Mekong Delta have showed some shortcomes that the flood response were mostly focused on relief works and recovery after floods while the flood prevention activities (before flood occurs) were not yet adequate. The people do not have enough information and knowledge in coping with the disaster. Repeatedly in the early 90s of the last century, big floods happened in the Mekong Delta have caused many casualties, significant damage to production, property and infrastructure. Many policies for flood management have been issued, in particular the Decision No.99/TTg on long-term orientation and 5-year plan (1996-2000) for the development of irrigation and transport system in the Mekong Delta. In 1996, a research project on flood control in Long Xuyen Quadrangle was also deployed. The effectiveness of this project has been tested through successful flood control during the 1999 flood and the historical flood in 2000 whenVinh Te canal and the flood release system had discharged about 13 billion m^3 of water to the West Sea, helped to significantly reduce flood area. So far, this system is well functioning and have effectively achieved multiple objectives such as: flood control, flood release and retention, improving environment, providing water for irrigation, navigation and residents (DMC, 2011a).

Under the future climate change, extreme daily precipitation, extreme rainfall in flood season may increase leading to higher flood risk in most of the basins in Viet Nam (Chapter 4). Therefore, the successful measures used in previous flood control works should be well considered for replication as climate change adaptation measures such as: building/strengthening river and sea dikes; planting and conservation of protective forests along rivers and the coast line; appropriate planning of residential areas, construction standards for flood- and storm-prone areas etc.

9.2.3. Flash floods – hazard threatening the mountainous areas

9.2.3.1. Introduction

Vietnam is located in the humid tropical region, with many areas of high rainfall intensity and high slope of the terrain; therefore flash floods are common natural disasters. Flash floods often occur unexpectedly, creating very intensive flow threatening human life, destroying infrastructure and could significantly impact socio-economic development. In the context of global climate change, precipitation pattern changes and is difficult to predict, the risk of flash floods is much higher (Tran Thuc and La Thanh Ha, 2012).

According to the statistics of the Central Steering Committee for Flood and Storm Control (CCFSC), from 1989 to 2007, flash floods happen every year with a total of 194 events, total loss of more than 1,860 billion VND. Most flash floods occur in mountainous, sparsely populated areas. However, some flash floods are very intensive and destructive, causing losses of life and property of the people in large area, especially to the residents living in the valley when flash floods swept through (Tran Thuc and La Thanh Ha, 2012).

9.2.3.2. Some typical flash flood events

On the night of 8/8/2008, heavy rainfall in a large area had led to flash floods, landslides and inundation in many locations of Lao Cai province. Also on that night, a flash flood with mud and rock occurred and was considered as the largest flash flood in the history of Lao Cai. The flash flood had killed 66 people (missing and dead), most of the main roads were congested, many buildings, houses, paddies, etc. were heavily damaged (Steering Committees for Flood and Storm Control and Search and Rescue of Lao Cai). In particular, the flood with mud and rock on the night of 8 August had wiped out the village of Tung Chin (Bat Xat district), buried and washed away 22 people. Hundreds of hectares of rice and vegetable fields in Trinh Tuong Commune were lost and washed away (Tran Thuc and La Thanh Ha, 2012).

In August 2012, also in Lao Cai, due to the influence of a tropical depression combined with convergence of high winds, the eastern districts of the province have had average rainfall of more than 45 mm, particularly in the area of Bac Ha, local rainfall of more than 200 mm lasted for several hours. On 31st August, due to very heavy rainfall, the watershed primary forests were eroded then break off to form a severe flash flood that swept through the residential area of Nam Du and Nam Cham villages, Nam Luc Commune, Bac Ha district, Lao Cai Province.

This flash flood had killed 11 people and injured 9 people, tens of houses of the villagers have been washed away and damaged. The flood flattened 10 hectares of land, paddy fields and gardens. More than 6 km of inter-village roads near Nam Luc village were completely paralyzed and burried under tens of thousands cubic meters of rock and mud; wireline communication network was damaged, contact between the affected village and the provincial Steering Committee for Flood and Storm Control and Search and Rescue had to rely entirely on unstable mobilephone connection.

Table 9-3. Some typical flash floods

Time	Location	Discription	Impacts on Human	Impacts
8/8/2008	Lao Cai	On the night of 8/8/2008, widespread heavy rain had caused flash floods, landslides and inundation in many parts of Lao Cai province. It was considered the biggest flash flood in Lao Cai history.	No. of dead: 88.	Transport collapsed, infrastructures, houses, rice and vegetable fields, were heavily damaged.
31/8/2012	Lao Cai	On 31 August 2012, due to heavy rainfall, the primary bamboo forests in the watershed were eroded forming water obstruction, then break off to form a flash flood that swept through the residential areas of Nam Du and Nam Cham village, Nam Luc Commune, Bac Ha district, Lao Cai Province.	No. of dead: 11; No. of injured: 9.	The flash flood flattened 10 hectares of land and gardens. Inter-village roads were completely paralyzed and burried under tens of thousands cubic meters of rock and mud; wireline communication network was damaged.
26/4/2010	Ha Giang	At 23 pm on 26/4/2010 in the area of Xin Man district, Ha Giang province, prolonged rains had caused severe flash flood.	No. of dead: 5; No. of injured: 3.	6 houses were washed away, 607 houses were damaged, estimated loss - 35 billion VND.
14/8/2010	Yen Bai	A heavy rain lasted for 90 minutes had caused flash floods in Lien Son village, Lang Thip Commune, Van Yen district, Yen Bai province	No. of dead: 7	Tens of hectares of paddy fields burried, roads destroyed, transport collapsed, bridges, culverts, weirs and many houses were washed away.

(Source:Tran Thuc, La Thanh Ha, 2012; National Centre for Hydro-Meteorology 2010, 2013)

In addition to the two above-mentioned flash floods causing loss of life and property in Lao Cai, there were some other flash floods also making serious consequences such as the flash flood occurred on 26 April 2010 in the area of Xin Man district, Ha Giang province killing 5 people, injuring serioulу 3 people, washing away 6 houses, damaging other 607 houses, estimated loss was about 35 billion VND. In the morning of 14 August 2010, a heavy rain lasted for 90 minutes in large area had caused flash flood in Lien Son village, Lang Thip Commune, Van Yen district of Yen Bai province, making 7 dead, burying dozens of hectares of paddy fields, destroying many transportation works, washing many houses away. Table 9-3 describes some typical flash flood events and the damages and impacts they caused in Vietnam.

9.2.3.3. Intervention measures

After the flash flood in 2008 in Lao Cai, with heavy loss of lives and property, the Government and scientists pointed out a number of limitation issues in the prevention of flash floods as follows: (1) living habits and custom of the ethnic minority people: The flash flood areas are mainly living places of the Dao minority group who have habits and custom to set houses and live near the streams and rivers with very high risk of flash floods; (2) It is necessary to establish an effective early warning system for flash flood: studies on factors related to mortality due to flash floods in the provinces of Lao Cai, Yen Bai, Phu Tho have shown that the risk of fatality in the households that did not receive early warning information is 2 times higher than those received information (Ha Van Nhu, 2011); and (3) low public awareness: Most people living in flash-flood prone areas are minority ethnic groups, with limited educational level and awareness. They have behaviors and habits that mutiple the risk of fatality such as passing through the flood areas (11.5%) and living in the forest camps (7.7%) (Ha Van Nhu, 2011).

Recognizing these problems, in addition to mobilization of rescue forces and deal with consequences after flash floods, Lao Cai authority has launched a number of synchronized and long-term solutions to reduce the damage caused by flash floods including: (1) promote the warning/information dissemination and rise people's awareness on prevention of flash floods and landslides; (2) organize the relocation of people out of the high risk areas; (3) construct the rural infrastructure for possible prevention and control of flash floods (embankments, stream diversions) and early warning (loudspeakers, poles and boards with warning signs); and (4) enhance the capacity of search and rescue groups, organization of post-disaster recovery under the "four on-the-spots" motto (leadership on the spot, human resources and forces on the spot, materials and logistics on the spot).

In 2012, before the rainy season, Lao Cai province had carefully prepared for the workforce, planning on flash flood prevention and control, ensuring transport, smooth information dissemination and communication and the mobile rescue force as necessary. The province has moved 561 households out of dangerous, high-risk areas, mainly those were households living in high risk areas of flash floods and landslides in Sa Pa, Bat Xat, Van Ban and Bao Yen districts (according to Mr. Doan Van Huong, Deputy Chairman of the Provincial People's Committee). In the flash flood on 31 August 2013, rescue and search forces had timely deployed on-site, with the army's support of more than 600 solders have searched for the missing, helped families of Dao ethnic group in Nam Cham and Nam Du villages (Nam Luc Commune) to clean the houses and fix the damages after the flood. Thanks to the promptly implemented rescue and relief, the damages caused by this flash flood have been limited.

Along with the positive interventions in Lao Cai province mentioned above, many non-governmental organizations had also offerred support for local community facing frequent flash floods. For example, the project "Community pariticipation in prevention and response to fash floods, landslides and adaptation to climate change" in Ha Giang province was deployed in Vi Xuyen and Bac Me districts, Ha Giang province. This project provided models to prevent and respond to flash floods and landslides at local level, to support livelihoods for poor people living in areas with frequent flash floods and landslides.

9.2.3.4. Lessons learned

Some lessons learned from the above mentioned flash floods are as follows:

Relocating the local population from high flood-risk areas can significantly reduce the loss of lives and property, but this process may be difficult, could take a lot of time and energy because in mountainous areas, people live dispersedly and transport system is very poor. Experiences showed that because of ancient living habits and custom, it is difficult to convince ethnic people to relocate permanently to a new place. It may need to build temporary shelters or convince people to live in a new place but still maintain works in the fields and look afer livestocks in the old houses. The relocation measures can only be effective if there is obvious and high possibility of flash floods, reliable forecast and timely warning of flash floods (Tran Thuc and La Thanh Ha, 2012).

Limited resources is one of the most important issues in the prevention and response to such disasters like flash flood. Flash floods often occur in mountainous areas, with undeveloped economy and low literacy levels. The poor are more vulnerable to damages caused by natural disasters, despite the efforts of the government to protect them (World Bank, 2011).

To partially overcome the resource limitation, it is crucial to have the community participation. Organizing the drills to prevent and respond to flash floods is very important to help the government and people to accumulate experience and react promptly when flash floods occur.

In addition to the immediate intervention, there should be combination of other supporting measures such as supporting livelihood activities to improve their lives and to adapt to climate change, especially for the poor households living in areas frequently hit by flash floods and landslides. The economic autonomy can help people to respond better to emergency situations.

Preventing and responding to flash flood should be considered and integrated with other activities under general context of climate change. Community and people participation should be encouraged and general information about climate change be provided, for example to encourage people living in mountainous areas to protect the watershed upstream forests – which can serve as shields and buffer to reduce the intensity and damages of the flash floods.

9.2.4. Urban Flooding: a threat and challenge for urban planning

9.2.4.1. Introduction

Urbanization is an inevitable and unstoppable trend. However, the process of urbanization will also increase the risk of natural disasters. For any city, the level of risk and damages from extreme weather is affected much by the quality of construction works and infrastructure of the city. The risk level is also influenced by the level of success in urban planning and land use management towards reducing the impacts of climate change in the context of urban construction and expansion. At the same time, the level of preparedness of the people and quality of service in an emergency situation are also important factors (Satterthwaite, 2008). Urban flooding risk will affect the urban plannings and policies and directly affect the residents living in urban areas.

Urban flooding is becoming increasingly popular in Vietnam. Urban flooding usually does not cause many casualties, but may cause huge damage and loss to properties and strongly affect the people daily life and production because urban areas have high density of population, infrastructure, wealth, assets. The most vulnerable and affected group are the poor people living in weak and temporary houses with low foundation, especially the rural-to-urban migrants. Each urban area has different characteristics and causes of flooding, thus it is required to have various preventive measures.

All the five big cities directly under the central Government of Vietnam (Hanoi, Hai Phong, Da Nang, Can Tho and Ho Chi Minh City) and the coastal urban systems are at high risk of natural disasters and strongly affected by climate change.

For a large urban area such as Ha Noi, currently the urban flooding problem is not affected by upstream river floods thanks to the protection of dike system, flood detention and distribution zoning and a cascade of upstream reservoirs in the Red River system. The main cause of flooding in Hanoi is long-lasting but local heavy rain in the area, while the drainage system does not meet the requirement of rapid drainage. Existing study results have showed that the majority of heavy rains causing urban flooding are associated with long-lasting heavy rains during the occurrence of extreme precipitation events (Nguyen Van Thang et al, 2011). To solve the problem of urban flooding in Ha Noi, the main measures are synchronous drainage system as well as upgrading and strengthening the operation of drainage pump stations.

Such low-lying area as Ho Chi Minh City, because it is located at the mouth of many big rivers of the Sai Gon - Dong Nai river system, is strongly influenced by fluctuations of river flow and tides. In the area, there are large upstream reservoirs but their flood prevention capacity is not high. Thus, flooding problem in Ho Chi Minh city is mostly caused by local rains and tides, sometimes by flood discharge of the reservoirs. In addition, another cause of urban flooding in Ho Chi Minh City is that large area and volume of the low-lying natural wetlands being able to regulate flood water were occupied or encroached for buildings or city development. Besides, because the Saigon river bed has shrunk due to sedimentation or encroachment, this phenomenon may occur most strongly and frequently in recent times (Ho Long Phi, 2007).

The cities in central region are mostly located near-by the rivers with short and steep terrain; therefore flooding is mainly caused by river overflow from upstream floods. On the river systems of central region there are also many large reservoirs, however most of them have no or negligible flood control volume. The sudden flood discharge of these reservoirs may also cause significant flooding to the downstream cities. The historical flood in 1999 in central region, which was formed by upstream flood combined with heavy rainfall in the downstream and coastal areas, caused severe inundation of 1-2 m in almost all the coastal towns from Quang Tri to Quang Ngai provinces. This was the historical flood for the central region in terms of depth, duration and scale (DMC, 2011a).

9.2.4.2. Some typical events of urban flooding

Table 9-4 below describes two typical urban flooding events in the two largest cities in Vietnam, Hanoi and Ho Chi Minh City. The flooding in Hanoi in 2008 was typical for concentrated and intensive local rainfall, caused by long-lasting heavy rains in Hanoi and surrounding areas. The flooding in 2013 in Ho Chi Minh City was typical for lowland areas, strongly influenced by the tidal regime.

9.2.4.3. Responses and adaptation measures

The flooding in 2008 was historical for Hanoi with record rainfall over the last 100 years. Total rainfall during 3 days in Hanoi area was from 350-550 mm, a number of points with larger rainfall such as Gia Lam district: 633 mm, Ha Dong: 812 mm, Thanh Oai: 914 mm. After the record rainfall on 30 October to 2 November 2008, more than 20,000 households in Ha Noi, mainly in suburban areas, were seriously inundated. To cope with this situation, since 4 November, the Hanoi Department of Transportation has mobilized 30 high trucks to freely transport people through the deeply flooded areas. To solve flooding problems in some areas, on 6 November, Hanoi Drainage Company allocated 100 pumping vehicles to pump water from the areas of Giai Phong, Tran Duy Hung, Tan Mai streets. Along with vehicles to pump out water from flooded sites, the company arranged the forces to inspect and handle cases of broken or loss of gas cap. Yen So pumping station operated at full capacity in order to reduce the load to the rivers and lakes within the city (http://hanoi.gov.vn/).

On 6 November, the Hanoi People's Committee decided to use 160 billion VND from the reserved fund and commodities for Tet holiday to provide commodities source serving the people and to stabilize market prices after flooding. The city authroty had also decided to support 15 million VND to the families of each died victim and 5 million VND to those whose house was destroyed. For the isolated areas from where people had to move, the city had supported more than 62 tons of instant noodles, alocated 8 billion VND to support the most affected districts. More than 500 barrels of cleans water have been sent to the isolated resident areas.

After the urban flooding in 2008 in Hanoi, a variety of solutions have been proposed to cope with the risk of flooding in the future such as enhancing research on the extreme phenomenon, capacity building for forecasting and flood warning services, strenthening the city's flood drainage capability and developing flood risk maps (Tran Thuc and Le Nguyen Tuong, 2010).

For Ho Chi Minh City, the floods in late October, November and in early December 2013 were extremely serious, the tidal peak on 20 October 2013 was 1.68 m - hit a historical record of the last 61 years. Because of very complex behaviour of high tides, since 2009 the People's Committee of Ho Chi Minh City in collaboration with the Ministry of Agriculture and Rural Development have specifically strengthened the works to prevent and cope with urban flooding in Ho Chi Minh City in Decision 1547/QD-TTg dated October 28, 2008 of the Prime Minister. In particular, the city focused on building dike system along the Saigon River and the adjacent roads; building tide-control gates and sluices in the estuaries of Saigon, Nha Be and Vam Co rivers with more than 176 km dike, 13 large and hundreds of small tide - control sluices. However, the progress of the work was very slow due to difficulties in land clearance. Some temporary solutions are also used such as setting in 1,200 valve to prevent tide at sluice gates, locating 40 pumping stations with capacity from 1,000 m^3 to 8,000 m^3 per hour (Government of Vietnam, 2008b).

Table 9-4. Some typical urban floodings

Period	Location	Discription	Damage
November 2008	Hanoi	Since midnight on 30/10/2008, a record rainfall over the last 100 years has occurred and lasted for several days in the North, especially in Hanoi.	22 people were killed, many streets were flooded, some of which were collapsed. Nearly 35,000 households were flooded,

Period	Location	Discription	Damage
		This unseasonal heavy rain exceeding all forecasts have caused large scale severe flood in the history of Hanoi.	damaged. Estimated damage was over 3,000 billion VND.
2013	Ho Chi Minh City	In late October, November and early December 2013, high tides in Ho Chi Minh city exceeded the III alarming level causing severe flooding in areas along the rivers, canals and low-lying areas. On 20/10/2013, tide peak was 1,68m - hit a 61-year history record. On 5 – 6/12/2013, the tide peaked from 1.63 - 1.65m.	A section of embankments in Binh Thanh District broke down and overflowed their banks in most suburban embankments, causing widespread flooding. Some works against flooding was also "disable". Because many embankments broke during the night, quickly rising water spilled into the households, seriously impacting the economic and social activities.

(Source: Tran Thuc and Le Nguyen Tuong, 2010, (CCFSC), 2008, CFSC - Ho Chi Minh City, 2013)

While complete elimination of the risk of urban flooding can not be done, in order to better control its impacts and damages, limit the consequences and support the reconstruction process, policy makers need to understand the causes and the risks that urban flooding can cause to people life and production, infrastructure in the cities. For example, the combination of heavy rains and rising river levels is the leading reason causing inundation in cities such as Hanoi and Can Tho, while in the coastal cities such as Hai Phong, Nha Trang and Ho Chi Minh city, inundation is due to a combination of heavy rain, the river flood and high tide.

9.2.4.4. Lessons learned

The municipalities of Vietnam today is particularly sensitive and vulnerable to natural disasters, including floodings. Hanoi, Ho Chi Minh City and other cities in Vietnam have gradually expanded due to population growth and pressure on infrastructure. However, the urban planning was still inappriate, disasters problems and climate change are not yet incorporated into planning therefore there is increasing risk of natural disasters, especially urban flooding caused by extreme rainfallsD and sea level rise.

For emergency response in the cases of urban flooding, recently the Government, the line ministries, sectors and municipalities had conduct timely response and rescue actions, had mobilized the collaboration between the different relevant agencies such as Police, Department of Transportation and Public Works, Urban Drainage Companies etc. However, due to the lack of means and resources on the spot as well as low awarness of people, the damages still high.

To prevent urban flooding effectively, the urban master planning and integration of DRR and CCA should be considered as priority (Tran Thi Lan Anh, 2012). In fact the individual solution were not so effective. In this context, a number of non-governmental organizations have been implementing various projects and activities to enhance the resilience of cities in Vietnam. In particular, the most important issues are: integration of CCA and DRR into urban planning and development; capacity building for local urban communities to prepare better to disasters and recover quicker after shocks (ACCCRN, 2009) (Section 5.6.1, Chapter 5).

9.2.5. Drought: the hidden threat

9.2.5.1. Introduction

In Viet Nam, drought is the third natural disaster in terms of damage scale after typhoon and flood (DMC, 2011a; UNDP, 2000). Every year, droughts happen in various location with different time scale and intensity, causing considerable damage to the socio-economic activities, especially water resources and agriculture (Nguyen Đuc Ngu, 2002). In recent years, the occurrence of sever droughts has increased in many parts of the country, but mainly focused on the time of winter-spring (from January to April) and summer-autumn (from May to August) rice seasons (MONRE, 2012). However, depending on the region drought events have occurred at different times (Ngo Trong Thuan, 2007).

- In the North: droughts usually occur during winter time, from October-November and last until January-February, sometime even until March-April due to very low or no rainfall. Heatwaves usually occur during summer time, causing water shortage for irrigation and residential water supply, seriously affecting human health and consume more energy for pumping irrigation and cooling.

- In the South and Central Highland: heatwaves together with droughts usually occur during March-April, affecting the growth and development of not only rice but other industrial crops such as coffee, black peper etc.

- In the Central coast: prolong heatwaves and droughts usually occur during the mid-summer, creating shortage of irrigation water for summer-autumn rice season.

The El Nino/La Nina phenomena and Southern Oscillation, commonly called ENSO often occur in combination with cliamte/weather extremes such as drought and flooding in Viet Nam as in many other places globally. Hot phase of El Nino often increase droughts in the South-East Asia (Section 3.4.3). Many drought events in different regions of Viet Nam are closely linked with activation of El Nino phenomenon manifested by temperature increase and decrease of rainfall in comparison with inter-annual average values (Nguyễn Đức Ngữ, 2002). Studies on drought in each of the territorial regions of Viet Nam have shown clear impact of El Nino phenomenon to the intensity and magnitude of drought events occurred in the region (Nguyen Đuc Ngu, Nguyen Trong Hieu, 2002; Tinh Dang Nguyen, 2006).

In the future, under the influence of climate change, drought events can occur with increasing frequency and severity, the number of consecutive dry days may extend in number of areas of Viet Nam. Drought events will be increased with relatively high spped during the whole 21 century in the drought-prone regions such as South of Central Viet Nam and the Central Highland (Section 3.5.2).

