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

Summary for Policymakers

January 2015

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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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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).

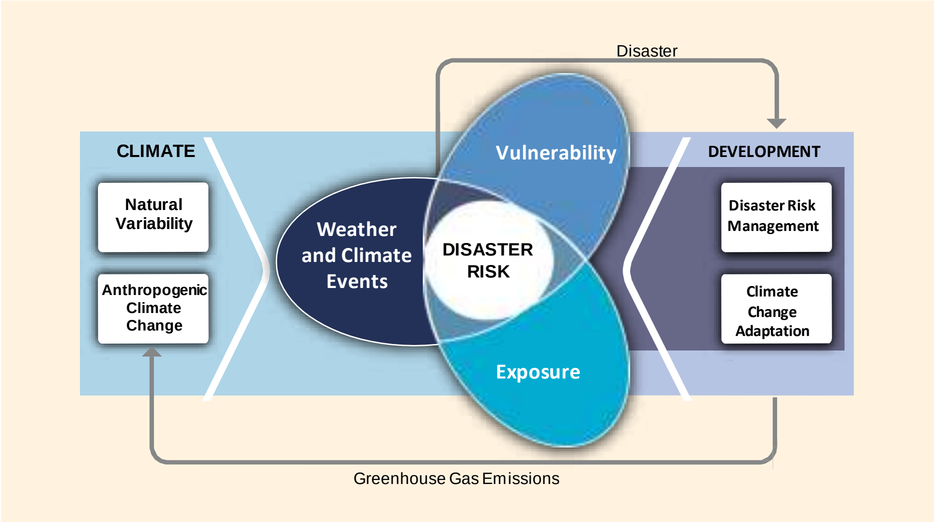
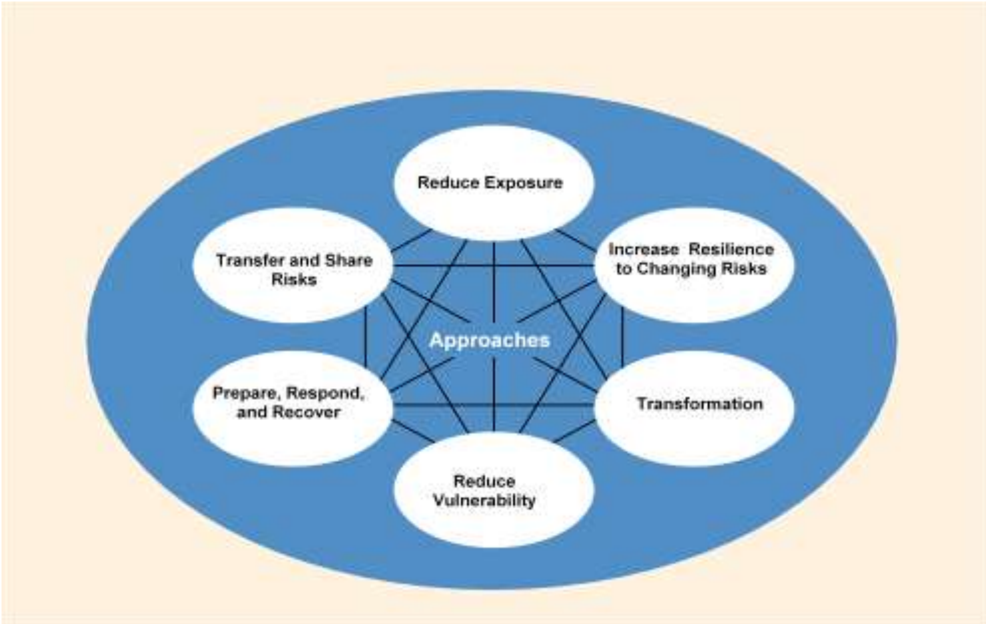


Figure SPM-2. Adaptation and Disaster Risk Management Approaches for reducing and managing disaster risk in a changing climate



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 ...), forest fires (Northwest, Central Highlands, the South West ...) greatly harming many social-economic sectors, especially for agriculture and therefore these regions are also vulnerable. The Mekong Delta region is under a "double" threat because it is affected by climate change as well as upstream river dams. In the