9.2.5.2. Some typical drought events

The three recent sever drought events have been selected for case study include those of the years 1997-1998, the years 2004-2005 and the year 2010 (Table 9-5). These three drought events have been selected because of their scale, severity as well as significance of damagaes caused.

Table 9-5. Some typical drought events

Event	Description	Areas where drought occurred	Agriculture losses	Monetary losses (estimated) VND
The 1997-1998 drought	The 1997 rainy season ended one month ealier than inter-annual average. Monthly rainfalls of the first 6 months of 1998 were only 30 - 70 % of inter-annual average.	All over the country.	Total loss of 120,000 ha.	5,200 billions
The 2004-2005 drought	Low rainfall and the rainy season ended 1- 1,5 month earlier than inter-annual average	The North, Central Highland, South of Central Viet Nam, South-East region.	Total loss of 142,300 ha.	2,420 billions
The 2010 drought	Overall rainfalls of the first 6 months of 2010 were very low, maximum rainfall reached only 70-80%, some places got only 20-30% of inter-annual average rainfalls, prolonged heatwaves.	Most heavily in Central Viet Nam.	Hundreds of thousand hectares were lost.	2,500 billions

(Source: DMC, 2011a)

a. Drought and water shortage in the years 1997-1998

The rainy season at the end of 1997 completed one month ealier than inter-annual average, Monthly rainfalls of the first 6 months of 1998 had reached only 30 - 70 % of the same period of previous year. In the Central Highland, South-East region and the Mekong River Delta there were almost zero rainfall. No rain in the Central Viet Nam from early June untill end of August. Together with decreased rainfall, monthly avearage temperatures of the first half of 1998 were 1 - 3^{o}C higher than inter-annual average leading to increase evapo-tranpiration. Many heatwaves happened during the period from March to May in the South and from June to August of 1998 in the Central Viet Nam. In many places, temparature reached even 37-39^{o}C, leading to serious drought early Summer-Autumn rice season (UNDP, 2000).

Water in rivers and streams have depleted at an alarming pace. Water levels at large rivers were 0,5-1,5 m lower than inter-annual average. Due to low water levels and low flows in the rivers combined with strong north-east winds, saline water have intruded deeply into the rivers of Central and Southern Viet Nam for about 15-20 km, in some locations of the Mekong River Delta, it reached even 50 km. Salitity were higher than inter-annual average for 2-3$^{o}/_{oo}$ and appeared earlier for 10-15 days.

The drought and water shortage in dry season of 1997-1998 was considered as most serious event so far, widespreaded to almost all regions of the country and led to significant losses of rice yield: more than 750,000 hectares of rice paddies suffered from drought (120,000 ha of rice were totally lost); 236,000 hectares of industrial crops and fruit orchards had suffered from drought (almost 51,000 ha were lost); 3.1 millions of people suffered from shoratage in residential/drinking water supply. Total economic losses from this drought event were approximately 5,200 billions of VND (Vietnamese Dong) (DMC, 2011a).

b. Drought in the years 2004-2005

During dry season of the years 2004-2005, due to early completion of previous rainy season and prolonged heatwaves, the water shortage situation was widespread in all three regions of Viet Nam. Water level and flow in most of the rivers and steams were very low (but the situation was not as severe as in 1997-1998). In the North, water level of Red River at Ha Noi in early March had reach lowest mark of 1,72 m since 1963. In the Central Viet Nam and the Central Highland, river flows were much lower than average of the same period, some rivers were totally dried out; many lakes and reservoirs were not able to supply water. In the South, low rainfall and drought in a prolonged time had led to very low water levels, serious water shortage and significant saline intrusion. Water levels at the upstream stations of the Mekong River in February and March of 2005 had almost reached the historically lowest record of the year 1998. Salinity in the Mekong estuaries in Southern Viet Nam had considerably increased, saline water intrusion happened earlier and deeper inland up to 50 km from the estuaries (DMC, 2011a).

Total areas of agricultural lands suffered from drought were 262,660 hectores from which about 142,300 hectares were totally lost, especially in the Central Highland and South-East region (Le Sam and Nguyen Dinh Vuong, 2008; Oxfam, 2005). Total losses from drought during this period in the provinces of the Central Highland and South-East region had reached 1,700 billion VND. In the Mekong River Delta, most of the losses were in rice production and other crops such as maize, vegetables and sugar canes…. About 50% of the rice cultivation areas in the Red River Delta have suffered from serious water shortage during tillage and sowing. Across the whole country, the drought had left almost 1 million hectares of Winter-Spring and Summer-Autumn rices and substitute crops with water shortage, more than 300,000 heads of livestock and about 1,680,000 residents suffered from drinking water shortage (DMC, 2011a).

c. Drought in the year 2010

During the first six months of 2010, overall rainfalls across the country were quite low, in some places it reached only 20-30% of inter-annual average. Rainy season in the South and Central Highland came later for about one month. Saline water intrusion happened in many locations directly affecting production, livelihood and well-being of people. There was a serious decrease of inflow to most of the irrigation and hydropower reservoirs leading to very low water level, almost reaching the dead water level of the reservoirs.

Total rainfall in the Central Viet Nam during the first six months of 2010 was only 10 - 20% of inter-annual average. The provinces of Central Viet Nam like Thua Thien Hue, Da Nang, Quang Nam, Binh Dinh… had suffered from one of the most severe and prolonged droughts and heatwaves of the last decades. In particular, the temperature in several areas of Central Viet Nam had reached maximum record of over 42^{o}C (National Hydro-Meteorological Service, 2010). Heatwaves and drougts had increased the risk of forest fire to very high level. According to the MARD's statistics, the prolonged drought of 2010 in the Central Viet Nam had led to total yield loss of hundreds thousands hectares of Summer-Autumn rice. Estimated losses were almost 2,500 billions VND (statement of the Deputy Minister of MARD Mr. Bui Ba Bong in the meeting on 25 June 2010).

9.2.5.3. Activities to respond to drought

The National Hydro-Meteorological Service and the MONRE had provided early forecast about serious drought during the 1997-1998 event. The Government of Viet Nam had supported tens of billions VND to provide water supply for the residents of 18 affected provinces. The other losses and damages which could not be fully calculated and registered include losses due to: socio-economic and environmental problems, erosion, desertification, malnutrition and damaged overall and mental health of millions of people (DMC, 2011a). The provincial and local authorities have set concrete plans and implemented practical measures to respond to and reduce the impacts of the drought but the effectiveness and results were still very limitted due to inappropriate economic potential and irrigation infrastructure, limitted and small scale adaptive etc.

During the drought event of 2004-2005, for emergency response, the Ministry of Agriculture and Rural Development has set out a number of practical measures such as:

- Strict management for effective and timely use of water resources; take maximum advantage of all natural sources of water, including water pumped from underground, from the rivers at the same time preserve water in the lakes/ponds for the most difficult time;
- Dredging of canals to ensure proper irrigation and water supply. The Government of Viet Nam had provided emergency assistance of 30 billions VND for dredging of the canal gates and mainstreams in two major branches of the Red River - the Nhue and Bac Hung Hai river systems. Better management of water distribution, alternating between locations for more effective irrigation; Encourage water saving.
- The Government had provided emergency support of 100 billions VND to the provinces to cope with the consequences of the drought and water shortage as well as 1,500 tons of rice for the people to avoid hunger (DMC, 2011a).

As emergency relief work, a number of non governmental organizations had helped the people in Ninh Thuan province to cope with the drought by providing foods, drinking water, water containers, seeds and restoration of water sources (Oxfam et al, 2005).

The drought event in 2010 had drawn attention and direct management and intervention of the central Government. The MARD had sent directives to the provinces to: shift the summer rice's sowing time or to plant short-term food crops in the areas with less reliable water access, e.g. those vegetables and legumes that need less water; provide enough clean water for the people and drinking water for the livestock.

The Government also required the provincial and local authorities to actively use the local funds allocated for natural disasters prevention for responding to the drought. The Prime Minister had decided to allocate 300 billions VND to support the provinces in dealing with the drought, especially for the North of Central region (185 billions VND) and the South of Central Coast (115 billions VND) for pumping water, buying new seeds and replanting rice/crops in the areas with total yield losses. The Vietnam Electricity Corporation (EVN) had set priority to provide enough electricity for combating the drought. The National Hydro-Meteorological Service had closely monitored and provided timely forecasts and warning of drought and water shortage. The provincial authorities and Departments of Agriculture and Rural Development (DONRE) had implemented synchronized measures against the drought at local level such as: water savings, ensuring sufficient water supply for already replanted rice areas, sowing new rice for the next season in the irrigated lands etc. (Government of Viet Nam, 2010c).

9.2.5.4. Lessons learned

Analysing the drought situation and responding activities in Viet Nam in the recent years, we can see that the drought prevention and control works were very passive and of low efficiency. Although the drought forecast and warnings were issued beforehand, the prevention and responding activities were very ineffective partly because of limitted resources, partly due to the lack of adequate attention and awareness from both the government and the people. Most of the activities were focused on emergency relief and remedy of the damages when the drought already happened. In the future, under climate change impacts the drought risk will be significantly increased with more severity and duration (Chapter 3), the damage and losses might be much greater, it therefore requires more proactive and strategic solutions. To solve the problem of drought, water shortage and prevent the related damages and losses in a sustainable way a complex of simultaneously planned measures is needed, including those aiming at appropriate use/allocation of water resources (DMC, 2011a, 2011b), namely:

- Conduct integrated planning of water resources according to river-basins and "key economic areas" approaches; Develop practical plans for reasonable exploitation and rational use of water resources for each sector/province;
- Planning for the protection and development of water sources and watersheds, including both structural and non-structural measures which should be associated with protection and development of water-regenerating forests;
- Develop policies and mechanisms for operation management and water distribution in the large multi-purpose reservoirs;
- Develop prioritizing policies for sharing water resources amongst users to ensure common interest and based on the severity of the drought/water shortage they suffer;
- Converse economic structure of the region/area to fit the natural conditions and supplying ability of water resources in each region, each river basin. Develop and test economic models and livelihood schemes with drought-resistant crop and animal species which need less water;
- Encourage the techniques and technologies that promote water-saving, water recycling and re-use as well as reduce water pollution;
- Overall institutional strengthening towards better drought/water shortage management (Le Sam and Nguyen Dinh Vuong, 2008).

In addition, the drought monitoring and forecasting works as well as drought-responsive planning should be performed regularly and consecutively in a proactive and timely manner. Afforestation and forest protection are also effective water conservation measures, helping to limit evapo-transpiration and to prevent furture drought (Nguyen Đuc Ngu, 2002).

9.2.6. Temperature extremes: Damaging cold and heat waves

9.2.6.1. Context

Viet Nam climate is a typical monsoon tropical climate with year-round hot and humid conditions and a relatively cold winter in the North. Freezing cold (when daily mean temperature is below 15^{o}C) and damaging cold event (when it's below 13^{o}C) usually happen during the mid-winter months in the North of Viet Nam (from December to February) (Duong Van Kham and Tran Hong Thai, 2011; Vu Thanh Hang et al, 2010), however sometimes it occurs latter, at the end of February – early March (Ngo Trong Thuan, 2007). The prolonged freezing and damaging cold events cause significant damages to agriculture, for both cultivation and animal farming, and adversely impact human health, especially of the elderly, children and poor people (Duong Van Kham and Tran Hong Thai, 2011; Vu Thanh Hang et al, 2010). In recent years with the change of weather pattern, the freezing and damaging cold events happen more frequently in the Northern mountainous regions (Chu Thi Thu Huong and Phan Van Tan, 2012).

In the opposite, the tropical monsoon climate also brings widespread heat waves to most of the regions of Viet Nam in different periods. In the North, heat waves usually occur during summer time together with drought causing water shortage for irrigation and residential water supply, seriously affect human health, well-being and lead to more energy consumption for water pumping and cooling. In the South and Central Highland heat waves and drought events usually occur at the end of dry season and adversely affect farming and production. In the Central Coast, prolonged heat waves typically happen in the mid-summer leading to water shortage for the replanting of summer-autumn rice (Ngo Trong Thuan, 2007). Recently there is a clear increasing trend of number and duration of heat waves nationwide, especially in the Central Viet Nam (Phan Van Tan, 2010).

According to the results of Chapter 3, the mean temperature will increase which in turn can lead to more severe heat waves, decrease in number of cold events and increase of mean minimum temperature. However, extreme cold temperature will still occur with consequent freezing and damaging cold events and hoar frosts in some regions (Section 3.5.5).

9.2.6.2. Analysis of some historical damaging cold events and heat waves

The damaging cold event of January-February 2008 and the severe heat wave of June-July 2010 have been chosen for analysis because of their severity, extreme temperature records and duration leading to very serious damages and losses.

Table 9-6. Some historical damaging cold events and heat waves

Event	Location	Description	Extreme temperature	Damage and losses
The extended freezing and damaging cold event on Jan-Feb 2008.	The North and North of Central Viet Nam	The historical freezing cold (mean T^o <15^{o}C) and damaging cold (mean T^o <13^{o}C) events occurred from 14 Jan. to 20 Feb. 2008 with a record duration of 38 days.	Minimum temperature in some areas in the North dropped to record low point: In Sa Pa -1,0 ^{o}C, In Mẫu Sơn -2,0 ^{o}C.	52.000 heads of livestock have died in 15 northern mountainous provinces and 6 central coastal provinces. Total loss from livestock: 200 billions VND. More than 100,000 ha of winter-spring rice lost.
Severe heat waves on June-July 2010.	The North, North and Middle of Central Viet Nam	Two severe and prolonged heat waves (mean T^o. >35^{o}C) occurred, in some places it last for more than one month	Maximum temperature in: Hòa Bình: 41.8°C, Hà Nội: 40.4°C Thanh Hóa: 42.0°C, Nghệ An: 42.2°C.	Hundreds thousands hectares of crops suffered from water shortage and saline water intrusion.

(Source: National Hydro-Meteorological Service, 2008, 2009, 2010, 2011; MARD, 2008a)

a. The historical freezing and damaging cold event in 2008

The historical freezing and damaging cold event lasted for 38 days during January-February 2008 was the historical event with very high number of cold days (there were 31 days of damaging cold in the Northern Delta and Midland; 22 days of freezing and damaging cold occurred in northern part of Central Viet Nam among which 2/3 were damaging cold event) and the daily minimum temperature has dropped to lowest historical record (Table 9-6).

During this cold event, the minimum temperature had dropped down to record value in some locations of the Northern mountainous region such as: in Sa Pa (Lào Cai province): -1,0 ^{o}C, in Mẫu Sơn (Lạng Sơn province): -2,0 ^{o}C. Ice and snow frost lasting for many days have occurred in high mountainous areas of Lạng Sơn, Lào Cai, Hà Giang, Sơn La, Lai Châu provinces. This year was the record year when longest duration of damaging cold and largest areas of ice and snow had ever occurred in Viet Nam (Nguyễn Văn Thắng, 2009; National Hydro-Meteorological Service, 2008).

According to the MARD's report, during this period about 52.000 heads of livestock have died due to cold and frost in the 15 northern mountainous provinces and 6 central coastal provinces. Total loss only from livestock was 200 billions VND, more than 100,000 hectares of winter-spring rice was lost (MARD, 2008).

The public health data have shown that during this period of freezing and damaging cold, the cases of climate-related diseases registered in hospitals such as acute respiratory inflammation, cold or stroke have increased for 10-20%. Especially, the stroke cases increased for 11-19%.

b. The record heat wave on June-July 2010

Due to active El Nino phenomenon occurred from October 2009 to mid of May 2010, during June to July 2010 there were two prolonged and serious heat waves in the North and Central Viet Nam. In some provinces of the North and North-Central, the maximum temperature reached 40 - 41°C, in some places even 42°C. These wide-spread heat waves were of longest duration and highest intensity in the historical records of Viet Nam (National Hydro-Meteorological Service, 2011).

The heat waves and drought had resulted in significant water shortage for hundreds of thousands hectares of rice, substitute and industrial crops. Tens of thousands hectares of rice in the Central region and Central Highland had been lost. Beside the serious damages caused for agriculture production, these heat waves had strongly affected human health and residential water supply, also led to severe shortage of electricity due to high demand for cooling, especially in urban areas.

9.2.6.3. Adaptation measures

The severe heat wave in June-July 2010 in combination with serious drought had increased damages due to water shortage, especially to agriculture and people well being. However, the preparedness and response to such prolong heat wave and drought was still very limited and passive.

In response to the initial information on damages and losses due to the damaging cold event in 2008, the Government of Viet Nam had made immediate decision to provide support and compensation to the affected regions in order to recover rice production and livestocks farms suffered from the impacts. The serious losses in livestocks and poultries farming have indicated a limited preparedness and readiness of farmers to such events. With traditional habit of natural outdoor feeding, the farmers didn't prepare cover or reserve enough animal food for winter therefore many livestocks have died not only from cold but from starvation.

Many effective measures have been conducted under the project *Raising awareness and supporting preparedness* such as awareness raising compaign for local communities to protect human health (especially the elderly and children) in which borchures were produced on diseases and harm caused by damaging cold events and concrete preventive and protective measures were proposed. Number of local information agents have been trained on communications skills and many measures to prepare for and respond to damaging cold have been practiced (CARE, 2013). Awareness raising activities for the ethnic minorities and communities in mountainous regions require more attention and efforts not only on the content but also on the forms of communications materials (simple brochures, cards, flipped pictures, or CD) as well as local dialects and languages. It's also important to apply the indigenous knowledge of the local communities and ethnic people in coping with cold events, which efficiently use the local environment and plants for this purpose. Besides, the supporting activities against freezing and damaging cold can be integrated into the state-funded projects or programmes in order to strengthen the coping capacity, protecting crops and plants, esure food security as well as human and animal health.

9.2.6.4. Lessons learned

In fact, there is a serious limitation in recording and reporting statistics on damages due to heatwaves, causing difficulty for damage evaluation and control. Initial works have been conducted on forecasting and warning of heatwaves however the effectiveness of preparedness and coping measures is still limited.

Unlike the flood and storm control works, local authority in many areas usually pay less attention to intiate and control the warning of and preparation for damaging cold. As consequence after each damaging cold event, more and more farming households fall into deeper poverty because each lost head of cattle or horse meant loss of the whole family's capital. Therefore, the local authorities need to strengthen the propaganda and guidance for the community on preparation and coping with cold events in cultivation and animals husbanry such as: shelters, enclosed and covered feeding facilities, reserving and enhancing livestock/animal foods with vitamins, carbonhydrate and minerals during cold event.

In the long-term perspective, it is necessary to study and apply adaptive farming practice and methods to climate change impacts. In order to achive that, comprehensive research and studies should be conducted in combination with applying indigenous knowledge of the community. Another important aspect is to promote appropriate knowledge stransfer and application of scientific results in production and farming practices, policy support and actions to guide the mountainous communities to build shelters, closed feeding facilities and grow feeding grass.

9.2.7. Saline water intrusion in the Mekong Delta

9.2.7.1. Introduction

Saline water intrusion is a common phenomenon in coastal areas of Viet Nam happening in different scales, whereas the Mekong Delta, the Central coastal provinces as well as Dong Nai river delta are known as high risk region (DMC, 2011a). In the recent years, due to impacts of sea level rise and flow change related to climate change and upstream development, saline intrusion have manifested much deeper inland in the Red river and Mekong river deltas (Trần Thanh Xuân et al, 2011).

In principle, saline water intrusion into rivers/canals happens because the reduced flow and water level during dry season give room for sea water flow upward the river channel. This natural phenomenon happens regularly every year therefore can be predicted to some extent. In addition, the soil and land in coastal areas have high risk of salinization due to endosmosis or anabiosis.

In the Mekong River Delta, due to the landscape's natural characteristics, most of the areas are suffereing from salinization. Main reasons of this process are: low average elevation of the terrain; very complicated and interlaced canal system connecting to the East Sea and West Sea with different and complex tide regimes; prolonged droughts combined with heatwaves leading to low water level and flow in the dry season and deeper saline water intrusion in the rice and special crops paddies near Tien and Hau rivers (main channels of the Mekong mainstream). Even areas with relatively higher evelation are suffering from saline water intrusion during peak months of the dry season.

Saline water intrusion is seriously threatening livelihood and well-being of communities in the Mekong River Delta. In some years, water level in the Mekong mainstream decreased very intensively so that saline water intrusion reached up to 60 - 70 km inland, creating significant difficulty to peole livelihood and well being (DMC, 2011a).

9.2.7.2. Typical events of saline water intrusion

a. Damaging event of saline water intrusion in the Mekong River Delta during January – February 2010

Due to early onset of the dry season with intensive heatwaves from mid November of 2009, about 20,000 hectares of winter-spring rice paddies suffered from salinization and more than 45,000 hectares of other rice paddies have faced serious water shortage in Soc Trang and Bac Lieu provinces. In Bac Lieu province, saline water with concentration of 3,3‰ - 5‰ have intruded deeply inland in Gia Rai and Phuoc Long districts while in Hong Dan district there was even 6‰ of saline water intrusion. In Hau Giang province, it was registered a severe saline concentration of 7‰ at Xa Phien village, Long My district and of 5‰ at Vi Thanh town.

During this event of serious drought and saline water intrusion, about 6,000 hectares of rice paddies in Ca Mau province have been lost. Drought and saline conditions have threatened people livelihood and tens of thousands hectares of acassia forest in the Lower U Minh protected area. In Ca Mau province, more than 21,000 hectares of forest have suffered from severe water shortage and highest levels (levels 4-5) of forest fire warning have been registered in more than 8,000 hectares of forest within the biosphere reserve area of Lower U Minh.

b. Saline water intrusion in the Mekong River Delta during March – April 2011

During period of March – April 2011, the monthly maximum saline concentration of 16.7 g/l was registerd at Cau Noi station in Vam Co river (a large branch of Mekong river) of Long An province, which was higher than the average (monthly maximum) value of 9 years period (2002-2010) for about 2.2 g/l. Similarly at Vam Kenh station of Tien Giang province, Binh Dai station of Ben Tre province, Tra Kha station of Tra Vinh province and Dai Ngai station of Soc Trang province, the recorded monthly maximum salinity were higher or equal to that of 9-years average (from 2002 to 2010).

During this severe salinity intrusion event, large areas of rice paddies have lost or reduced rice yield in three out of eight coastal provinces of the Mekong River Delta, namely Soc Trang, Ben Tre and Tra Vinh provinces. In total there were more than 100 hectares in Soc Trang, 2,615 hectares in Bac Lieu and 11,827 hectares of rice paddies in Tra Vinh province have been damaged due to drought and saline water intrusion.

9.2.7.3. Adaptation measures

In order to cope with saline intrusion at local level, firstly it’s needed to raise people’s awareness about the status and impacts of saline intrusion as well as impacts of climate change to this phenomenon, especially the poor communities living in the high risk areas. Key actions to be undertaken are: (1) Raise awareness on the risk of saline intrusion for the local people; (2) Communication on the measures to respond to saline intrusion at local level; (3) Provide guidance and advices to the local community on changing their behaviour of water usage (water saving/conservation) and fresh water storage schemes.

In parallel with the above mentioned actions, the central and provincial authorities and responsible institutions have proposed a number of constructual and non-constructual measures. In the Mekong River Delta, the following measures were proposed for dealing with saline intrusion: (1) Improved rules for operational regulation (when and how much to open/close) of the saline prevention sluices; (2) Investment, construction or/and improvement of the integrated irrigation system; (3) Better control of the ground water extraction activities to avoid the saline intrusion into the aquifers; (4) Change the crop pattern towards salinity resilient crops; (5) Propose new production pattern and livelihood options which are adaptive to the changing salinity; (6) Develop and select the salinity resilient crop varieties, more appopriate cultivation regime, change crop calendar etc.

The project “Studying indegenous knowledge and saline water intrusion” implemented by the Central Viet Nam Rural Development Center has focused on the impacts of saline intrusion on the rural people’s (mainly farmers) livelihood as well as indigenous knowledge, autonomous adaptive actions of the local communities to deal with saline intrusion. The study has pointed out the difficulties, challenges and needs of local people for additional support to the local efforts to deal with saline intrusion. The study also recommended more in-depth studies on crop or animal varieties adaptive and/or resilient to salinization (Võ Chí Tiến et al, 2010 pages 8, 9).

Several NGOs have conducted assessments of saline intrusion situation in some provinces of the Mekong River Delta such as Ben Tre, Tien Giang, Soc Trang, Ca Mau and Kien Giang under the overall program to assess exposure, vulnerability, adaptive capacity and adaptation measures in the Mekong River Delta. For example, the WWF report has provided results of analysis of saline intrusion conditions and impacts to ecosystems as well as recommendations on reservation of fresh water sources, including both surface and ground water sources (WWF, 2012 page 71).

One more example is the CARE International's project on Strengthening the capacity for disaster management in Thanh Hoa province which supported farmer households to select the rice varieties resilient to salinity and have got positive response and appreciation from the farmers. An important point that this project has highlighted is that introduction of new rice varieties should be combined with hand-on technical and practical training for the farmer in the field (Farmers Field School or FFS) about each stage of the plant's growth and in the easy-to-understand and effective way. This project has also supported local communities to construct a number of simple irrigation canals to bring fresh water from the river to the canals and wash out salinity in the soil of more than 200 hectares of rice paddies (Buffle et al, 2010 page 5).

9.2.7.4. Lessons learned

In order to better adapt to saline water intrusion, in-depth research and studies on crop varieties or alternative livelihood options at local level are crucially needed to give direction to effective adaptation options. As in the case of Quang Tri province, an remarkable combination of scientific research, experiences and indigenious knowledge with active participation and engagement of leading farmers and local communities have drawn attention on effectiveness of measure implementation and harmonisation with the local conditions. Another lesson learned is to combine adaptation measures to saline intrusion with transferring knowledge and skills to the farmers through such method as Farmers Field School (FFS) to increase the effectiveness and impacts of the technical measures.

Community participation in the construction and operation monitoring of salinity prevention infrastructures should be ensured so that the community can rise their voice and strengthen their role in the decisions at community level, reduce the government investment and maintenance cost and also ensure the sustainability of the infrastructures.

Some other hard measures such as construction of saline prevention weirs or barrages are usually expensive, require proper cost-benefit analysis. Promoting participatory mangrove planting and restoration in combination with livelihood diversification and awareness raising can help to reduce the impacts of salinity intrusion as well as impacts of typhoons and and storm surge (Buffle et al, 2010).

9.2.8. Early warning system and disaster risk reduction

9.2.8.1. Introduction

Early warning system is used to warn and communicate about the change of hazards in different time scales – from hours, days, weeks, month, season etc. up to decades, in order to make decisions on urgent responsive actions, evacuation or long-term preparedness (Brunet et al, 2010). An effective early warning system can help to significantly reduce the losses and damages from disasters. Especially in the context of climate change when disasters become more unpredictable, the role of early warning system is increasingly important. In the context of climate change, effective disaster risk reduction activities require smooth coordination and collaboration between sectors and organizations to define appropriate adaptation options, through vulnerability assessment and preparedness actions (Choularton, 2007; Braman et al, 2010).

According to the Hyogo Framework for Action (HFA), and early warning system need to be "people-centered". The warning messages/communications should be timely, understandable for the users and should consider spatial, social conditions of the location as well as gender and local livelihood (UNISDR, 2010). In the warning message, beside the prediction of the disaster risk there must be guidance or recommendations for actions based on the warning information.

Some pilot studies have shown that if the early warning system would function effectively, the damages and losses, especially human losses can be significantly reduced. Early warning system is very important at all levels, from local level (Chapter 5), central/national level (Chapter 6) and international (Chapter 7), aiming to provide important information for the decision making process, ensuring sustainable development (Chapter 8).

An effective early warning system should comprise 4 key components: (1) Detect/identify, monitor and predict the hazards; (2) Analyze the related risks; (3) Disseminate/communicate the timely warning; (4) Implement the preparedness and emergency response plan (Chapter 5).

At present, the early warning system in Viet Nam is mainly based on the weather forecasting bulletins which provide short-term warnings with the lag time suffient for implementation of the emergency response plan. However, the actions that can be undertaken are still limited because the lag time for dangerous weather event's warning is usually only 24 hours. Besides, due to limited resources it's difficult to conduct many response actions except for emergency evacuation (Chapter 5). Therefore, livelihood and assets of people, especially the poor and vulnerable groups, can be severly affected despite the possible reduction of human lives losses.

In practice, most of the current early warning systems in Viet Nam are focused on short-term warning, such as for extreme rainfall, storms and whirlwind, however an improved and longer-term forecasting and warning system (e.g. monthly, seasonal or sub-seasonal) is considered. With the increase of disasters in climate change context, disaster risk reduction works aim at changes of extreme events due to climate change (such as flood, drought, heatwaves, typhoons) that may occur more frequently and lead to more socio-economic damages (Chapters 4, 5). An effective early warning system should also provide potential adaptation measures to reduce the damages from the predicted extreme events as well as mechanism to raise community awareness on disaster risks and to promote further improvement of policy and decision making process at various levels.

Although short-term forecast of extreme events is important and draws increasing attention, the longer-term forecast and preparednes works should not be neglected. The conventional adaptation tools/methods based mainly on historical observation data (e.g. the flow mornitoring data over the past 50 - 100 years) may not take into account the potential/future changes of climate variables and therefore may lead to less accurate conclusions. Thus, to enhance accuracy and effectiveness of the forecasting/warning work and adaptation activities, both warning and adaptation should be considered in short-term and long-term scales.

While benefits of the early warning system for disaster risk reduction works are widely acknowledged and accepted by the communities, a proactive attitude towards preparedness and readiness (to disaster) is still new for the people. Most of the communities start taking responsive actions only when the disasters are about to start or already happen, or just upon the call for emergency response (Chapter 5). In fact, the applicability for early warning practices of the weather and climate forecast bulletins with lead time more than several days is still very limited, usually due to the higher uncertainty of the long-time forecasts (Hansen et al, 2011). In addition, the forecasting information should be communicated/disseminated in an easy and suitable format and language for the target users via appropriate communications means and tools. Thus, the regular feedback and interaction between forecasting services and the information receiving communities are crucial (Chapters 5 and 6).

9.2.8.3. Adaptation activities

Key principle in disaster prevention and response defined in the Viet Nam Law on Natural Disaster Prevention and Control 2013 is that “disaster prevention actions should be implemented following regulations, comply with the assignment levels and upon close coordination between the entities and in accordance with the levels of disaster risk”. The Law also pointed out clear roles and responsibilities of institutions in coordination of forecasting, warning and communications of disaster information as well as disaster management works (Chapter 6).

Regarding the early warning sytem in particular and disaster risk reduction in general, the Government of Viet Nam has clear policy to encourage and promote the application of advanced science and technologies. The Government has also increased investment on information system for early warning and diversified the communications and dissemination of disaster information to the people (Government of Viet Nam, 2007; National Assembly, 2013).

The project “Advancing the forecasting technology and hydro-meteorological monitoring network, period 2010-2012” (Government of Viet Nam, 2010b) as part of the Strategy for Development of the Hydro-Meteorological Services up to 2020, has achieved some initial but important results by equipping and and putting into operation series of automatic monitoring stations, establishment of additional radar stations, studying and testing high-resolution forecasting models, integrated forecasting system as well as modernization of information and communication system (Bui Van Đuc, 2012).

Another project called “Flash flood risk investigation, zoning and early warning of flash flood possibility in mountainous areas of Viet Nam – Phase 1: Northern mountainous region” has developed flash-flood risk maps for 14 provinces of the Northern mountainous region, conducted trainings and transffered the project’s results and knowledge to the local authorities and communities (La Thanh Ha, 2009). The project has strengthened capacity of provincial and local authorities in early warning of flash flood possibility, improved the preparedness as well as reduced the losses and damages due to flash flood in this areas.

The Mekong River Commission’s project “Hydrological monitoring system for the Lower Mekong Basin” (HYCOS) aimed to support the four Member Countries: Cambodia, Laos, Thailand and Viet Nam to establish a reliable hydrological monitoring system in the Lower Mekong Basin, to consolidate and strengthen the meteo-hydrological stations with rainfall and water-level automatic gauging system; the data storage and management system; the telemetry monitoring system allowing data transfer via satellite or other communications means (Chapter 5).

The project "Investigation, assessment and zoning of landslide risk in mountainous areas of Viet Nam to serve the planning and management of disaster prevention in climate change context" is being implemented by the Minsitry of Natural Resources and Environment (MONRE) with the involvement of multiple agencies within and outside the Ministry.

Other on-going projects such as: Supporting the disaster management system in Viet Nam (UNDP); Disaster risk management (World Bank); Developing the tower-system for disaster warning (MONRE, 2012); Pilots on disaster early warning system (supported by Japanese Government),… have common objective to develop the early warning systems for various disasters, to improve the coordination and management of disaster reponse before, during and after the events in order to minimize the damages and losses caused by natural disasters.

9.2.8.4. Lessons learned

The chapter has shown good practices and examples of effective early warning systems, especially in the case of typhoon, flood and flash flood in Viet Nam. The case studies on typhoon (Section 9.2.1 of Chapter 9) have highlighted the benefits of the forecasting bulletins and high-accuracy and timely typhoon warning. Besides, appropriate communications of information and actions guide as well as preparedness of community has helped to minimize the damages and losses due to typhoon and flood in the recent years in Viet Nam. In particular, the warning of heavy rainfalls after storms is crucial to support the flood control and prevention and timely evacuation, especially in the areas prone to landsides and flash flood.

The analyses of early warning system's effectiveness in extreme events are usually made public in the mass media while there are little official documentation on this topic. After the big flood in 2001 in the Mekong River Delta, the interviews of local rescue staffs have shown that, according to their oppinion, the weather forescat bulletins and flood warning works have been significantly improved after the flood season in year 2000. The National Hydro-Meteorological Service has been better equipped for more effective warning system as well as information communication to the people (Neefjes, 2002).

The important achievements in recent years in seasonal, sub-seasonal and yearly forecasts has significantly contributed to the improvement of extreme weather and climate events's prediction (Phan Van Tan, 2010). The climate forecasts and outlooks for three-months period based on the ENSO information can provide information on possibility of temperature extremes and drought events etc. The decade-scale climate projections are being improved to provide basis for the early warning systems in the future (MONRE, 2012; Chapter 3).

However, accurate forecast/prediction alone is not enough for an effective early warning system but it also requires appropriate coordination of all components: disseminations and communications of the forecasts, preparedness and response actions, post-disaster relief and recovery (Chapter 6).

9.2.9. "Four on-the-spot" Motto – A basic principle

9.2.9.1. Introduction

As a country regularly and strongly affected by typhoons, floods and other extreme weather events while having limited infrastructure and communications system, Viet Nam has gained many valuable experiences and pratices from local level. One of these experiences is the "Four on-the-spot" Motto, including "leadership on-the-spot, human resources on-the-spot, means and materials on-the-spot, and logistics on-the-spot", as mentioned in the Chapter 5 (Section 5.4.2). The motto has been mentioned and regulated in many legal documents since 2006, such as Decree No.08/2006/ND-CP issued by the Government of Viet Nam on 16/01/2006; Decision No.172/2007/QD-TTg on 16/11/2006; Implementation Plan of National Strategy for Natural Disaster Prevention and Mitigation up to 2020; Decree No.14/2010/NĐ-CP in 27/2/2010; Law on Natural Disaster Prevention and Control 2013 etc. The mentioned legal documents have once again confirmed the value and effectiveness of this "Four on-the-spot" Motto in proactive response to and recovery from natural disaster and extreme weather events. This section will analyze the "Four on-the-spot" Motto as the efficient and very effective principle in managing the risks of extreme events and disasters to advance climate change adaptation over the last few years.

9.2.9.2. Implementation of the "Four on-the-spot" Motto

The Motto is consistent with the Vietnamese thousand-years-old tradition and indegenous knowledge of "people as the root" or in other words, making people the very center of any action. The key point of the Motto is "to rely mainly on one's own strength", in practice it means solving local problems with local or "on-the-spot" resources (JANI, 2011)

When extreme events and disasters occurred, response and rescue actions can face lots of obstacles and difficulties e.g. in transportation, communications, especially moving from one to another place during the flood. Thus, the Motto is one of the best solutions for natural disaster prevention and control (Vũ Thị Thu Lan et al, 2011). It becomes an important foundation at local level for the response actions, rapid recovery and stabilization after the disaster (Implementation Plan of National Strategy for Natural Disaster Prevention and Control up to 2020).

The Motto can be implemented efficiently for all types of frequently occurring disasters in Vietnam during all phases of a natural disaster - before, during and after the disaster, esspecially effective for the first and the third phases. Before the disaster, the Motto is manifested in proactive preparation and prevention such as strengthening houses, mooring boats, trimming plants, and esspecially population evacuation and preparation of necessary equipments and materials. During the disaster, the Motto can help to enhance the process of emergency response, search and rescue or first-aid for injured people as well as protecting the properties. In the post-disaster phase, the Motto can help in quicker stabilization of people life and livelihood. In fact, the Motto is of best help for the pre- and post-disaster phases (JANI, 2010). The recovery process after the disaster often requires mobilizing external resources from outside of affected areas e.g. support from other regions, central government or international assistance. However, the Motto can be most effective only if there is a good and well coordinated plan at local level from management, resouces mobilization to implementation arrangement.

Practice has showed that only in locations where the "Four on-the-spot" Motto was well implemented, the proactive response was effective and the losses and damages were limited. In the contrary, in location where the Motto and preparation works were neglected the response actions were usually passive and confused when serious disaster came (DMC, 2011a).

Specifically, details on implementation of the “Four on-the-spot” Motto at local level are described and analysed as follows:

- *Leadership on-the-spot*: the main target group of this Motto is the local authorities and leaders at different levels, including the local government, the Party, the political, social or community organizations, the military or self-defence forces based in the same location. They should be main actors involved in steering and directing local efforts for preventing the disasters and reducing the impacts in regular basis or in emergency. This close and direct leadership from local authority to each residential block within the affected area can make specific, rapid and effective solutions for disaster prevention/response thanks to their excellent understanding of the natural and social conditions of this particular area. Leadership on-the-spot has brought positive results in disaster response at provincial and local levels. For example, during Typhoon Damrey in 2005, the leaders of Thanh Hoa Provincial Committee for Flood and Storm Prevention and Control (CFSC) have visited some critical communes (such as Đa Lộc, Ngư Lộc and Hải Lộc Communes) to strengthen the local leadership. In particular, they have directly commanded the evacutation of about 29,000 people within 3 days as well as reinforcement of weak fragments of sea dikes in these areas (about), which eventually have reduced damages from the storm. In Quang Nam Province, the provincial CFSC has directly coordinated the evacuation of approximately 60,000 people (about 16,000 households) from critical areas before the Ketsana Typhoon occurred. During this typhoon, the Motto has proved itself very well throughout the whole process of preparation, responding to and recovering from disaster (CARE, 2011).

- *Human resources on-the-spot*: include local people, rescue groups, military and other armed forces based in the local area. These groups contribute a great support in managing the risks of extreme events and disasters to advance climate change adatation. The fact is that they are the best people being able to withstand and respond to disaster in order to protect their own home because they know and love their own land more than anyone else. For instance, in Hau Loc district, Thanh Hoa province during typhoon Damrey (Typhoon No.7) in 2005, local government had managed to mobilize more than 1.500 people volunteering to work for the evacuation, rescue and recovery during and after the disaster. There were lots of people have risked their life to reinforce the Dike by stone during the typhoon (JANI, 2011). These local human resources play an essential role in guarding, protecting dikes during flood season, esspecially at village, commune and district levels; their core is usually military force (DMC, 2011a). Their contribution in communicating and disseminating information on extreme events is also important (details in Chapter 5, section 5.3.1.3). However, as an ad-hoc group compiled from diffirent components, they may need regular praticing or drills on rescue or disasters response for a better coordination.

- *Materials and means on-the-spot*: include local facilities, equipments and supplies which can be affected by or used to respond to natural disasters and extreme weather events in this particular locality. If the local equipments and facilities is protected and prepared appropriately and timely mobilized to respond to natural disasters and extreme weather events, the damage caused by disaster can be significantly reduced. Typically, a plan in strengthening the materials and means on-the-spot has been well developed in Quang An Commune, Quang Dien District, Thua Thien Hue province. The commune’s People’s Committees has also equipped two large moto-boats, many canoes and life jackets/life buoys for rescuers; prepared materials (soil, sand-bags, sacks, bamboo) to proactively handle in the situation if the dikes get broken; encouraged proactive preparation by the local people to respond to disaster, such as vehicles for relocation, house designed with loft for emergency... (JANI, 2011). This plan has assisted local people to be more proactive in response to natural disasters and extreme weather events.

- *Logistics on-the-spot*: include food, energy, fresh water etc. for people using during and after the disaster (Suu et al, 2010). The full preparation of necessities before disasters would ensure that people have most necessary stuffs for their "longer existence" during and after disaster, especially if the area is isolated from outside. It shall also help local people to be more proactive and independent from external help and supplies. There is one point needed to be considered in directing logistic preparation is that local people often subjectlively under-estimated disaster, so that the food prepared is often lesser than required. The detailed illustrations of the value of logistics on-the-spot are presented in Chapter 5 (Section 5.3.4).

9.2.9.3. Lesson learned

The Motto has raised full resrouces from central to local levels, by specifying the Motto in legal documents, from Law, Strategy, Action Plan from National level to province level, to specific plans at level of communes, villages, households in disaster risk management and climate change adaptation.
The extreme weather events and natural disasters, especially storms and floods have high volatility, so that the response must be flexible and on-time. There is a suitable Vietnamese idiom “better a neighbor near than a brother far off” for disaster risk management in all three phases – before, during and after the disaster, with the best result in pre-disaster phase.
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For the better “Four on-the-spot” implementation, it is necessary to build and develop detailed plans for every type of disasters, for every critical area with specific activities and resources in details. Local people and human resources should be trained in rescueing; local government should have frequent communication and guildline on disaster risk management and climate change adaptation, facilitate drills, and well prepare prevention/protection measures with appropriate conditions to be ready for implementing the “Four on-the-spot” Motto in DRM and CCA (Vu Thi Thu Lan et al, 2011).

The leadership is very important component, as the leader must be wise, experienced enough to better coordinate the integrated forces and resources on site. Investment in local facilities, vehicles, materials and supplies on site could be considered as one of the long-term measures to adapt to climate change.

In addition, mechanisms for mobilizing resources, included finance resource for the DRM works such as prevention, evacuation, relocation etc. should be clearly developed to promote the strength and solidarity between all levels of government and the people, and from people themself in terms of facilities and logistics on the spot.

9.2.10. Risk Transfer: the role of Insurance in Disaster Risk Management and Climate Change Adaptation in Agriculture

9.2.10.1. Introduction

Although the Law on Natural Disaster Prevention and Control 2013 had referred to "encourage insurance companies to do business in the Disaster Risk Insurance" (National Assembly, 2013, Article 5.5), however, no specific provisions had been issued. The Law on Insurance Business of Vietnam has not issued any provisions in compulsory insurance in natural disasters risk management yet.

In Vietnam, the property insurance is generally underdeveloped and only occupy a very small proportion in insurance market. The risk-sharing mechanism is often informal, mainly based on neighbourhood relationships helping each other or on supports from civil society organizations or non-governmental organizations. The private sector and business enterprises are usually not active or involved in natural disasters prevention yet, mostly relies on the government support. On the other hand, most of the DRR & CCA policies are oriented towards the communities but almost not mentioned the enterprises.

Agriculture is a potential market for insurance activities, as agriculture production is often affected directly by natural disasters such as typhoons, floods, drought, and saline water intrusion. Agricultural insurance, piloted in Vietnam from 1980, is a perspective policy to enhance sustainable development of agricultural production.

9.2.10.2. Implementation of Disaster Risk Insurance in Agriculture

In March 2013, the Vietnam National Reinsurance Company (Vinare) in collaboration with the Swiss Reinsurance Corporation (Swiss Re) have conducted a research on establishing a disaster risk insurance fund in Vietnam. This is a common joint-asset fund contributed by many insurance companies, specifically for great risk insurance which is unaffordable for a single insurer. In 2013, Vinare coordinates with the Ministry of Finance and some local, national and international insurance institutions to develop solutions on legal framework and learn experiences from the regional insurance market to create disaster insurance scenarios for Vietnam (Vinare, 2013).

In fact, agricultural insurance has been deployed in Vietnam early, for instance the rice insurance in Nam Dinh province was practiced by Bao Viet Insurance company in 1980. According to Decision No.315/QD-TTg (Government of Vietnam, 2011a) the Ministry of Finance and Ministry of Agriculture and Rural Development have pilotted agricultural insurance at national scale during period 2011-2013, with regulations that the Government will support 100% insurance fee to the farmers and individuals living in poverty; 80% for farmers and individuals near poverty threshold; and 60% for other households and individuals participating in pilot scheme of agricultural insurance. This policy aimed to support the farmers and agricultural producers to proactively overcome and compensate the financial losses caused by natural disasters, crop diseases, in order to ensure social security and stability in the rural areas and to facilitate agricultural production. Circular No. 47/2011/TT-BNNPTNT issued by MARD provided detailed guildelines for implementation of the above-mentioned Decision No. 315/QD-TTg to pilot agricultural insurance in 20 provinces for key agricultural products such as rice, cattle, pigs, poultry, fish, basa fish, black tiger shrimp, white shrimp (MARD, 2011).

In addition, the pilot insurance for agricultural products related to disaster risk has also been mentioned in a number of policies such as the project "Rural Trade Development for period 2010-2015, vision to 2020" which had activity on pilot implementation of agricultural insurance in some areas for some types of aquaculture products and crops (Government of Vietnam, 2010a, page 7).

The support and pilot programs have had some positive impact to the operation of agricultural insurance, and the insurance mechanisms were gradually improved. Revenue from agricultural insurance of Bao Viet corporation (in the first 6 months of every year) increased continuously from VND 2.740 billion in 2011 to 29.705 billion in 2012 and to 40.358 billion in 2013 (Bao Viet, 2013 Page 62 ; Bao Viet, 2012 page 59).

Additionally, a number of insurance products for certain types of plants and animals are also practiced such as insurance for rubber, dairy cow in the Central Highlands and insurance for basa fish. However, they are all stopped now by insurance companies because of losses. In other words, the risk in the agricultural sector is very high, as well as the interest from local people is low due to the strict conditions for compensation.

According to the Department of Insurance, Ministry of Finance, the proportion of farmers participating in agricultural insurance is very low, less than 1% of the total crop area, 0.24% for the cattle/cows, 0.1% for pigs and 0.04% for poultry. The implementation of agricultural insurance requires the participation of Government with supporting policies for sharing responsibilities and risks between the Government – the Insurance Companies and local people.

In 2010, BIDV Insurance Corporation (BIC) provided insurance for rubber trees before the storm for the Central Highlands, and part of the South East region but not for the coastal provinces of Central Vietnam, which has the highest number of typhoons landing every year. In 2011, Bao Minh Insurance Company also offered pilot package interrupted short-term insurance for drought risks to coffee farmers in Dak Lak province in the Central Highland.

After more than one year of implementation, the pilot agricultural insurance has been implemented in 20 provinces, with 98,294 households participated (88% of them are poor), total insurred value of crops and livestocks is VND 959.4 billion, the total premium is 48.7 billion, has generated 10.8 billion of compensation and in fact, the insurer has compensated more than 4 billion (as reported by the local and the insurance companies).

9.2.10.3. Lesson learned

Disaster risk insurance in agriculture has been implemented successfully in some developed countries, such as US, Japan, UK, France (detailed in Chapter 7), however it has not really succeeded in Vietnam due to following reasons:

- Awareness of local people for agricultural insurance is very limited; the procedures for receiving compensation are complicated;
- Agricultural production has many potential risks; agricultural practices of Vietnamese farmers are still scattered and decentralized; supporting policies and mechanisms for agricultural insurance are still incomplete, implementation process is complicated therefore can not attractinsurance companies investing into this kind of insurance.

9.2.11. Raising the community awareness

9.2.11.1. Introduction

The Law on Natural Disaster Prevention and Control 2013 (National Assembly, 2013) stated that disaster prevention is the responsibility of the entire population, in which the Government plays a key role in state management, while the people and communities play a proactive role in implementation. Local communities and people are the direct objects being affected by natural disaster, therefore the local people must be well aware of their roles and responsibilities in disaster prevention to make use of inner strength and available resources in order to follow the principle of proactive prevention, timely response, and effective recovery.

In disaster prevention and control, raising community awareness is one of the most practical and effective measures to mitigate the damage caused by natural disasters. It includes education, advocacy, training, community initiatives mobilization in disaster prevention and control. Its role has been identified clearly as key factor by the Government of Vietnam especially for climate change adaptation and disaster prevention and control. It was also stated in many important legislation documents, such as The Law on Natural Disaster Prevention and Control 2013, Strategy for Disaster Prevention and Reduction 2020 (2007), National Strategy on Climate Change (2011), National Target Program to Respond to Climate Change (2008). In these documents, raising public awareness is defined as a leading principle, responsibility and solution for the effective implementation of disaster prevention and control as well as climate change adaptation (Government of Viet Nam, 2007, 2008b, 2011c; National Assembly, 2013).
So far in Viet Nam, awareness raising is considered the first and very important measure in implementation and achievement of management objectives and social development in Vietnam.

9.2.11.2. Actual Implementation

In fact, many programs, projects and activities on raising public awareness have been implemented by the government and social organizations, especially the non-governmental organizations are particularly active and have significant contribution in this field.

Many programs and projects on awarness raising and capacity building for DRM and climate change adaptation have been approved by the Government, especially the program "Raising community awareness and community-based disaster risk management” period 2009-2020 (Government of Viet Nam, 2011b).
This program focused on 6000 communes with high risk of natural disasters, with objective of raising public awareness and organizing an effective model of community-based DRM in order to minimize the loss of property and human lives, to reduce the destruction of natural resources, environment and cultural heritage caused by disasters, to contribute to sustainable development of the countryand to ensure the national security and defense.

In addition, awareness raising has also recieved special attention in the sectoral and provincial/local policies and actions, such as "Guidance for implementation of community awareness raising and community-based isaster management" (MARD, 2011), Action Plan to respond to climate change at provincial/municipal level.

Besides, many social organizations and non-governmental organizations are also working to raise public awareness in prevention and mitigation to natural disasters, such as "Four on-the-spot Motto in disaster prevention and control"(CARE, Oxfam, World Vision, 2010); "Handbook for Natural Disaster Preparedness and Response Planning for Business Enterprises" (To Kim Lien et al, 2012); or "Education initiative on risk reduction for students" (CECI, 2011).

A numerous effective activities in enhancing the community capacity to cope with natural disasters have been conducted, for example project "Participatory Disaster Preparation and Mitigation Project" by Oxfam in cooperation with non-governmental organizations Vietnam - Austria (VANGOCA) from 2006 to 2010, aiming to raise the community awareness onprevention and reduction of disaster risk through communication and public education, to enable and encourage the community participation, especially of women and the poor. It also raised awareness and participation to organize voluntary advocacy groups or clubs to share

knowledge, to create skills for families and guide how to assess vulnerability by themselves at community level, how to build community plan and conduct trainnings following the disaster prevention plan by themselves (Becker and Nguyen Quoc Tuan, 2010 pages 12-13).
A model of community communications club called "living with floods" has been deployed in 24 communes of Tien Giang and Dong Thap provinces during 2008-2010. The clubs have conducted activities every month and based on 20 differentthemes of "Living with floods" concept to raise community awareness about the risks caused by natural disasters, especially floods. Every member have had chance to share their experiences and discuss on each topic of the club meeting, then recognize how to think and how to act to ensure the safety of each individual, each family and community. The club has succeeded in buiding a core volunteer team, developing communication materials, training for volunteers and deploying awareness rising activities(CARE, Oxfam, World Vision, 2010 Page 7-8).

A model of integration and dissemination of knowledge on disaster prevention into extracurricular activities for school students was organized by World Vision in Mo Duc and Duc Pho District, Quang Ngai province. It was a place with a lot of cases of injured or drowned children when disasters occurred. The model aimed to protect children from the adverse impacts of natural disasters and minimize the children casualties by creating a detailed action plan to improve the understanding of disaster for teachers and other school staff by integrating and disseminating knowledge of disaster prevention for school children and students into various means such as extracurricular classes, group discussions, songs, games, performing etc. The teachers and school students have received information on disasters response from this program, they then will transfer and disseminate further these information to the community (CARE, Oxfam, World Vision, 2010).

JANI (Joint Advocacy Initiative Network) is an advocacy project with the participation of 18 non-governmental organizations and others such as the Red Cross and the Women's Union in order to support the National Target Program to Respond to Climate Change (NTP.RCC). The JANI project focused on: (a) awareness raising and policy advocacy; (b) capacity building for the governmental units relevant to implementation of community-based DRM programs (c) share and learn the DRM good practices and models, as well as knowledge sharing between the network members. Training courses on Monitoring and Evaluation (under the Community-Based DRM Program) were organized for the government officials and staffs at central, provincial and local levels at 18 selected provinces. Teaching and learning materials on climate change adaptation and DRR have been compiled (MOET, 2012).

Another organization "Live and Learn" has compiled some materials and games for the school children on disaster risk and climate change adaptation measures. Vulnerability assessment tools have been designed with participation of the disable people; gender issues and the women's role in DRM and CCA activities have been emphasized. In addition, other highly vulnerable and marginalized groups such as children, the disable, the poor communities and ethnic minorities have always received proper attention during the process of project design and implementation.

Many DRM programs have been implemented in Vietnam by the international non-governmental organizations (NGOs) and the Red Cross from the 1990’s. In this program, training-of-trainer (TOT) courses on DRM and CCA have been conducted at all levels, from province to district, commune and down to village level (Le Phuong Hoa and Le Cong Luong, 2011 pages 16-18) (Tran Van Tuan, 2008 pages 18,20,32). Particular attention was drawn on raising the community's awareness on the types of disasters, knowledge on climate change as well as participatory DRM and adaptation planning at village and commune levels (Tran Van Tuan, 2008). As a result, the program had proved its effectiveness in preventing and responding to the latter occurred typhoons and disasters (Fox et al, 2011 pages 24, 26; Hoang Van Tu, 2010 pages 49-50).

Some other organizations have focused on supporting awareness raising, changing behavior, advocacy and fund raising for promising ideas and initiatives from the Youth in response to climate change (VNGOs and CC, SRD, Climate Change Working Group, 2011 Page 84).

Climate Change Working Group of the non-governmental organizations in Viet Nam (CCWG) has a separate sub-group working on the topic of behavior change, which carried out number of activities during 2012-2013 such as: enhancing the participation and cooperation between the NGOs and journalists on climate change, mainstreaming climate change and DRR into the school's curricula, promoting the behavior change towards climate change adaptation and sustainable development through the children- and Youth-centered initiatives - focus on young people, campaigns to promote the communities and stakeholder participation.

9.2.11.3. Lessons learned

As mentioned above, there were number of efforts from both the government and non-governmental organizations in Vietnam to raise the public awareness on disaster prevention and response as well as climate change adaptation through policies, advocacy and practical actions. Lesson learned through diverse activities on community awareness raising is that for each target group specific approach, methods and contents are needed for more effective learning and information sharing. The key target groups to raise awareness are vulnerable people such as the poor, the women, the children, the elderly, and the ethnic minorities living in disaster-prone areas. Besides, the process would be more effective if the selected and trained groups/individuals could spread/transfer further the information to the communities. Most active and effective are the core groups or "seeds" consisting of local youth, students, and local officials. For each target group, the form and content of propaganda and education should be developed specifically. Many practical activities and successful actions related to DRM have been conducted such as vulnerability assessment, DRM planning, transferring skills on disaster prevention and promoting community initiatives. As a result, the community's awareness, knowledge and skills on DRM and CCA has been increased significantly, loss and damages were reduced thanks to efforts of the government, civil societies and social organizations, the non-governmental organizations through many programs and projects. However, under climate change context when the natural disaster may become more complicated and unpredictable, awareness raising is still a necessity in order to promote the community's resilience and adaptive capacity to the increasing risks.

9.3 Lessons learned from the case studies

The typical case studies discussed in Chapter 9 related to hydro-meteorology and climate extreme have brought a number of lessons learned which can be applied in disaster risk management and climate change adaptation at all levels, from individual, community to national level. The lessons learned have shown substantial progress in the field of disaster risk reduction in Viet Nam as well as challenges that Viet Nam will face in the future because the socio-economic development process would require significant strengthening in all aspects of disaster management.

The case studies have shown that adapting to climate change and responding to natural disasters and extreme weather events require appropriate investment into both constructual and non-constructual measures. In the first place, for better preparedness an information system on disaster risk is needed. An early warning system is of utmost importance which should include forecasting and information services, appropriate preparedness and responses with special focus toward improving the quality of forecasting works and timeliness of warning. A successful and effective early warning system would require smooth coordination and synergy of all components: forecast, communications/ information dissemination, preparedness, rescue and disaster relief.

Analyses from the case studies also pointed out that it's worthwhile to invest in the long-term measures and plans for disaster preparedness and climate change adaptation. A number of successful measures are being implemented including those reducing vulnerability such as relocating residents from the high-risk areas, building shelters, or those aiming to better adaptation: building structures highly resilient to climate extremes, planting mangrove forests for storm surge protection. In the field of agriculture, it's necessary to study and apply adaptive methods of cultivation, farming and animal husbandry, agricultural insurance scheme that can reduce the risks, livelihood diversification etc. in order to stabilize and improve the farmers' production. Beside the policies supporting disasters risk reduction and climate change adaptation, scientific and technological know-how need to be applied and properly transferred to the farmers.

One more important lesson from the case studies is that it's crucial to build a policy framework to provide guidance, coordinate and allocate the resources. Disasters risk reduction and climate change adaptation need to be integrated into socio-economic planning at local level as well as urban planning; capacity of local communities should be strengthen for better preparedness and relief after the disasters. In addition, disasters risk reduction and climate change adaptation can be included into official training/educational programs at schools to improve the community knowledge and preparedness.

Coordination and cooperation between sectors and organizations from central to local levels are very important in disaster risk reduction and climate change adaptation. This will help to consolidate the inter-connection, effectively allocate the available resources and ensure that the proposed measures are well integrated. At local level, the "four local" principle can be very effective because it helps coordinating the local resources with efficiency in accordance with the local circumstances and ensuring the smooth and quick decision making and implementation.

Another important lesson is that active participation of local communities in disasters risk reduction and climate change adaptation should be encouraged through awareness rising and behavior change, appropriate communications of linkage between climate change and disasters, weather extreme as well as education for local communities.

The lessons learned from disaster management works have shown that for effective climate change adaptation one should focus not only on constructual measures but combine with non-constructual measures such as applying local knowledge and experiences, awareness rising and livelihood diversification, mobilizing all actors of socio-political system at each level, with clear allocation of responsibilities. Timely information sharing will help better-informed decision making, planning as well as implementation of locally appropriate and effective adaptation measures.

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http://www.wrd.gov.vn/

Website of the Ha Noi city's People Committee
http://hanoi.gov.vn/

SECTION 3 – ANNEXES

ANNEX 1:

GLOSSARY OF TERMS

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Abrupt climate change	Biến đổi khí hậu đột ngột	The nonlinearity of the climate system may lead to abrupt climate change, sometimes called rapid climate change, abrupt events, or even surprises. The term abrupt often refers to time scales faster than the typical time scale of the responsible forcing. However, not all abrupt climate changes need be externally forced. Some changes may be truly unexpected, resulting from a strong, rapidly changing forcing of a nonlinear system.	Tính phi tuyến của *hệ thống khí hậu* có thể dẫn đến *biến đổi khí hậu* đột ngột, thường được gọi là *biến đổi khí hậu nhanh, hiện tượng đột ngột* hay là *bất ngờ*. Từ *đột* ngột ám chỉ quy mô thời gian xảy ra nhanh hơn so với quy mô thời gian điển hình do lực cưỡng bức gây ra. Tuy nhiên, không phải tất cả các dạng biến đổi khí hậu đột ngột đều do *tác động cưỡng bức từ bên ngoài*. Một số thay đổi có thể xảy ra hoàn toàn bất ngờ, do tác động của những thay đổi hoặc lực cưỡng bức mạnh và nhanh.
Adaptation	Thích ứng	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate. (IPCC, 2012 page 36).	Trong hệ thống xã hội, thích ứng là quá trình điều chỉnh theo khí hậu thực tế hoặc dự kiến để hạn chế thiệt hại hoặc tận dụng các cơ hội có lợi. Trong hệ thống tự nhiên, thích ứng là quá trình điều chỉnh theo khí hậu hiện tại và theo những ảnh hưởng của khí hậu. Sự can thiệp của con người có thể tạo điều kiện thuận lợi cho việc điều chỉnh theo khí hậu dự tính (báo cáo IPCC, 2012 trang 36).
Adaptation (to climate change)	Thích ứng (với biến đổi khí hậu-BĐKH)	The adjustment in natural or human systems in response to actual and expected climatic stimuli, such as to moderate harm or exploit beneficial opportunities (IPCC, 2007c, used in: IPCC, 2012 page 36).	Thích ứng với BĐKH là sự điều chỉnh trong hệ thống tự nhiên hoặc nhân tạo để ứng phó với các tác nhân khí hậu hiện tại và tương lai, như làm giảm những những thiệt hại hoặc tận dụng các cơ hội có lợi (IPCC 2007c, trong báo cáo IPCC, 2012 trang 36).
Adaptation assessment	Đánh giá thích ứng	The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.	Đánh giá thích ứng là tiến hành xác định và đánh giá các giải pháp thích ứng với biến đổi khí hậu theo các tiêu chí như tính khả dụng, lợi ích, chi phí, hiệu quả, hiệu suất, và tính khả thi.
Adaptive capacity	Năng lực thích ứng	The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare	Sự kết hợp của tất cả các điểm mạnh, thuộc tính, và nguồn lực sẵn có cho một cá nhân, cộng đồng, xã hội, hoặc tổ chức có thể được sử dụng để chuẩn bị và thực hiện các

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		for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities. Adaptive capacity refers to the ability to anticipate and transform structure, functioning, or organization to better survive hazards (IPCC, 2012 page 72).	hành động để giảm tác động xấu, giảm thiệt hại hoặc tận dụng các cơ hội có lợi. Năng lực thích ứng đề cập đến khả năng dự đoán và thay đổi cơ cấu, chức năng, hoặc tổ chức để tồn tại tốt hơn trước các hiểm họa (báo cáo IPCC, 2012 trang 72).
Aerosols	Sol khí	A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 μm, that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds.	Là tập hợp những phần tử lỏng hoặc rắn có kích thước khoảng 0,01 - 10 μm tồn tại lơ lửng trong không khí ít nhất vài giờ. Sol khí có thể có nguồn gốc tự nhiên hoặc nhân tạo. Son khí có thể ảnh hưởng đến khí hậu theo các cách khác nhau: Ảnh hưởng trực tiếp thông qua tán xạ và hấp thụ bức xạ, ảnh hưởng gián tiếp thông qua mây như làm tăng số lượng hạt nhân ngưng kết, làm thay đổi tính chất quang học và tuổi thọ của mây.
Albedo	Suất phản chiếu	The fraction of solar radiation reflected by a surface or object, often expressed as a percentage. Snow-covered surfaces have a high albedo, the surface albedo of soils ranges from high to low, and vegetationcovered surfaces and oceans have a low albedo. The Earth's planetary albedo varies mainly through varying cloudiness, snow, ice, leaf area, and land cover changes.	Là mức độ phản chiếu ánh sáng mặt trời của một vật hay bề mặt, thường biểu thị bằng %. Bề mặt phủ tuyết có suất phản chiếu cao; mặt đất có suất phản chiếu thay đổi từ cao đến thấp; còn mặt phủ thực vật và đại dương có suất phản chiếu thấp. Suất phản chiếu của trái đất thay đổi chủ yếu qua các thay đổi của mây, tuyết, băng, diện tích lá và sự thay đổi độ che phủ.
Anthropogenic	Nhân tạo (do con người)	Resulting from or produced by human beings.	Kết quả do hoặc được tạo ra bởi con người.

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Anthropogenic emissions	Phát thải do con người	Emissions of greenhouse gases, greenhouse gas precursors, and aerosols associated with human activities. These activities include the burning of fossil fuels, deforestation, land use changes, livestock, fertilization, etc., that result in a net increase in emissions.	Phát thải các *khí nhà kính*, tiền chất khí nhà kính, và *sol khí* liên quan đến các hoạt động của con người, bao gồm việc đốt *nhiên liệu hóa thạch*, *chặt phá rừng*, *thay đổi sử dụng đất*, chăn nuôi, phân bón … mà hậu quả là tăng phát thải.
Atlantic Multi-decadal Oscillation (AMO)	Dao động đa thập kỷ Đại Tây Dương	A multi-decadal (65- to 75-year) fluctuation in the North Atlantic, in which sea surface temperatures showed warm phases during roughly 1860 to 1880 and 1930 to 1960 and cool phases during 1905 to 1925 and 1970 to 1990 with a range of the order of 0.4°C.	Sự biến động trong nhiều thập kỷ (65 - 75 năm) ở Bắc Đại Tây Dương, trong đó nhiệt độ bề mặt nước biển cho thấy giai đoạn ấm áp trong khoảng 1860-1880 và 1930-1960 và giai đoạn mát mẻ trong thời gian 1905-1925 và 1970-1990 với mức độ thay đổi là 0,4°C.
Atmosphere	Khí quyển	The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium, and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapor, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols.	Là lớp vỏ khí bao quanh Trái Đất. Bầu không khí khô bao gồm gần như hoàn toàn nitơ (78,1% tỷ lệ pha trộn khối lượng) và ôxy (20,9% tỷ lệ pha trộn khối lượng), cùng với một số lượng nhỏ các loại khí khác, chẳng hạn như argon (0,93% tỷ lệ pha trộn khối lượng), heli và các loại khí bức xạ nhà kính như carbon dioxide (0,035% tỷ lệ pha trộn khối lượng) và ozon. Ngoài ra, bầu không khí có chứa khí nhà kính là hơi nước, có một lượng thay đổi khá lớn nhưng thường khoảng 1% tỷ lệ pha trộn. Bầu không khí cũng có những đám mây và sol khí.
Available potential energy	Năng lượng tiềm năng sẵn có	That portion of the total potential energy that may be converted to kinetic energy in an adiabatically enclosed system.	Một phần của tổng số năng lượng tiềm năng có thể được chuyển đổi thành động năng trong một hệ thống đoạn nhiệt kèm theo.

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Baseline/reference	Đường cơ sở/ đường tham chiếu	The baseline (or reference) is the state against which change is measured. It might be a ‘current baseline,’ in which case it represents observable, present-day conditions. It might also be a ‘future baseline,’ which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.	Đường cơ sở (hoặc đường tham chiếu) là trạng thái để so sánh với sự thay đổi. Nó có thể là một 'đường cơ sở hiện tại’, đại diện cho điều kiện quan sát được hiện tại. Nó cũng có thể là một ' đường cơ sở tương lai‘, là tập hợp các điều kiện được lên dự tính ngoại trừ các yếu tố ảnh hưởng được quan tâm. Cách diễn giải khác của các điều kiện tham chiếu có thể làm phát sinh nhiều đường cơ sở khác nhau.
Capacity	Năng lực	Capacity refers to the combination of all the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to achieve established goals (IPCC, 2012 page 33). Capacity is an important element in most conceptual frameworks of vulnerability and risk. It refers to the positive features of people’s characteristics that may reduce the risk posed by a certain hazard. Improving capacity is often identified as the target of policies and projects, based on the notion that strengthening capacity will eventually lead to reduced risk. Capacity clearly also matters for reducing the impact of climate change (IPCC, 2012 page 72).	Năng lực là tổng hợp các nguồn lực, điểm mạnh và đặc tính sẵn có trong từng cá nhân, cộng đồng, xã hội và tổ chức có thể được sử dụng nhằm đạt được các mục tiêu chung (báo cáo IPCC, 2012 trang 33). Năng lực là một yếu tố quan trọng trong hầu hết các khung khái niệm dễ bị tổn thương và rủi ro. Năng lực dùng để chỉ các đặc điểm tích cực của người dân có thể làm giảm các rủi ro do một hiểm họa nhất định gây ra. Nâng cao năng lực thường được xác định như là mục tiêu của các chính sách và các dự án, dựa trên quan điểm cho rằng tăng cường năng lực cuối cùng sẽ dẫn đến giảm nguy cơ rủi ro. Năng lực đóng vai trò quan trọng trong việc giảm các tác động của biến đổi khí hậu (báo cáo IPCC, 2012 trang 72).
Carbon cycle	Chu trình các-bon	The term used to describe the flow of carbon (in various forms, e.g., as carbon dioxide) through the atmosphere, ocean, terrestrial biosphere, and lithosphere.	Thuật ngữ dùng để mô tả dòng các-bon (dưới các hình thức khác nhau, ví dụ như CO_2) trong bầu khí quyển, đại dương, sinh quyển trên mặt đất và thạch quyển.
Carbon dioxide (CO_2)	Đi-ô-xít các-bon CO_2	A naturally occurring gas fixed by photosynthesis into organic matter. A byproduct of fossil fuel combustion and biomass burning, it is also emitted from land use	Một loại khí sinh ra một cách tự nhiên bởi quang hợp tạo vật chất hữu cơ, là một sản phẩm phụ của việc đốt cháy nhiên liệu hóa thạch, đốt sinh khối và thay đổi sử dụng đất

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		changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured, thus having a Global Warming Potential of 1.	và các quy trình công nghiệp khác. Đây là khí nhà kính cơ bản do con người gây ra có ảnh hưởng đến sự cân bằng bức xạ của trái đất. Nó là khí tham chiếu để so sánh cho các loại khí nhà kính khác với tiềm năng nóng lên toàn cầu là 1.
Catchment	Lưu vực	An area that collects and drains precipitation.	Vùng thu và thoát nước mưa.
Clausius-Clapeyron relationship (or equation)	Phương trình Clausius-Clapeyron	The differential equation relating the pressure of a substance (usually water vapor) to temperature in a system in which two phases of the substance (water) are in equilibrium.	Phương trình vi phân liên quan đến áp lực của một chất (thường là hơi nước) theo nhiệt độ trong một hệ thống mà trong đó hai giai đoạn của chất (nước) đều trong trạng thái cân bằng.
Climate	Khí hậu	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. In various chapters in this report different averaging periods, such as a period of 20 years, are also used.	Theo nghĩa hẹp khí hậu thường được định nghĩa như là thời tiết trung bình, hoặc nghiêm ngặt hơn, như là mô tả thống kê về trung bình và sự biến động của các đại lượng có liên quan trên chu kỳ thời gian từ hàng tháng đến hàng nghìn hoặc hàng triệu năm. Thời đoạn thường dùng để tính trung bình các biến này là 30 năm như Tổ chức Khí tượng Thế giới định nghĩa. Các đại lượng có liên quan thông thường nhất là các biến bề mặt như nhiệt độ, giáng thủy và gió. Theo nghĩa rộng, khí hậu là trạng thái của hệ thống khí hậu bao gồm cả mô tả thống kê. Trong báo cáo SREX của IPCC thời đoạn 20 năm cũng được dùng để tính trung bình.
Climate change	Biến đổi khí hậu	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades	Là sự thay đổi trong trạng thái của khí hậu có thể được xác định (ví dụ như sử dụng các kiểm tra thống kê) bởi những thay đổi trong giá trị trung bình và/hoặc sự thay đổi thuộc tính của nó, và trong thời gian dài, thường là vài thập kỷ

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		or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[1]	hoặc lâu hơn. Biến đổi khí hậu có thể là do quy trình nội bộ tự nhiên hoặc cưỡng bức bên ngoài, hoặc thay đổi liên tục do con người lên các thành phần của khí quyển hay trong sử dụng đất.
Climate Change		Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC 2013, page 1450).	Biến đổi khí hậu liên quan đến một sự thay đổi trong trạng thái của khí hậu có thể được xác định (ví dụ như sử dụng các kiểm tra thống kê) bởi những thay đổi trong giá trị trung bình và/hoặc sự thay đổi thuộc tính của nó, và trong thời gian dài, thường là vài thập kỷ hoặc lâu hơn. Biến đổi khí hậu có thể là do quá trình nội bộ tự nhiên hoặc cưỡng bức bên ngoài như của chu kỳ mặt trời, hoạt động núi lửa, hoặc thay đổi liên tục do con người đến các thành phần của khí quyển hay trong sử dụng đất (IPCC 2013, trang 1450).
Climate extreme (extreme weather or climate event)	Cực đoan khí hậu (hiện tượng khí hậu hoặc thời tiết cực đoan)	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.	Là sự xuất hiện giá trị cao hơn (hoặc thấp hơn) giá trị ngưỡng của một yếu tố thời tiết hoặc khí hậu, gần các giới hạn trên (hay dưới) của dãy các giá trị quan trắc được của yếu tố đó. Để đơn giản, cả thời tiết cực đoan và khí hậu cực đoan được gọi chung là hiện tượng khí hậu cực đoan.
Climate feedback	Hồi tiếp khí hậu	An interaction mechanism between processes in the climate system is called a climate feedback when the result of an initial process triggers changes in a	Cơ chế tác động qua lại của các quá trình trong hệ thống khí hậu được gọi là hồi tiếp khí hậu kết quả của một quá trình ban đầu gây nên những thay đổi trong một quá trình

[1] This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change is defined as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

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		second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.	thứ hai đến lượt nó lại ảnh hưởng ngược trở lại quá trình ban đầu. Hồi tiếp dương làm tăng quá trình ban đầu, hồi tiếp âm làm giảm.
Climate model	Mô hình khí hậu	See: Global climate model	Xem: Mô hình khí hậu toàn cầu
Climate projection	Dự tính khí hậu	A projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models. Climate projections are distinguished from climate predictions in order to emphasize that climate projections depend upon the emission/ concentration/radiative-forcing scenario used, which are based on assumptions concerning, e.g., future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial uncertainty.	*Dự tính* các phản ứng của hệ thống khí hậu đối với phát thải hoặc kịch bản nồng độ các khí nhà kính và sol-khí, hoặc kịch bản *bức xạ cưỡng bức*, thường dựa trên mô phỏng của *mô hình khí hậu*. Dự tính khí hậu được phân biệt với các *dự báo khí hậu* để nhấn mạnh rằng dự tính khí hậu phụ thuộc vào phát thải/ nồng độ/ kịch bản bức xạ cưỡng bức được sử dụng, dựa trên giả thiết rằng, ví dụ, phát triển kinh tế-xã hội và công nghệ tương lai có thể có hoặc không được thực hiện và do đó mang tính không chắc chắn cao.
Climate scenario	Kịch bản khí hậu	A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate.	Một biểu diễn phù hợp và đơn giản hóa của khí hậu tương lai, dựa trên cơ sở một tập hợp nhất quán của các quan hệ khí hậu đã được xây dựng, sử dụng trong việc nghiên cứu hệ quả tiềm tàng của sự thay đổi khí hậu do con người gây ra, thường dùng như đầu vào cho các mô hình tác động. Các dự tính khí hậu thường được dùng như là nguyên liệu thô để xây dựng các kịch bản khí hậu, nhưng các kịch bản khí hậu thường yêu cầu các thông tin bổ sung ví dụ như các quan trắc khí hậu hiện tại.
Climate	Hệ thống khí	The climate system is the highly complex system	Hệ thống khí hậu là một hệ thống phức tạp bao gồm 5

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system	hậu	consisting of five major components: the atmosphere, the oceans, the cryosphere, the land surface, the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, and anthropogenic forcings such as the changing composition of the atmosphere and land use change.	thành phần chính: Khí quyển, đại dương, băng quyển, mặt đất, sinh quyển và các tương tác giữa chúng. Hệ thống khí hậu theo thời gian bị chi phối bởi các yếu tố động lực nội tại và từ bên ngoài như phun trào núi lửa, dao động của mặt trời và cưỡng bức nhân tạo như thay đổi thành phần khí quyển và thay đổi sử dụng đất.
Climate threshold	Ngưỡng khí hậu	A critical limit within the climate system that induces a non-linear response to a given forcing. See also Abrupt climate change.	Một giới hạn quan trọng trong hệ thống khí hậu gây ra phản ứng bất thường do sự cưỡng bức nào đó. Xem thêm Biến đổi khí hậu đột ngột.
Climate variability	Biến động khí hậu	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also Climate change.	Biến động khí hậu liên quan đến sự thay đổi trong trạng thái trung bình và các đặc trưng thống kê khác (như độ lệch chuẩn, sự xuất hiện các cực đoan,…) của khí hậu trên tất cả các quy mô không gian và thời gian lớn hơn quy mô của các hiện tượng thời tiết riêng lẻ. Biến động có thể là do các quá trình nội tại tự nhiên bên trong hệ thống khí hậu (biến đổi nội tại), hoặc do thay đổi của những tác động bên ngoài của tự nhiên và nhân tạo (biến động bên ngoài). Xem thêm BĐKH.
Cold days/cold nights	Ngày lạnh/đêm lạnh	Days where maximum temperature, or nights where minimum temperature, falls below the 10th percentile, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period.	Ngày có nhiệt độ cự đại, hoặc đêm có nhiệt độ tực tiểu, nằm dưới 10 phần trăm của phân bố xác suất nhiệt độ, trong đó thời kỳ 1961-1990 được dùng để tính phân bố xác suất nhiệt độ.
Community-based disaster risk	Quản lý rủi ro thiên tai dựa vào cộng	See Local disaster risk management.	Xem quản lý rủi ro thiên tai tại chỗ.

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
management	đồng		
Confidence	Mức độ tin cậy	Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence and on the degree of agreement. Confidence is expressed qualitatively.	Mức độ tin cậy vào giá trị của một phát hiện, dựa trên loại, số lượng, chất lượng, tính nhất quán về bằng chứng và mức độ thống nhất. Mức độ tin cậy định được thể hiện một cách định tính.
Control run	Chạy kiểm tra	A model run carried out to provide a 'baseline' for comparison with climate change experiments. The control run uses constant values for the radiative forcing due to greenhouse gases and anthropogenic aerosols appropriate to pre-industrial conditions.	Mô hình được chạy để cung cấp đường 'cơ sở' để so sánh với các thử nghiệm biến đổi khí hậu. Chạy kiểm tra sử dụng các giá trị cưỡng bức bức xạ do các khí nhà kính và các sol khí nhân tạo gây ra so với điều kiện tiền công nghiệp.
Convection	Đối lưu	Vertical motion driven by buoyancy forces arising from static instability, usually caused by near-surface cooling or increases in salinity in the case of the ocean and near-surface warming in the case of the atmosphere. At the location of convection, the horizontal scale is approximately the same as the vertical scale, as opposed to the large contrast between these scales in the general circulation. The net vertical mass transport is usually much smaller than the upward and downward exchange.	Chuyển động thẳng đứng do lực đẩy phát sinh từ sự bất ổn định tĩnh, thường được gây ra bởi sự làm mát gần bề mặt hoặc tăng độ mặn trong trường hợp của đại dương và sự nóng lên gần bề mặt trong trường hợp của bầu khí quyển. Tại vị trí của đối lưu, quy mô theo chiều ngang xấp xỉ quy mô theo chiều dọc, trái ngược với sự sự khác nhau nhiều giữa các quy mô trong hoàn lưu chung. Khối lượng vận chuyển theo chiều ngang thường là nhỏ hơn nhiều so với việc trao đổi lên và xuống.
Coping	Đối phó	The use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term. (IPCC, 2012 page 33).	Việc sử dụng các kỹ năng, các nguồn lực và các cơ hội sẵn có để xác định những điều kiện bất lợi, quản lý và khắc phục chúng, nhằm đạt được chức năng cơ bản trong ngắn hạn và trung hạn (IPCC, 2012 trang 33).
Coping with climate	Đối phó với biến đổi khí	Coping: the use of available skills, resources, and opportunities to address, manage, and overcome	Đối phó: Là việc sử dụng các kỹ năng, nguồn lực và cơ hội sẵn có để giải quyết, quản lý và khắc phục những điều kiện

Terms		Definitions	
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change	hậu	adverse conditions, with the aim of achieving basic functioning in the short to medium term (IPCC, 2012 page 558). Coping is typically used to refer to ex-post actions, while adaptation is normally associated with ex-ante actions. This implies that coping capacity also refers to the ability to react to and reduce the adverse effects of experienced hazards (IPCC, 2012 page 72)	bất lợi, với mục tiêu là hoàn thành được nhiệm vụ cơ bản trong mục tiêu ngắn hạn và trung hạn (báo cáo IPCC, 2012 trang 558). Đối phó được sử dụng để chỉ những hành động xảy ra sau một sự kiện nào đó, trong khi thích ứng thường gắn liền với hành động trước khi một sự kiện nào đó xảy ra. Điều này cho thấy khả năng đối phó là khả năng phản ứng và giảm nhẹ tác động tiêu cực của mối hiểm họa đã trải qua (báo cáo IPCC, 2012 trang 72).
Coping capacity	Năng lực đối phó	The ability of people, organizations, and systems, using available skills, resources, and opportunities to address, manage and overcome adverse conditions (IPCC, 2012 page 558).	Khả năng của người dân, các tổ chức, và các hệ thống, sử dụng kỹ năng, nguồn lực, và cơ hội sẵn có để giải quyết, quản lý và khắc phục những điều kiện bất lợi (báo cáo IPCC, 2012 trang 558).
Detection and attribution	Xác định và quy nguyên nhân	Climate varies continually on all time scales. Detection of climate change is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. Attribution of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence.	Khí hậu thay đổi trên các tất cả các quy mô thời gian. Xác định BĐKH là quá trình chứng tỏ rằng khí hậu đã biến đổi theo một tiêu chí thống kê được xác định, mà không chỉ ra nguyên nhân. Quy nguyên nhân BĐKH là quá trình đưa ra các nguyên nhân có thể nhất gây nên sự biến đổi được xác định với một mức chắc chắn nhất định.
Diabatic	Đoạn nhiệt	A process in which external heat is gained or lost by the system.	Một quá trình mà trong đó ngoại nhiệt tăng lên hay bị mất do hệ thống.
Disaster	Thiên tai	Disasters: severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that	Thiên tai: các thay đổi nghiêm trọng trong chức năng bình thường của một cộng đồng hay một xã hội do các hiểm họa tự nhiên tương tác với các điều kiện dễ bị tổn thương của xã hội, dẫn đến các ảnh hưởng bất lợi rộng khắp đối với con người, vật chất, kinh tế hay môi trường, đòi hỏi phải

Terms		Definitions	
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		require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012 page 31).	ứng phó khẩn cấp để đáp ứng các nhu cầu cấp bách của con người và có thể phải cần đến sự hỗ trợ từ bên ngoài để phục hồi (báo cáo IPCC, 2012 trang 31).
Disaster management	Quản lý thiên tai	Disaster management refers to social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels (IPCC, 2012 page 35).	Quản lý thiên tai được hiểu là quá trình xã hội trong xây dựng, thực hiện và đánh giá chiến lược, chính sách và biện pháp thúc đẩy và nâng cao phòng tránh thiên tai, ứng phó và phục hồi hoạt động ở các cấp tổ chức và xã hội khác nhau (báo cáo IPCC, 2012 trang 35).
Disaster preparedness	Phòng tránh thiên tai	Disaster preparedness measures, including early warning and the development of contingency or emergency plans, may be considered a component of, and a bridge between, disaster risk reduction and disaster management (IPCC, 2012 page 36).	Các biện pháp phòng tránh thiên tai, bao gồm cảnh báo sớm và xây dựng các kế hoạch dự phòng hoặc khẩn cấp, có thể được coi là một hợp phần và là cầu nối giữa giảm nhẹ rủi ro thiên tai và quản lý thiên tai (báo cáo IPCC, 2012 trang 36).
Disaster risk	Rủi ro thiên tai	Disaster risk is defined for the purposes of this study as the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012 page 32).	Rủi ro thiên tai được định nghĩa cho nghiên cứu này là khả năng xảy ra các thay đổi nghiêm trọng trong các chức năng bình thường của một cộng đồng hay một xã hội ở một giai đoạn thời gian cụ thể, do các hiểm họa tự nhiên tương tác với các điều kiện dễ bị tổn thương của xã hội, dẫn đến các ảnh hưởng bất lợi rộng khắp đối với con người, vật chất, kinh tế hay môi trường, đòi hỏi phải ứng phó khẩn cấp để đáp ứng các nhu cầu cấp bách của con người và có thể phải cần đến sự hỗ trợ từ bên ngoài để phục hồi (báo cáo IPCC, 2012 trang 32).
Disaster risk management (DRM)	Quản lý rủi ro thiên tai	Disaster risk management is defined in this report as the processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster	Quản lý rủi ro thiên tai được định nghĩa trong báo cáo này là các quá trình xây dựng, thực hiện và đánh giá chiến lược, chính sách và các biện pháp để nâng cao sự hiểu biết về rủi ro thiên tai, thúc đẩy giảm nhẹ rủi ro thiên tai và

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		disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC, 2012 page 34). Where the term risk management is employed in this chapter and report, it should be interpreted as being a synonym for disaster risk management, unless otherwise made explicit. Disaster risk management can be divided to comprise two related but discrete sub-areas or components: disaster risk reduction and disaster management.	chuyển giao, thực hiện cải tiến liên tục trong phòng chống, ứng phó và phục hồi sau thiên tai, với mục đích rõ ràng để tăng cường an ninh cho con người, hạnh phúc, chất lượng cuộc sống và phát triển bền vững (báo cáo IPCC, 2012 trang 34). Thuật ngữ "quản lý rủi ro" được sử dụng trong chương này và trong báo cáo này được hiểu như là một từ đồng nghĩa với quản lý rủi ro thiên tai, trừ trường hợp được giải thích rõ. Quản lý rủi ro thiên tai có thể được chia thành hai thành phần có liên quan nhưng riêng lẻ: giảm nhẹ rủi ro thiên tai và quản lý thiên tai.
Disaster risk management (Prospective or proactive)	Quản lý rủi ro thiên tai (tiềm năng hoặc chủ động)	Prospective (proactive) disaster risk management can contribute in important ways to avoiding future, and not just reducing existing, risk and disaster (IPCC, 2012 page 36).	Quản lý rủi ro thiên tai tiềm tàng (chủ động) có thể đóng góp trong những cách thức quan trọng để không chỉ làm giảm rủi ro và thiên tai hiện tại và còn tránh những rủi ro thiên tai trong tương lai (báo cáo IPCC, 2012 trang 36).
Disaster risk reduction (DRR)	Giảm nhẹ rủi ro thiên tai	Disaster risk reduction denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk, reducing hazard, existing exposure, or vulnerability, and improving resilience (IPCC, 2012 page 34).	Giảm nhẹ rủi ro thiên tai vừa là một mục tiêu hoặc mục đích chính sách vừa là các biện pháp chiến lược và công cụ được sử dụng để dự đoán rủi ro thiên tai trong tương lai, giảm hiểm họa, giảm mức độ phơi bày trước hiểm họa, hoặc tình trạng dễ bị tổn thương, và nâng cao khả năng chống chịu (báo cáo IPCC, 2012 trang 34).
Environment al disaster	Thảm họa môi trường	Direct physical impacts of human activity and natural physical processes on the environment are fundamental causes (with possible direct feedback impacts on social systems) (IPCC, 2012 page 32).	Tác động trực tiếp của hoạt động con người và quá trình tự nhiên đối với môi trường là những nguyên nhân cơ bản (với tác động phản hồi trực tiếp có thể xảy ra đối với hệ thống xã hội) (báo cáo IPCC, 2012 trang 32).
Social	Thảm họa xã	Extreme impacts on social systems but may or may	Là các tác động nghiêm trọng đến hệ thống xã hội nhưng

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disaster	hội	not impact on the physical and ecological systems (IPCC, 2012 page 32).	có thể có hoặc không tác động đến các hệ thống tự nhiên và sinh thái (báo cáo IPCC, 2012 trang 32).
Disaster mitigation	Giảm nhẹ thiên tai	Disaster mitigation is used to refer to actions that attempt to limit further adverse conditions once disaster has materialized (IPCC, 2012 page 36).	Giảm nhẹ thiên tai được sử dụng để chỉ những hành động nhằm hạn chế các điều kiện bất lợi để giảm thiệt hại do thiên tai (báo cáo IPCC, 2012 trang 36).
Disaster management cycle	Chu trình quản lý thiên tai	The disaster management cycle depicts the sequences and components of so-called disaster management. In addition to considering preparedness, emergency response, rehabilitation, and reconstruction, it also included disaster prevention and mitigation as stated components of ‘disaster management’ and utilized the temporal notions of before, during, and after disaster to classify the different types of action (IPCC, 2012 page 35).	Chu trình quản lý thiên tai mô tả các trình tự và các thành phần được gọi là quản lý thiên tai. Ngoài việc xem xét việc chuẩn bị sẵn sàng, ứng phó khẩn cấp, phục hồi chức năng và tái thiết, chu trình cũng bao gồm phòng tránh thiên tai và giảm nhẹ giống như các thành phần của "quản lý thảm họa” và sử dụng các khái niệm thời gian trước, trong, và sau thiên tai để phân loại các hành động khác nhau (báo cáo IPCC, 2012 trang 35).
Disaster risk continuum	Tính liên tục của rủi ro thiên tai	In the notion of a ‘disaster risk continuum’, risk is seen to evolve and change constantly, requiring different modalities of intervention over time, from pre-impact risk reduction through response to new risk conditions following disaster impacts and the need for control of new risk factors in reconstruction. The disaster risk continuum considers the ways different components and actions merge and can act synergistically with and influence each other, and for its incorporation of disaster risk reduction considerations (IPCC, 2012 page 35).	Trong khái niệm về “tính liên tục của rủi ro thiên tai", rủi ro được xem là phát triển và thay đổi liên tục, đòi hỏi phương thức can thiệp khác nhau theo thời gian, từ giảm nhẹ rủi ro trước khi bị tác động thông qua việc ứng phó với các điều kiện rủi ro mới sau tác động thiên tai và sự cần thiết phải kiểm soát các yếu tố nguy cơ mới trong việc tái thiết. Sự liên tục của rủi ro thiên tai đòi hỏi phải xem xét cách thức mà các thành phần khác nhau và các hoạt động được liên kết và có thể hỗ trợ và ảnh hưởng lẫn nhau, kết hợp với các cân nhắc giảm nhẹ rủi ro thiên tai (báo cáo IPCC, 2012 trang 35).
Disaster risk prevention (Disaster	Phòng ngừa rủi ro thiên tai (Phòng ngừa	Disaster risk prevention and disaster prevention refer, in a strict sense, to the elimination or avoidance of the underlying causes and conditions that lead to	Trong một nghĩa hẹp, phòng ngừa rủi ro thiên tai và phòng ngừa thiên tai là sự loại bỏ hoặc tránh các nguyên nhân và điều kiện dẫn đến thiên tai, do đó ngăn ngừa được rủi ro

Terms		Definitions	
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prevention)	thiên tai)	disaster, thus precluding the possibility of either disaster risk or disaster materializing (IPCC, 2012 page 36).	thiên tai hoặc thiệt hại vật chất do thiên tai (báo cáo IPCC, 2012 trang 36).
Diurnal temperature range	Chênh lệch nhiệt độ ngày	The difference between the maximum and minimum temperature during a 24-hour period.	Sự chênh lệch nhiệt độ cao nhất và thấp nhất trong vòng 24 giờ.
Downscaling	Chi tiết hóa	Downscaling is a method that derives local- to regional-scale (up to 100 km) information from larger-scale models or data analyses.	Chi tiết hóa là các phương pháp để thu được các thông tin có tỷ lệ không gian nhỏ hơn, tới cấp địa phương hoặc cấp vùng (từ 10 đến 100 km), từ các mô hình hoặc các phân tích số liệu có tỷ lệ lớn hơn.
Drought	Hạn hán	A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. A megadrought is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more.	Một thời kỳ với thời tiết khô bất thường đủ dài để gây ra sự mất cân bằng nước nghiêm trọng. Hạn hán là thuật ngữ được hiểu một cách tương đối, vừa liên quan đến thiếu hụt mưa, vừa liên quan đến đối tượng bị ảnh hưởng. Ví dụ, tình trạng thiếu mưa trong mùa sinh trưởng có ảnh hưởng tới sản xuất hoặc chức năng của hệ sinh thái nói chung (do độ ẩm đất khô hạn, được gọi là hạn nông nghiệp), dòng chảy mặt và thấm sẽ ảnh hưởng đến nguồn cung cấp nước (gọi là hạn thủy văn). Một thời kỳ dài thiếu hụt lượng mưa nghiêm trọng được gọi là hạn khí tượng v.v… Một siêu hạn hán là một đợt hạn hán kéo dài và trên diện rộng, kéo dài lâu hơn so với bình thường, thường là một hoặc nhiều thập kỷ.
Early warning	Hệ thống cảnh báo sớm	The set of capacities needed to generate and disseminate timely and meaningful warning	Tập hợp các năng lực cần thiết để tạo ra và phổ biến các thông tin cảnh báo kịp thời và có ý nghĩa để cho phép các

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
system		information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.	cá nhân, cộng đồng và các tổ chức bị đe dọa bởi một mối nguy hiểm chuẩn bị và hành động một cách thích hợp và có đủ thời gian để giảm khả năng bị tổn hại hoặc mất mát.
El Niño-Southern Oscillation (ENSO)	El Niño-Dao động Nam (ENSO)	The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of 2 to about 7 years, is collectively known as the El Niño-Southern Oscillation. It is often measured by the surface pressure anomaly difference between Darwin and Tahiti and the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña.	Thuật ngữ El Nino được sử dụng ban đầu để mô tả dòng nước ấm chảy có chu kỳ dọc theo bờ biển Ecuador và Peru, ảnh hưởng đến nghề cá địa phương. Nó được xác định bởi vùng biển ấm của Thái Bình Dương vùng nhiệt đới về phía đông đường đổi ngày. Sự kiện đại dương này gắn liền với sự dao động của hình thế khí áp quy mô lớn vùng nhiệt đới và cận nhiệt đới, được gọi là dao động nam. Hiện tượng kết hợp khí quyển –đại dương này, thường xuất hiện 2 đến 7 năm, được gọi chung là dao động nam El Nino (ENSO). Nó thường được đo bởi sự chênh lệch khí áp giữa trạm Darwin và trạm Tahiti và nhiệt độ bề mặt biển trong vùng trung tâm và phía đông khu vực xích đạo Thái Bình Dương. Trong suốt thời kỳ ENSO, tín phong thịnh hành bị suy yếu, giảm hiện tượng nước trồi, làm thay đổi các dòng chảy đại dương như là nhiệt độ bề mặt biển ấm lại tăng cường sự suy giảm tín phong. Hiện tượng này có ảnh hưởng lớn tới chế độ gió, nhiệt độ bề mặt biển và lượng giáng thủy trong khu vực nhiệt đới Thái Bình Dương. Nó ảnh hưởng tới khí hậu trong toàn khu vực Thái Bình Dương và nhiều khu vực khác trên thế giới thông qua các liên kết xa toàn cầu. Pha lạnh của ENSO được gọi là La Nina.
Emissions scenario	Kịch bản phát thải	A plausible representation of the future development of emissions of substances that are potentially	Đại diện khả dĩ của sự phát triển trong tương lai của khí thải theo quan điểm đã có hoạt động tiềm năng của bức xạ

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		radiatively active (e.g., greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (such as technological change, demographic and socioeconomic development) and their key relationships. Concentration scenarios, derived from emissions scenarios, are used as input to a climate model to compute climate projections.	(ví dụ, các loại *khí nhà kính, sol khí*), dựa trên một tập hợp chặt chẽ và nhất quán của các giả định về các nhân tố tác động (ví dụ như cơ cấu dân số và phát triển kinh tế xã hội, thay đổi công nghệ) và các mối quan hệ chủ yếu giữa chúng. Kịch bản nồng độ, xuất phát từ kịch bản phát thải, được sử dụng như là đầu vào cho mô hình khí hậu để tính toán dự báo khí hậu
Ensemble	Tổ hợp	A group of parallel model simulations used for climate projections. Variation of the results across the ensemble members gives an estimate of uncertainty. Ensembles made with the same model but different initial conditions only characterize the uncertainty associated with internal climate variability, whereas multi-model ensembles including simulations by several models also include the impact of model differences. Perturbed parameter ensembles, in which model parameters are varied in a systematic manner, aim to produce a more objective estimate of modeling uncertainty than is possible with traditional multimodel ensembles.	Một tập hợp các mô phỏng song song bằng mô hình được sử dụng để dự đoán khí hậu. Dao động của các kết quả của các tổ hợp trên được coi là sự không chắc chắn. Tổ hợp được thực hiện với mô hình tương tự nhưng điều kiện ban đầu khác nhau nên chỉ đặc trưng cho sự không chắc chắn liên quan đến dao động khí hậu nội tại, trong khi tổ hợp nhiều mô hình bao gồm mô phỏng theo một số mô hình và bao gồm cả tác động của sự khác biệt của mô hình. Tổ hợp tham số nhiễu động, trong đó các thông số mô hình được thay đổi một cách hệ thống, nhằm mục đích để tạo ra một ước tính khách quan hơn về sự không chắc chắn của mô hình hơn là khả năng tổ hợp đa mô hình truyền thống.
Evapotranspiration	Bốc thoát hơi	The combined process of evaporation from the Earth’s surface and transpiration from vegetation.	Là quá trình kết hợp giữa bốc hơi từ bề mặt Trái đất và quá trình thoát hơi từ thực vật.
Exposure	Mức độ phơi bày	Exposure is employed to refer to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or	Mức độ phơi bày (trước hiểm họa) được sử dụng để chỉ sự hiện diện (theo vị trí) của con người, sinh kế, các dịch vụ môi trường và các nguồn tài nguyên, cơ sở hạ tầng, hoặc các tài sản kinh tế, xã hội hoặc văn hóa ở những nơi có thể chịu những ảnh hưởng bất lợi bởi các hiện tượng tự nhiên và vì thế có thể là đối tượng của những tổn hại, mất mát,

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		damage (IPCC, 2012 page 32)	hư hỏng tiềm tàng trong tương lai (báo cáo IPCC, 2012 trang 32)
External forcing	Sự cưỡng bức từ bên ngoài	External forcing refers to a forcing agent outside the climate system causing a change in the climate system. Volcanic eruptions, solar variations, and anthropogenic changes in the composition of the atmosphere and land use change are external forcings.	Sự cưỡng bức từ bên ngoài chỉ một tác nhân từ bên ngoài đến *hệ thống khí hậu* gây ra sự thay đổi trong *hệ thống khí hậu.* Sự phun trào núi lửa, những biến đổi của mặt trời và những thay đổi *do con người gây ra* đối với thành phần của *khí quyển* và *thay đổi sử dụng đất* là các cưỡng bức từ bên ngoài.
Extratropical cyclone	Siêu áp thấp nhiệt đới	Any cyclonic-scale storm that is not a tropical cyclone. Usually refers to a middle- or high-latitude migratory storm system formed in regions of large horizontal temperature variations. Sometimes called extratropical storm or extratropical low.	Bất kỳ xoáy thuận nào quy mô đó thì không phải là một xoáy thuận nhiệt đới. Đây thường nói đến sự di chuyển của hệ thống bão được hình thành do thay đổi nhiệt độ trên một vùng rộng lớn ở vĩ độ trung bình hoặc vĩ độ cao. Đôi khi được gọi là siêu bão hoặc siêu áp thấp
Extreme coastal high water (also referred to as extreme sea level)	Mực nước cực đại ven biển	Extreme coastal high water depends on average sea level, tides, and regional weather systems. Extreme coastal high water events are usually defined in terms of the higher percentiles (e.g., 90th to 99.9th) of a distribution of hourly values of observed sea level at a station for a given reference period.	Mực nước cực đại ven biển phụ thuộc vào mức nước trung bình, thủy triều, và các hệ thống thời tiết khu vực. Hiện tượng mực nước cực đại thường được xác định theo tần suất phần trăm (ví dụ, 90 để 99.9) của của dãy số liệu đo đạc mực nước biển theo giờ tại một trạm trong một thời gian tham chiếu (đủ dài).
Extreme events	Hiện tượng cực đoan	Extreme events are defined as the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends (‘tails’) of the range of observed values of the variable (IPCC, 2012 page 30) For simplicity, both extreme weather and extreme climate events are referred to collectively as climate extremes. Extreme events are often but not always associated with disaster. This association will depend on the	Hiện tượng cực đoan là sự xuất hiện một giá trị của một yếu tố thời tiết hoặc khí hậu cao hơn (hoặc thấp hơn) một giá trị ngưỡng, gần các giới hạn trên (hay dưới) của dãy các giá trị quan trắc được của yếu tố đó (báo cáo IPCC, 2012 trang 30) Để đơn giản, cả thời tiết cực đoan và khí hậu cực đoan được gọi chung là khí hậu cực đoan. Hiện tượng cực đoan thường nhưng không luôn luôn liên quan đến thiên tai. Mối quan hệ này sẽ phụ thuộc đặc biệt vào các điều kiện tự nhiên, địa lý, và xã hội. Hiện tượng tự

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		particular physical, geographic, and social conditions that prevail. Non-extreme physical events also can and do lead to disasters where physical or societal conditions foster such a result (IPCC, 2012 page 31)	nhiên không cực đoan cũng có thể dẫn đến các thiên tai khi các điều kiện tự nhiên hoặc xã hội tác động thêm vào (báo cáo IPCC, 2012 trang 31)
Famine	Nạn đói	Scarcity of food over an extended period and over a large geographical area, such as a country. Famines may be triggered by extreme climate events such as drought or floods, but can also be caused by disease, war, or other factors.	Tình trạng khan hiếm thực phẩm trong một thời gian dài và trên một khu vực địa lý rộng lớn, chẳng hạn như một quốc gia. Nạn đói có thể được gây ra bởi các hiên tượng khí hậu cực đoan như hạn hán, lũ lụt, nhưng cũng có thể được gây ra bởi bệnh tật, chiến tranh, hoặc các yếu tố khác.
Flood	Lũ lụt	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.	Lũ lụt là sự chảy tràn trên các giới hạn bình thường của dòng chảy hoặc hồ chứa hoặc sự tích tụ nước gây ngập úng khác thường. Lũ lụt bao gồm lũ sông (sông ngòi), lũ quét, ngập lụt đô thị, lũ lụt do mưa, lũ ống, ngập lụt ven biển, lũ phát sinh do băng tan.
Frozen ground	Đất đóng băng	Soil or rock in which part or all of the pore water is frozen. Perennially frozen ground is called permafrost. Ground that freezes and thaws annually is called seasonally frozen ground.	Đất hoặc đá mà một phần hoặc tất cả nước trong các lỗ rỗng được đông lạnh. Mặt đất quanh năm đông lạnh được gọi là băng vĩnh cửu. Mặt đất đóng băng và tan ra hàng năm được gọi là mặt đất đông lạnh theo mùa.
Glacial lake outburst flood (GLOF)	Lũ hồ băng	Flood associated with outburst of glacial lake. Glacial lake outburst floods are typically a result of cumulative developments and occur (i) only once (e.g., full breach failure of moraine-dammed lakes), (ii) for the first time (e.g., new formation and outburst of glacial lakes), and/or (iii) repeatedly (e.g., ice-dammed lakes with drainage cycles, or ice fall).	Lũ kết hợp với sự tan chảy bùng phát của hồ băng. Lũ hồ băng bùng phát thường là kết quả của sự tích nước và xảy ra (i) chỉ một lần (ví dụ, vi phạm nghiêm trọng tích băng - xây đập), (ii) lần đầu tiên (ví dụ, hình thành mới và sự bùng nổ của hồ băng), và / hoặc (iii) liên tục (ví dụ, xây đập với chu kỳ hệ thống thoát nước(không hợp lý), hoặc sạt lở băng).
Glacier	Sông băng	A mass of land ice that flows downhill under gravity	Khối băng trên mặt đất trôi từ núi xuống do sự tự biến dạng

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		(through internal deformation and/or sliding at the base) and is constrained by internal stress and friction at the base and sides. A glacier is maintained by accumulation of snow at high altitudes, balanced by melting at low altitudes or discharge into the sea.	và hiện tượng trượt ở mặt đáy. Một sông băng được duy trì do sự tích tụ tuyết ở các vùng cao so với mặt biển, được cân bằng qua sự tan chảy xuống các vùng có độ cao thấp hơn hoặc chảy ra biển.
Global climate model (also referred to as general circulation model, both abbreviated as GCM)	Mô hình khí hậu toàn cầu (GCM)	A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. Coupled Atmosphere-Ocean Global Climate Models (AOGCMs), also referred to as Atmosphere-Ocean General Circulation Models, provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available. There is an evolution toward more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and interannual climate predictions.	Sự mô tả bằng số của *hệ thống khí hậu* và diễn giải tất cả hoặc một phần các thuộc tính lý, hóa và sinh của các thành phần của nó cùng quá trình tương tác và *phản hồi* của các thành phần này. *Hệ thống khí hậu* có thể được mô tả bằng các mô hình có độ phức tạp và tính chất khác nhau (ví dụ khác nhau về số chiều không gian, về loại hình và độ chi tiết của các qúa trình lý, hóa hoặc sinh học v.v.). Các mô hình kép hoàn lưu chung khí quyển-đại dương (*AOGCM*) có thể miêu tả một cách tương đối chi tiết *hệ thống khí hậu*, một số mô hình phức tạp hơn xem xét cả các quá trình hóa học và sinh học. Các mô hình khí hậu được áp dụng như một công cụ để nghiên cứu và mô phỏng *khí hậu*, nhưng đồng thời cũng phục vụ cho các mục đích tác nghiệp, như *dự báo khí hậu* theo tháng, mùa và nhiều năm.

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Global surface temperature	Nhiệt độ bề mặt toàn cầu	The global surface temperature is an estimate of the global mean surface air temperature. However, for changes over time, only anomalies, as departures from a climatology, are used, most commonly based on the area-weighted global average of the sea surface temperature anomaly and land surface air temperature anomaly.	Nhiệt độ bề mặt toàn cầu là một ước lượng của nhiệt độ không khí bề mặt trung bình toàn cầu. Tuy nhiên, đối với những biến đổi theo thời gian, chỉ giá trị dị thường, tính từ trung bình khí hậu, được sử dụng, thông thường dựa trên giá trị trung bình có trọng số theo diện tích của dị thường nhiệt độ bề mặt biển và dị thường nhiệt độ không khí bề mặt đất.
Governance	Quản trị	The way government is understood has changed in response to social, economic, and technological changes over recent decades. There is a corresponding shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognizing the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of nongovernmental actors, and of civil society.	Là cách mà chính phủ đã thay đổi để đáp ứng với những thay đổi xã hội, kinh tế và công nghệ trong thập kỷ gần đây. Có một sự thay đổi tương ứng từ chính phủ đúng quy định của một quốc gia đến một khái niệm toàn diện hơn về quản trị, công nhận những đóng góp của các cấp chính quyền khác nhau (toàn cầu, quốc tế, khu vực, địa phương) và vai trò của khu vực tư nhân, của các thành phần phi chính phủ , và của xã hội dân sự.
Greenhouse effect	Hiệu ứng nhà kính	Greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface-troposphere system. This is called the greenhouse effect. Thermal infrared radiation in the troposphere is strongly coupled to the temperature of the atmosphere at the altitude at which it is emitted. In the troposphere, the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, -19°C, in balance with the net	Các khí nhà kính hấp thụ hiệu quả bức xạ hồng ngoại nhiệt phát ra bởi bề mặt của Trái đất, bởi chính khí quyển do có cùng các khí nhà kính, và do các đám mây. Bức xạ khí quyển được phát ra từ mọi phía, bao gồm cả đi xuống bề mặt Trái đất. Vì vậy các loại khí nhà kính giữ nhiệt bên trong lớp bề mặt đất và tầng đối lưu. Hiện tượng này được gọi là hiệu ứng nhà kính. Bức xạ nhiệt hồng ngoại trong tầng đối lưu quan hệ chặt chẽ với nhiệt độ của khí quyển tại độ cao mà ở đó nó được phát xạ. Trong tầng đối lưu, nhiệt độ thường giảm theo độ cao. Thực tế, bức xạ hồng ngoại phát ra không gian bắt đầu từ một độ cao với nhiệt độ trung bình -19 oC, trong cân bằng với bức xạ mặt trời thuần đi vào, khi bề mặt Trái đất được giữ ở nhiệt độ cao hơn nhiều, trung bình là + 14 oC. Sự gia tăng nồng độ các khí nhà kính

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		incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, 14°C. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing that leads to an enhancement of the greenhouse effect, the so-called enhanced greenhouse effect.	dẫn đến độ chắn sáng hồng ngoại của khí quyển gia tăng và do đó bức xạ vào vũ trụ hiệu quả từ độ cao cao hơn ở một nhiệt độ thấp hơn. Điều này gây ra một tác động bức xạ dẫn đến sự tăng cường của hiệu ứng nhà kính, cái gọi là gia tăng hiệu ứng nhà kính.
Greenhouse gas	Khí nhà kính	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, which absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and brominecontaining substances, dealt with under the Montreal Protocol. Besides CO2, N2O, and CH4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).	Các khí nhà kính là các thành phần khí của khí quyển, gồm cả các khí trong tự nhiên và các khí sinh ra do hoạt động của con người, hấp thụ và phát xạ bức xạ ở các bước sóng cụ thể trong khoảng phổ của bức xạ hồng ngoại nhiệt phát ra từ bề mặt Trái đất, khí quyển và mây. Các đặc tính này gây ra hiệu ứng nhà kính. Hơi nước (H2O), điôxit cacbon (CO2), ôxit nitơ (N2O), khí mê tan (CH4), và ôzôn (O3) là các khí nhà kính chính trong khí quyển Trái đất. Hơn nữa, có một số khí nhà kính hoàn toàn là do con người thải vào bầu khí quyển, chẳng hạn như halocarbons và các chất khác có các thành phần chứa clo và brôm, được xem xét trong Nghị định thư Montreal. Bên cạnh các khí CO2, N2O, CH4, Nghị định thư Kyoto xem xét cả các khí nhà kính SF6, HFCs và PFCs
Hazard	Hiểm họa	The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage	Sự xuất hiện tiềm tàng của các hiện tượng tự nhiên hoặc do con người gây ra có thể gây thương tật, chết người hoặc ảnh hưởng sức khỏe, làm hư hại hoặc mất mát tài

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English	**Vietnamese**	**English**	**Vietnamese**
		and loss to property, infrastructure, livelihoods, service provision, and environmental resources. (IPCC, 2012 page 32)	sản, cớ sở hạ tầng, sinh kế, cung cấp dịch vụ và tài nguyên môi trường (IPCC, 2012 trang 32) (Có thể chon một trong hai lựa chọn)
Hazard	Hiểm họa	Hazard refers to the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements (IPCC, 2012 page 69)	Hiểm họa là để chỉ khả năng xuất hiện trong tương lai của các hiện tượng tự nhiên hoặc do con người gây ra mà có thể có tác động bất lợi đến các đối tượng dễ bị tổn thương và các đối tượng bị phơi bày trước thảm họa (báo cáo IPCC, 2012 trang 69)
Hazardous physical events	Các hiểm họa tự nhiên	The hazardous physical events referred to in the definition of disaster may be of natural, socio-natural (originating in the human degradation or transformation of the physical environment), or purely anthropogenic origins (IPCC, 2012 page 31)	Các hiểm họa tự nhiên được đề cập trong định nghĩa của thiên tai có thể là tự nhiên, tự nhiên -xã hội (bắt nguồn từ các hoạt động làm suy giảm hoặc biến đổi môi trường tự nhiên của con người), hoặc có nguồn gốc hoàn toàn do con người tạo nên (báo cáo IPCC, 2012 trang 31)
Heat wave (also referred to as extreme heat event)	Sóng nhiệt	A period of abnormally hot weather. Heat waves and warm spells have various and in some cases overlapping definitions. See also Warm spell.	Một thời gian thời tiết nóng bất thường. Sóng nhiệt và đảo nhiệt có định nghĩa khác nhau và chồng chéo trong một số trường hợp. Xem thêm đảo nhiệt.
Holocene	Thế Toàn Tân	The Holocene geological epoch is the latter of two Quaternary epochs, extending from about 11.6 thousand years before present to and including the present.	Thế Holocene/ thế Toàn Tân là thời đại địa chất sau này của hai thời đại Đệ tứ, kéo dài từ khoảng 11.600 năm trước đến hiện tại.
Human security	An ninh con người	Human security can be said to have two main aspects. It means, first, safety from such chronic threats as hunger, disease, and repression. And second, it means protection from sudden and hurtful disruptions in the patterns of daily life – whether in	An ninh con người có thể được cho là có hai khía cạnh chính. Nó có nghĩa là, trước tiên, an toàn từ các mối đe dọa thường xuyên như đói, bệnh tật, và đàn áp. Và thứ hai, nó có nghĩa là bảo vệ khỏi sự gián đoạn đột ngột và gây tổn thương trong cuộc sống hàng ngày - cho dù trong nhà,

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		homes, in jobs, or in communities. Such threats can exist at all levels of national income and development.	trong công việc, hoặc trong cộng đồng. Các mối đe dọa như vậy có thể tồn tại ở tất cả các mức độ thu nhập và phát triển.
Hydrological cycle (also referred to as water cycle)	Chu kỳ thủy văn (Tham khảo thêm chu kỳ nước)	The cycle in which water evaporates from the oceans and the land surface, is carried over the Earth in atmospheric circulation as water vapor, condenses to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, and/or discharges into streams and flows out into the oceans, and ultimately evaporates again from the oceans or land surface. The various systems involved in the hydrological cycle are usually referred to as hydrological systems.	Chu kỳ trong đó nước bốc hơi từ các đại dương và bề mặt đất, được vận chuyển trên mặt đất vào hoàn lưu khí quyển dạng hơi nước, ngưng tụ thành những đám mây, kết tủa lại như mưa hoặc tuyết, bị chặn lại bởi cây cối và thực vật, cung cấp cho dòng chảy trên mặt đất, thấm vào đất, vào nước ngầm, và / hoặc xả vào dòng chảy và chảy ra các đại dương, và cuối cùng là bốc hơi một lần nữa từ các đại dương hoặc bề mặt đất. Các hệ thống khác nhau tham gia vào chu trình thủy văn thường được gọi là hệ thống thủy văn.
Impacts	Tác động	Effects on natural and human systems. In this report, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change.	Ảnh hưởng đến hệ thống tự nhiên và con người. Trong báo cáo này thuật ngữ "Tác động" dùng để chỉ ảnh hưởng đến hệ thống tự nhiên và con người của các hiện tượng vật lý, của thiên tai và của BĐKH
Indian Ocean Dipole (IOD)	IOD	Large-scale interannual variability of sea surface temperature in the Indian Ocean. This pattern manifests through a zonal gradient of tropical sea surface temperature, which in one extreme phase in boreal autumn shows cooling off Sumatra and warming off Somalia in the west, combined with anomalous easterlies along the equator.	Biến trình năm quy mô lớn của nhiệt độ bề mặt nước biển ở Ấn Độ Dương. Hình thế này thể hiện thông qua một gradient đới của nhiệt độ bề mặt biển nhiệt đới, mà trong một pha cực đoan trong các biểu hiện dịu mát mùa thu ngoài khơi đảo Sumatra và ấm lên ngoài khơi Somalia ở phía tây, kết hợp với dònghướng đông bất thường dọc theo đường xích đạo.
Insurance/reinsurance	Bảo hiểm/tái bảo hiểm	A family of financial instruments for sharing and transferring risk among a pool of at-risk households, businesses, and/or governments. See Risk transfer.	Một tập hợp các công cụ tài chính để chia sẻ và chuyển hoán rủi ro trong một loạt các hộ gia đình các doanh nghiệp, và / hoặc các chính phủ bị tổn hại. Xem thêm Chia

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			sẻ rủi ro
Landslide	Sạt lở đất	A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure.	Một khối lượng của vậtchất đổ xuống dốc bằng trọng lực, thường được hỗ trợ của nước khi vật liệu được bão hòa. Sự chuyển động của đất, đá, hoặc các mảnh vụn xuống dốc có thể xảy ra nhanh chóng, hoặc có thể đến chậm, suy dần.
Land surface air temperature	Nhiệt độ không khí bề mặt	The air temperature as measured in well-ventilated screens over land at 1.5 to 2 m above the ground.	Nhiệt độ không khí được đo ở bề mặt thoáng cách mặt đất 1.5m đến 2m
Land use and land use change	Sử dụng đất, chuyển đổi sử dụng đất và lâm nghiệp	Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have radiative forcing and/or other impacts on climate, locally or globally.	Sử dụng đất là tổng hợp các công việc bố trí, các hoạt động và đầu tư được tiến hành trên một dạng lớp phủ đất nào đó (hàng loạt các hoạt động của con người). Các mục đích xã hội và kinh tế đối với vùng đất đó được quản lý (thí dụ: chăn nuôi, khai thác gỗ, bảo tồn v.v...). Thay đổi sử dụng đất là sự thay đổi việc sử dụng hoặc quản lý bởi con người có thể dẫn đến sự thay đổi lớp phủ đất. Thay đổi sử dụng đất và lớp phủ đất có thể có tác động đến độ phản xạ, bốc thoát hơi, các nguồn và bể hấp thụ các khí nhà kính và các đặc điểm khác của hệ thống khí hậu và do đó có thể gây ra bức xạ cưỡng bức và/hoặc những tác động khác lên khí hậu địa phương hoặc toàn cầu
Lapse rate	Tỷ lệ thay đổi	The rate of change of an atmospheric variable, usually temperature, with height. The lapse rate is considered positive when the variable decreases with height.	Tốc độ thay đổi của một biến trong khí quyển, thường là nhiệt độ với độ cao. Tỷ lệ thay đổi là dương khi biến giảm theo độ cao

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Latent heat flux	Thông lượng ẩn nhiệt	The flux of heat from the Earth's surface to the atmosphere that is associated with evaporation or condensation of water vapor at the surface; a component of the surface energy budget.	Thông lượng của nhiệt từ bề mặt Trái đất lên khí quyển liên quan đến sự bốc hơi hay ngưng tụ nước tại bề mặt, là một thành phần của quỹ năng lượng bề mặt.
Likelihood	Vòng đời	A probabilistic estimate of the occurrence of a single event or of an outcome, for example, a climate parameter, observed trend, or projected change lying in a given range. Likelihood may be based on statistical or modeling analyses, elicitation of expert views, or other quantitative analyses.	Một ước tính xác suất của sự xuất hiện của một sự kiện đơn lẻ hoặc một kết quả, ví dụ, một tham số khí hậu, xu thế, hoặc sự thay đổi dự kiến nằm trong một phạm vi nhất định. Sự hiện diện có thể dựa trên phân tích thống kê hay mô hình, các quan điểm chuyên gia, hoặc phân tích định lượng khác.
Local disaster risk management (LDRM)	Quản lý rủi ro thiên tai tại chỗ	The process in which local actors (citizens, communities, government, non-profit organizations, institutions, and businesses) engage in and have ownership of the identification, analysis, evaluation, monitoring, and treatment of disaster risk and disasters, through measures that reduce or anticipate hazard, exposure, or vulnerability; transfer risk; improve disaster response and recovery; and promote an overall increase in capacities. LDRM normally requires coordination with and support from external actors at the regional, national, or international levels. Community-based disaster risk management is a subset of LDRM where community members and organizations are in the center of decision making.	Là quá trình mà trong đó chủ thể địa phương (người dân, cộng đồng, các tổ chức phi lợi nhuận, các cơ quan, và doach nghiệp) tham gia và có quyền trong việc xác định, phân tích, đánh giá, giám sát và xử lý rủi ro thiên tai và thảm họa, thông qua các biện pháp làm giảm hoặc biết trước nguy hiểm, mức độ tiếp xúc, hoặc dễ bị tổn thương; chuyển hoán nguy cơ; cải thiện ứng phó thiên tai và phục hồi; thúc đẩy sự gia tăng khả năng tổng thể. LDRM thường đòi hỏi phải phối hợp, hỗ trợ của các chủ thể từ bên ngoài ở cấp khu vực, quốc gia hay quốc tế. Quản lý rủi ro thiên tai dựa vào cộng đồng là một tập hợp con của LDRM nơi các thành viên và các tổ chức cộng đồng ở trong trung tâm của việc ra quyết định.
Mass movement	Sạt lở hàng loạt	Mass movement in the context of mountainous phenomena refers to different types of mass transport processes including landslides, avalanches, rock fall, or debris flows.	Sạt lở hàng loạt là hiện tượng ở các vùng núi là các quá trình di chuyển khối lượng lớn bao gồm lở đất, lở tuyết, đá rơi, hoặc dòng chảy các mảnh vụn.

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Mean sea level	Mực nước biển trung bình	Sea level measured by a tide gauge with respect to the land upon which it is situated. Mean sea level is normally defined as the average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. See Sea level change.	Mực nước biển được đo bởi trạm đo thủy triều và để so với mặt đất nơi đặt trạm. Mực nước biển thường được định nghĩa là mực nước trung bình tương đối của nước biển qua một thời gian, chẳng hạn như một tháng hay một năm, đủ dài để tính trung bình các yếu tố như sóng và triều. Xem thêm Biến đổi mực nước biển
Meridional overturning circulation (MOC)	Vòng tuần hoàn muối nhiệt	Meridional (north-south) overturning circulation in the ocean quantified by zonal (east-west) sums of mass transports in depth or density layers. A main deep ocean current flows through all the world's oceans and is known as the thermohaline circulation or global conveyor belt. This movement is slow and is driven by differences in density of the water caused by variations in salinity and temperature. At high latitudes, the water is chilled by the low atmospheric temperature and becomes saltier as sea ice crystallizes out. Both these factors make it denser and the water sinks. From the deep sea near Greenland, such water flows southwards between the continental landmasses on either side of the Atlantic. When it reaches the Antarctic, it is joined by further masses of cold, sinking water and flows eastwards. It then splits into two streams that move northwards into the Indian and Pacific Oceans. Here it is gradually warmed, becomes less dense, rises towards the surface, and loops back on itself. Some flows back into the Atlantic. It takes a thousand years for this circulation pattern to be completed	Dòng hải lưu sâu chảy qua tất cả các đại dương trên thế giới và được gọi là **vòng tuần hoàn muối nhiệt**. Sự chuyển động của khối lượng lớn này chậm và được điều khiển bởi sự khác biệt về tỷ trọng của nước do sự khác biệt về độ mặn và nhiệt độ giữa các đại dương. Ở vĩ độ cao, nước được gia lạnh bởi nhiệt độ không khí thấp và trở nên mặn như biển băng kết tinh. Cả hai yếu tố này làm cho nó đặc hơn, và nước chìm xuống dưới. Từ biển sâu gần bắc cực, nước kiểu này chảy về phía nam giữa các lục địa ở hai bên bờ Đại Tây Dương. Khi nó đạt đến Nam Cực, nó kết hợp với các khối lạnh khác, chìm xuống và chảy về phía đông. Sau đó nó chia tách thành hai dòng di chuyển về phía bắc vào Ấn Độ Dương và Thái Bình Dương. Ở đây nó từ từ ấm lên, trở nên ít dày đặc hơn, trồi lên bề mặt và tiếp tục lặp lại vòng tuần hoàn đó. Một số dòng chảy trở lại vào Đại Tây Dương. Phải mất một ngàn năm để mô hình lưu thông này hoàn tất.
Mitigation (of	giảm nhẹ (rủi	The lessening of the potential adverse impacts of	Là làm giảm bớt các tác động tiêu cực tiềm ẩn của các

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disaster risk and disaster)	ro thiên tai và thiên tai)	physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.	nguy cơ vật lý (bao gồm cả những nguy cơ con người gây ra) thông qua các hành động làm giảm mức độ nguy hiểm, mức độ phơi nhiễm, và khả năng bị tổn thương.
Mitigation (of climate change)	Giảm nhẹ (biến đổi khí hậu)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases. Mitigation refers to the reduction of the rate of climate change via the management of its causal factors (the emission of greenhouse gases from fossil fuel combustion, agriculture, land use changes, cement production, etc.) (SREX page 36)	Là sự can thiệp của con người làm giảm nguồn và cải thiện bể chứa các khí nhàn kính Giảm nhẹ là việc giảm tốc độ của biến đổi khí hậu thông qua việc quản lý các tác nhân của nó (phát thải khí nhà kính từ quá trình đốt cháy nhiên liệu hóa thạch, từ nông nghiệp, từ thay đổi sử dụng đất, từ sản xuất xi măng, v.v…) (báo cáo IPCC, 2012 trang 36)
Modes of climate variability	Các dạng biến động khí hậu	Natural variability of the climate system, in particular on seasonal and longer time scales, predominantly occurs with preferred spatial patterns and time scales, through the dynamical characteristics of the atmospheric circulation and through interactions with the land and ocean surfaces. Such patterns are often called regimes, modes, or teleconnections. Examples are the North Atlantic Oscillation (NAO), the Pacific-North American pattern (PNA), the El Niño-Southern Oscillation (ENSO), the Northern Annular Mode (NAM; previously called the Arctic Oscillation, AO), and the Southern Annular Mode (SAM; previously called the Antarctic Oscillation, AAO).	Biến động tự nhiên của hệ thống khí hậu, đặc biệt là trên quy mô mùa và những quy mô dài hơn mùa, phần lớn xảy ra với các dạng ưu tiên theo hình thế không gian và các quy mô thời gian, thông qua các đặc trưng động lực của hoàn lưu khí quyển và thông qua các tương tác với bề mặt đất và đại dương. Những dạng hình thế như vậy được gọi là những chế độ, dạng, hoặc liên kết xa. Ví dụ như dao động Bắc Đại Tây Dương (NAO), hình thế Bắc Mỹ -Thái Bình Dương (PNA), dao động nam El Nino (ENSO), kiểu dao động hình khuyên phía Bắc (NAM; trước đây gọi là dao động Bắc Cực, AO) và kiểu dao động hình khuyên phía Nam (SAM; trước đây gọi là dao động Nam Cực, AAO).
Monsoon	Gió mùa	A monsoon is a tropical and subtropical seasonal reversal in both the surface winds and associated precipitation, caused by differential heating between a continental-scale land mass and the adjacent ocean. Monsoon rains occur mainly over land in summer.	Gió mùa là một loại gió đổi hướng theo mùa tại các khu vực nhiệt đới và cận nhiệt đới tại bề mặt và lượng mưa liên quan do sự khác biệt về quy mô lục địa và đại dương liền kề. Mưa do gió mùa thường xảy ra trên đất liền vào mùa hè

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
National disaster risk management systems (or structures)	Hệ thống (hoặc cơ cấu) quản lý rủi ro thiên tai quốc gia	Synergy, collaboration, coordination, and development of multidisciplinary and multi-agency schemes are increasingly seen as positive attributes for guaranteeing implementation of disaster risk reduction and disaster risk management in a sustainable development framework. The notion of national disaster risk management systems (or structures) is discussed in detail in Chapter 6. (IPCC, 2012 page 36)	Sự hợp lực, hợp tác, phối hợp và phát triển các chương trình đa lĩnh vực và đa ngành đang ngày càng được xem như là mô hình tích cực để bảo đảm thực hiện giảm nhẹ rủi ro thiên tai và quản lý rủi ro thiên tai trong khuôn khổ phát triển bền vững. Khái niệm về hệ thống (hoặc cơ cấu) quản lý rủi ro thiên tai quốc gia sẽ được thảo luận chi tiết trong Chương 6. (báo cáo IPCC, 2012 trang 36)
National systems for managing the risks from climate extremes and disasters	Hệ thống quốc gia quản lý rủi ro thiên tai và cực đoan khí hậu	National systems for managing the risks from climate extremes and disasters are the core of the country which comprise multiple actors from national and sub-national governments, private sector, research bodies, and civil society, including community-based organizations, playing differential but complementary roles to manage risk according to their accepted functions and capacities in order to meet the challenges of observed and projected trends in exposure, vulnerability, disasters and climate extremes (SREX, page 341)	Hệ thống quốc gia quản lý rủi ro thiên tai và cực đoan khí hậu là hệ thống bao gồm các chủ thể từ quốc gia, vùng, cơ quan chính phủ, khối tư nhân, các nhà nghiên cứu, các tổ chức xã hội các tổ chức cộng đồng có vai trò khác nhau nhưng bổ sung cho nhau để quản lý các rủi ro phù hợp với năng lực và vai trò được giao của họ nhằm đáp ứng những thách thức hiện tại và tương lai của xu hướng tăng lên của mức độ phơi nhiễm, tình trạng dễ bị tổn thương, thiên tai và cực đoan khí hậu (SREX, trang 341)
Nonlinearity	Phi tuyến tính	A process is called nonlinear when there is no simple proportional relation between cause and effect. The climate system contains many such nonlinear processes, resulting in a system with a potentially very complex behavior. Such complexity may lead to abrupt climate change. See also Predictability.	Một quá trình được gọi là phi tuyến khi không có mối quan hệ tỷ lệ thuận đơn giản giữa nguyên nhân và hậu quả. Hệ thống khí hậu có nhiều quá trình phi tuyến như vậy, kết quả trong một hệ thống với một tính chất có tính rất phức tạp. Tính phức tạp như vậy có thể dẫn đến biến đổi khí hậu đột ngột. Xem thêm Dự báo được
North Atlantic Oscillation	Dao động bắc đại tây dương	The North Atlantic Oscillation consists of opposing variations in barometric pressure near Iceland and near the Azores. It therefore corresponds to	Dao động Bắc Đại Tây Dương bao gồm dao động tương phản trong áp suất khí quyển gần Iceland và gần Azores. Do đó nó tương ứng với biến động về sức gió chính tây

Terms		Definitions	
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(NAO)		fluctuations in the strength of the main westerly winds across the Atlantic into Europe, and thus to fluctuations in the embedded cyclones with their associated frontal systems.	qua Đại Tây Dương đến châu Âu, và đến biến động các cơn bão kết hợp với các hệ thống front liên quan của chúng.
Northern Annular Mode (NAM)	Dao động hình khuyên phía bắc	A winter fluctuation in the amplitude of a pattern characterized by low surface pressure in the Arctic and strong mid-latitude westerlies. NAM has links with the northern polar vortex into the stratosphere. Its pattern has a bias to the North Atlantic and has a large correlation with the North Atlantic Oscillation.	Một biến động mùa đông trong biên độ của một hình thế đặc trưng bởi khí áp bề mặt thấp ở Bắc Cực và dòng chính tây vĩ độ trung bình. NAM đã liên kết với những xoáy cực bắc vào tầng bình lưu. Hình thế của nó thiên về phía Bắc Đại Tây Dương và có một sự tương quan lớn với Dao động Bắc Đại Tây Dương.
Pacific Decadal Oscillation (PDO)	Dao động thập kỷ Thái bình dương	The pattern and time series of the first empirical orthogonal function of sea surface temperature over the North Pacific north of 20°N. PDO broadened to cover the whole Pacific Basin is known as the Inter-decadal Pacific Oscillation (IPO). The PDO and IPO exhibit virtually identical temporal evolution.	Hình thê và chuỗi thời gian các chức năng trực giao thực nghiệm đầu tiên của nhiệt độ bề mặt nước biển trên Bắc Thái Bình Dương về phía bắc 20 ° N. PDO mở rộng để bao gồm toàn bộ lưu vực Thái Bình Dương được biết đến như thập kỷ Dao động nội-Thái Bình Dương (IPO). PDO và IPO tiến hóa theo thời gian hầu như giống hệt nhau.
Parameterization	thông số hóa	In climate models, this term refers to the technique of representing processes that cannot be explicitly resolved at the spatial or temporal resolution of the model (sub-grid scale processes) by relationships between model-resolved larger-scale flow and the area- or time-averaged effect of such sub-grid scale processes.	Trong mô hình khí hậu, thuật ngữ này đề cập đến các kỹ thuật đại diện cho quá trình không thể được giải quyết một cách rõ ràng ở độ phân giải không gian hoặc thời gian của mô hình (các quá trình quy mô tiểu lưới) bởi mối quan hệ giữa mô hình liên quan quy mô lớn hơn và ảnh hưởng của các quá trình khu vực - hoặc trung bình thời gian của quy mô lưới nhỏ.
Percentile	Phân vị	A percentile is a value on a scale of 100 that indicates the percentage of the data set values that is equal to or below it. The percentile is often used to estimate the extremes of a distribution. For example, the 90th (10th) percentile may be used to refer to the threshold	Phân vị là một giá trị trên thang 100 cho biết tỷ lệ phần trăm của giá trị dữ liệu đó bằng hoặc thấp hơn nó. Phân vị thường được sử dụng để ước lượng cực trị của một phân bố. Ví dụ, phân vị thứ 90 (thứ 10) có thể sử dụng để nói tới ngưỡng cực trị trên (dưới).

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
		for the upper (lower) extremes.	
Permafrost	Đóng băng vĩnh cửu	Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least 2 consecutive years.	Mặt đất (đất hoặc đá và bao gồm đá và vật liệu hữu cơ) còn lại bằng hoặc thấp hơn 0°C trong ít nhất 2 năm liên tiếp
Predictability	Dự báo được	The extent to which future states of a system may be predicted based on knowledge of current and past states of the system.	Quy mô mà trạng thái tương lai của một hệ thống có thể được dự báo dựa vào sự hiểu biết về trạng thái hiện tại và quá khứ của hệ thống đó.
Probability density function (PDF)	Hàm mật độ xác suất	A probability density function is a function that indicates the relative chances of occurrence of different outcomes of a variable. The function integrates to unity over the domain for which it is defined and has the property that the integral over a sub-domain equals the probability that the outcome of the variable lies within that sub-domain. For example, the probability that a temperature anomaly defined in a particular way is greater than zero is obtained from its PDF by integrating the PDF over all possible temperature anomalies greater than zero. Probability density functions that describe two or more variables simultaneously are similarly defined.	Là một hàm chỉ ra cơ hội tương đối cho sự xuất hiện các kết quả khác nhau của một biến. Tích phân của hàm bằng 1 trên toàn miền tính. Hàm được định nghĩa và có tính chất là tích phân trên một miền tính con bằng với xác suất của giá trị của biến nằm bên trong miền tính con đó. Ví dụ, xác suất mà dị thường nhiệt độ được định nghĩa theo cách nào đó là lớn hơn 0 nhận được từ hàm mật độ xác suất của nó bằng cách tích phân hàm mật độ xác suất trên tất cả các giá trị dị thường nhiệt độ lớn hơn 0. Các hàm mật độ xác suất mô tả 2 hoặc nhiều biến hơn cũng được định nghĩa tương tự
Projection	Dự tính	A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty. See also Climate	Là diễn tiến tiềm tàng trong tương lai của một đại lượng hoặc tập hợp của các đại lượng, thường được tính toán với sự hỗ trợ của mô hình. Các dự tính được phân biên với các dự báo để nhấn mạnh rằng các dự tính phụ thuộc vào các giả thiết, ví dụ, sự phát triển trong tương lai của kinh tế xã hội và công nghệ có thể hoặc chưa chắc đã xảy ra, và do đó dẫn đến những bất định trong kết quả tính toán. Xem them Dự tính khí hậu, dự báo khí hậu. Xem thêm Dự tính

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
		projection.	khí hậu.
Proxy climate indicator	Phương pháp đại diện khí hậu	A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies include pollen analysis, tree ring records, characteristics of corals, and various data derived from ice cores. The term 'proxy' can also be used to refer to indirect estimates of present-day conditions, for example, in the absence of observations.	Phương pháp đại diện khí hậu là sự diễn giải các thông tin địa phương bằng cách sử dụng các nguyên lý vật lý và lý sinh, nhằm biểu diễn một sự kết hợp nào đó của các biến thiên liên quan đến khí hậu trong quá khứ. Dữ liệu liên quan đến khí hậu thu được theo cách này gọi là dữ liệu đại diện. Ví dụ của phương pháp đại diện bao gồm sự phân tích phấn hoa, vòng năm của cây, đặc điểm san hô và các dữ liệu khác thu được từ lõi băng
Radiative forcing	Tác động bức xạ	Radiative forcing is the change in the net, downward minus upward, irradiance (expressed in W m–2) at the tropopause due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun. Radiative forcing is computed with all tropospheric properties held fixed at their unperturbed values, and after allowing for stratospheric temperatures, if perturbed, to readjust to radiative-dynamical equilibrium. Radiative forcing is called instantaneous if no change in stratospheric temperature is accounted for. For the purposes of this report, radiative forcing is further defined as the change relative to the year 1750 and, unless otherwise noted, refers to a global and annual average value. Radiative forcing is not to be confused with cloud radiative forcing, a similar terminology for describing an unrelated measure of the impact of clouds on the irradiance at the top of the atmosphere.	Tác động bức xạ là sự thay đổi trong bức xạ thuần của trái đất (tính bằng W m–2), bằng bức xạ đi xuống trừ bức xạ đi lên tại đối lưu hạn do sự thay đổi trong một nhân tố tác động bên ngoài của BĐKH, ví dụ như sự thay đổi nồng độ CO2 hoặc bức xạ mặt trời. Tác động bức xạ được tính toán với tất cả các thuộc tính tầng đối lưu được cố định tại các giá trị không xáo trộn, và cho phép nhiệt độ tầng bình lưu, nếu như có xáo trộn, điều chỉnh về trạng thái cân bằng bức xạ - động lực. Tác động bức xạ được coi là tức thời nếu không tính đến sự thay đổi về nhiệt độ tầng bình lưu. Nhằm phục vụ mục đích của báo cáo đánh giá của IPCC, tác động bức xạ tiếp tục được định nghĩa là sự thay đổi giá trị trung bình toàn cầu và hàng năm so với năm 1750 (trừ khi có ghi chú khác). Không nên nhầm lẫn giữa tác động bức xạ với tác động bức xạ của mây, một thuật ngữ dùng để mô tả thước đo về tác động của các đám mây đối với bức xạ ở đỉnh bầu khí quyển.

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Reanalysis	Tái phân tích	Reanalyses are atmospheric and oceanic analyses of temperature, wind, current, and other meteorological and oceanographic quantities, created by processing past meteorological and oceanographic data using fixed state-of-the-art weather forecasting models and data assimilation techniques. Using fixed data assimilation avoids effects from the changing analysis system that occur in operational analyses. Although continuity is improved, global reanalyses still suffer from changing coverage and biases in the observing systems.	Số liệu tái phân tích là các số liệu phân tích của khí quyển và đại dương, gồm có nhiệt độ, gió, các dòng và các đại lượng khí tượng và hải dương học khác, được tạo ra bằng cách xử lý số liệu khí tượng và đại dương trong quá khứ sử dụng các mô hình dự báo thời tiết hiện đại và kỹ thuật đồng hóa số liệu. Sử dụng đồng hóa số liệu tránh được ảnh hưởng từ sự thay đổi hệ thống phân tích xảy ra trong các phân tích nghiệp vụ. Mặc dù liên tục được cải thiện nhưng số liệu tái phân tích toàn cầu vẫn đang chịu sự thay đổi về độ bao phủ và những sai số hệ thống trong các hệ thống quan trắc.
Relative sea level		See Mean sea level.	Xem Mực nước biển trung bình
Resilience	Khả năng chống chịu	Resilience is defined as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions. (IPCC, 2012 page 34)	Khả năng chống chịu được định nghĩa là khả năng của một hệ thống và các hợp phần của nó có thể phán đoán, hấp thụ, điều chỉnh và vượt qua những ảnh hưởng của một hiện tượng nguy hiểm một cách kịp thời và hiệu quả kể cả khả năng giữ gìn, hồi phục và tăng cường các cấu trúc và chức năng cơ bản quan trọng của hệ thống đó. (báo cáo IPCC, 2012 trang 34)
Resistance	Khả năng kháng cự	Resistance refers to the ability to avoid suffering significant adverse effects. (IPCC, 2012 page 38)	Khả năng chống chịu là khả năng để tránh bị những ảnh hưởng bất lợi lớn. (báo cáo IPCC, 2012 trang 38)
Return period	Chu kỳ lặp lại	An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity.	Khoảng thời gian trung bình giữa các lần xuất hiện một hiện tượng (ví dụ như lũ lụt hoặc mưa lớn) với cường độ và phạm vi xác định

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Return value	giá trị lặp lại	The highest (or, alternatively, lowest) value of a given variable, on average occurring once in a given period of time (e.g., in 10 years).	Giá trị cao nhất (hoặc thấp nhất) của một biến nhất định, trung bình xảy ra một lần trong một thời gian nhất định (ví dụ, trong 10 năm).
Risk transfer	Chia sẻ rủi ro	Risk transfer refers to the process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise, or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party. (IPCC, 2012 page 35)	Chia sẻ rủi ro liên quan đến các quá trình chia sẻ chính thức hoặc không chính thức những hậu quả tài chính của những rủi ro cụ thể từ một bên này sang một bên khác, nhờ đó một hộ gia đình, cộng đồng, doanh nghiệp, hay chính phủ sẽ có được các nguồn lực từ các bên khác sau khi thiên tai xảy ra, để phân chia những lợi ích xã hội hay tài chính hiện tại hoặc được đền bù từ các bên khác. (báo cáo IPCC, 2012 trang 35)
Runoff	Dòng chảy mặt	That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water. See Hydrological cycle.	Đó là một phần của lượng mưa không bay hơi và không bị thẩm thấu, nhưng chảy qua mặt đất hoặc trên mặt đất đến khu trữ nước. Xem thêm Chu kỳ thủy văn
Scenario	Kịch bản	A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline. See also Climate scenario and Emissions scenario.	Một mô tả hợp lý và đơn giản về việc tương lai có thể phát triển như thế nào, dựa trên một tập hợp chặt chẽ và nhất quán của các giả thuyết về các nhân tố điều khiển cùng với các mối quan hệ quan trọng. Các kịch bản có thể bắt nguồn từ những dự tính, nhưng thường được dựa trên các thông tin bổ sung từ nhiều nguồn, đôi khi còn được kết hợp với một cốt truyện có tình tiết. Xem thêm Kịch bản khí hậu và Kịch bản phát thải
Sea level change	Biến đổi mực nước biển	Changes in sea level, globally or locally, due to (i) changes in the shape of the ocean basins, (ii) changes in the total mass and distribution of water and land ice, (iii) changes in water density, and (iv) changes in ocean circulation. Sea level changes	Mực nước biển có thể thay đổi, ở cả quy mô toàn cầu lẫn khu vực, nguyên nhân do (i) sự thay đổi hình dạng đại dương, (ii) sự thay đổi tổng lượng nước và (iii) sự thay đổi mật độ nước biển. Biến đổi mực nước biển do sự thay đổi mật độ nước được gọi là giãn nở nhiệt - muối. Sự thay đổi

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
		induced by changes in water density are called steric. Density changes induced by temperature changes only are called thermosteric, while density changes induced by salinity changes are called halosteric. See also Mean sea level.	mật độ, nếu do sự thay đổi nhiệt độ thì gọi là giãn nở nhiệt, trong khi sự thay đổi mật độ do thay đổi nồng độ muối gọi là giãn nở muối. Xem thêm Mực nước biển trung bình
Sea surface temperature (SST)	Nhiệt độ mặt nước biển	The sea surface temperature is the temperature of the subsurface bulk temperature in the top few meters of the ocean, measured by ships, buoys, and drifters. From ships, measurements of water samples in buckets were mostly switched in the 1940s to samples from engine intake water. Satellite measurements of skin temperature (uppermost layer; a fraction of a millimeter thick) in the infrared or the top centimeter or so in the microwave are also used, but must be adjusted to be compatible with the bulk temperature.	Nhiệt độ mặt nước biển là nhiệt độ của lớp nước xáo trộn trong khoảng vài mét trên cùng của đại dương, được đo bằng tàu, phao tiêu và thuyền cá. Trên các tàu, các phép đo mẫu nước được lấy lên bằng xô đa số được chuyển đổi trong những năm 1940 để có thể đo từ dụng cụ đặt trực tiếp trong nước. Nhiệt độ lớp màng (lớp trên cùng) đo từ vệ tinh bằng hồng ngoại (cho lớp dày cỡ một phần của 1 mm) hoặc bằng sóng siêu cao tần (cho lớp dày vài cm) , cũng được sử dụng, tuy nhiên phải hiệu chỉnh để tương thích với nhiệt độ lớp nước xáo trộn
Sensible heat flux	Thông lượng hiển nhiệt	The flux of heat from the Earth's surface to the atmosphere that is not associated with phase changes of water; a component of the surface energy budget.	Thông lượng hiển nhiệt là thông lượng nhiệt từ bề mặt trái đất đến khí quyển không liên quan đến những thay đổi pha của nước; là một thành phần của quỹ năng lượng bề mặt.
Sensitivity	Mức độ nhạy cảm	Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damage caused by an increase in the frequency of coastal flooding due to sea level rise) (AR5; IPCC, 2014)	Mức độ nhạy cảm là mức độ một hệ thống bị ảnh hưởng tiêu cực hoặc tích cực do biến đổi hoặc dao động khí hậu. Ảnh hưởng có thể trực tiếp (ví dụ như sự thay đổi sản lượng cây trồng trong việc đáp lại dao động của nhiệt độ) hoặc tác động gián tiếp (ví dụ như thiệt hại gây ra bởi sự gia tăng tần suất lũ lụt ven biển do mực nước biển dâng). (IPCC, 2014)

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Significant wave height	Chiều cao sóng đại diện	The average height of the highest one-third of the wave heights (trough to peak) from sea and swell occurring in a particular time period.	Chiều cao trung bình của một phần ba chiều cao lớn nhất của sóng (từ chân đếnđỉnh) từ biển lặng và động trong một thời gian xác định
Soil moisture	Độ ẩmđất	Water stored in or at the land surface and available for evapotranspiration.	Lượng nước lưu trữ ở trong hoặc tại bề mặt đất và có thể bốc hơi.
Southern Annular Mode (SAM)	Dao động hình khuyên phia Nam	The fluctuation of a pattern like the Northern Annular Mode, but in the Southern Hemisphere.	Dao động giống như dao động hình khuyên phía Bắc (NAM;nhưng ở nam bán cầu),
SRES scenarios	Các kịch bản SRES	See Emissions scenario.	Các kịch bản SRES là các kịch bản phát thải được phát triển bởi Nakićenović và Swart (2000) và được sử dụng, bên cạnh các kịch bản khác, như là cơ sở cho một số dự tính khí hậu được trình bày trong chương 10 của báo cáo đánh giá lần thứ 4 của IPCC. Xem thêm Kịch bản phát thải
Storm surge		The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.	Sự gia tăng nhất thời, tại một địa phương cụ thể, với độ cao của biển do điều kiện khí tượng cực đoan (áp suất khí quyển thấp và / hoặc gió mạnh). Các cơn bão được xác định như là sự dư thừa trên mức mong đợi từ sự thay đổi thủy triều đơn lẻ vào thời gian và địa điểm nhất định.
Storm tracks	Quỹ đạo bão	Originally, a term referring to the tracks of individual cyclonic weather systems, but now often generalized to refer to the regions where the main tracks of extratropical disturbances occur as sequences of low (cyclonic) and high (anticyclonic) pressure systems.	Ban đầu, đây là một thuật ngữ đề cập đến quỹ đạo của hệ thống thời tiết xoáy thuận riêng lẻ, nhưng bây giờ thường được tổng quát hoá để chỉ các khu vực mà ở đó quỹ đạo chính của các nhiễu động ngoại nhiệt đới xuất hiện như là chuỗi của những hệ thống áp thấp (xoáy thuận) và hệ thống áp cao (xoáy nghịch).

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Streamflow	Dòng chảy	Water flow within a river channel, for example, expressed in $m^3 s^{-1}$. A synonym for river discharge.	Dòng nước trong sông, ví dụ dòng chảy bằng $m^3 s^{-1}$. Đồng nghĩa với lưu lượng sông (tại mặt cắt)
Surface temperature		See Global surface temperature, Land surface air temperature, and Sea surface temperature.	Xem: Nhiệt độ bề mặt toàn cầu, nhiệt độ không khí mặt đất, nhiệt độ bề mặt nước biển
Sustainable development	Phát triển bền vững	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.	Phát triển đáp ứng các nhu cầu của hiện tại mà không ảnh hưởng đến khả năng của các thế hệ tương lai để đáp ứng nhu cầu của họ.
Transpiration	Thoát hơi	The evaporation of water vapor from the surfaces of leaves through stomata.	Thoát hơi nước từ bề mặt lá qua khí khổng
Transformati on	Đổi mới	The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems).	Các thay đổi của các thuộc tính cơ bản của một hệ thống (bao gồm cả hệ thống giá trị, chế độ quy định, lập pháp, hoặc hành chính; tổ chức tài chính và các hệ thống công nghệ, sinh học).
Tropical cyclone	Xoáy thuận nhiệt đới	The general term for a strong, cyclonic-scale disturbance that originates over tropical oceans. Distinguished from weaker systems (often named tropical disturbances or depressions) by exceeding a threshold wind speed. A tropical storm is a tropical cyclone with one-minute average surface winds between 18 and 32 $m s^{-1}$. Beyond 32 $m s^{-1}$, a tropical cyclone is called a hurricane, typhoon, or cyclone, depending on geographic location.	Thuật ngữ chung cho một vùng xáo trộn quy mô bắt nguồn trên vùng biển nhiệt đới. Phân biệt với hệ thống yếu hơn (thường được đặt tên nhiễu động nhiệt đới hoặc áp thấp) bởi quá một ngưỡng tốc độ gió. Một cơn bão nhiệt đới là một áp thấp nhiệt đới với sức gió bề mặt trung bình một phút từ 18 đến 32 $m s^{-1}$. Ngoài 32 $m s^{-1}$, một xoáy thuận nhiệt đới được gọi là một cơn bão, cuồng phong, lốc xoáy, tùy thuộc vào vị trí địa lý.
Uncertainty	Tính bất định	An expression of the degree to which a value or relationship is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. Uncertainty may	Biểu hiện mức độ không được biết một cách rõ ràng của một giá trị (ví dụ như trạng thái của hệ thống khí hậu trong tương lai). Tính bất định có thể là kết quả của sự thiếu thông tin hoặc từ sự không thống nhất về những gì được

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
		originate from many sources, such as quantifiable errors in the data, ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgment of a team of experts. See also Likelihood and Confidence.	biết hoặc thậm chí có thể biết được. Điều đó xảy ra do nhiều nguyên nhân, từ các lỗi định lượng trong dữ liệu đến sự không rõ ràng trong các khái niệm hoặc thuật ngữ, hoặc do tính bất định trong dự tính các hoạt động của con người. Do đó, tính bất định có thể được biểu diễn bằng các biện pháp định lượng, ví dụ như khoảng giá trị được tính bởi nhiều mô hình khác nhau; hoặc các trình bày định tính, ví dụ như phản ánh cách nhìn nhận của một nhóm các chuyên gia. Xem thêm Vòng đời và Mức độ tin cậy
Urban heat island	Đảo nhiệt các đô thị	The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on.	Sự ấm lên tương đối của một thành phố so khu vực nông thôn xung quanh, kết hợp với những thay đổi trong dòng chảy, ảnh hưởng khu bê tông trên giữ nhiệt, những thay đổi trong suất phản chiếu bề mặt, những thay đổi trong ô nhiễm và sol khí, và v.v...
Vulnerability	Tính dễ bị tổn thương	Vulnerability refers to the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events. (IPCC, 2012 page 69) Vulnerability is the propensity or predisposition to be adversely affected. Such predisposition constitutes an internal characteristic of the affected element. In the field of disaster risk, this includes the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events (Wisner et al., 2004). Vulnerability is a result of diverse historical, social, economic, political, cultural, institutional, natural resource, and environmental conditions and processes. (IPCC, 2012 page 31)	Tính dễ bị tổn thương đề cập đến khuynh hướng của các yếu tố nhạy cảm với hiểm họa như con người, cuộc sống của họ, và tài sản bị ảnh hưởng bất lợi khi bị tác động bởi các hiểm họa (báo cáo IPCC, 2012 trang 69). Tính dễ bị tổn thương là xu hướng hay khuynh hướng bị ảnh hưởng xấu. Khuynh hướng này cấu thành một đặc tính nội bộ của các yếu tố ảnh hưởng. Trong lĩnh vực rủi ro thiên tai, điều này bao gồm các đặc tính của một người hoặc một nhóm và tình hình của họ có ảnh hưởng đến khả năng của họ để dự đoán, đối phó với, chống lại, và phục hồi từ các tác động có hại của hiện tượng vật lý (Wisner et al., 2004). Tính dễ bị tổn thương là kết quả của nguồn tài lực xã hội, điều kiện lịch sử, kinh tế, chính trị, văn hóa, thể chế, tài nguyên thiên nhiên và điều kiện môi trường và các quy trình. (IPCC, 2012 trang 31)

Terms		Definitions	
English	**Vietnamese**	**English**	**Vietnamese**
Warm days/ warm nights	Ngày nóng/ đêm nóng	Days where maximum temperature, or nights where minimum temperature, exceeds the 90th percentile, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period.	Những ngày khi nhiệt độ tối cao, hoặc đêm có nhiệt độ tối thấp vượt quá ngưỡng 90 phần trăm của sự phân bố dãy số liệu nhiệt độ nhiều năm thường là 1961-1990
Warm spell	Đợt nóng	A period of abnormally warm weather. Heat waves and warm spells have various and in some cases overlapping definitions. See also Heat wave	Là thời kỳ có thòi tiết nóng bất thường. Sóng nhiệt và các đợt nóng là khác nhau và trong một vài trường hợp được hiểu là một. Xem thêm sóng nhiệt

ANNEX 2: ACRONYMS

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ASEAN	Association of Southeast Asian Nations
CCFSC	Central Committee for Flood and Storm Control,
CCWG	Climate Change Working Group
CIDA	Canadian International Development Agency
DARD	Ministry of Agriculture and Rural Development
DMC	Disaster Management Centre
DMWG	Disaster Management Working Group
DOET	Provincial Department of Education and Training
DONRE	Provincial Department of Natural Resources and Environment
DOST	Provincial Department of Science and Technology
DPI	Provincial Department of Planning and Investment
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
GCF	Green Climate Fund
GEF	Global Environment Facility
GFSC	Global Framework for Climate Services
GNDR	Global Network of Civil Society Organisations for Disaster Reduction
HFA	Hyogo Framework for Action
IMHEN	Institute of Meteorology, Hydrology and Environment
INDCs	Intended nationally determined contribution
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
JICA	Japan International Cooperation Agency
K.Eximbank	Export-Import Bank of Korea
KP	Kyoto Protocol
LDCs	Các nước kém phát triển nhất

MARD	Ministry of Agriculture and Rural Development
MOET	Ministry of Education and Training
MOHA	Ministry of Home Affairs
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
MPI	Ministry of Planning and Investment
MRC	Mekong River Commission
NWP	Nairobi work programme
NCHMF	National Center for Hydro-meteorological Forecasting
NGOs	Non-government organizations
SP-RCC	Support Programme to Respond to Climate Change in Vietnam
UNSDR	United Nations. International Strategy for Disaster Reduction
VCCI	Vietnam Chamber of Commerce and Industry
WRD	Water Resources Directorate

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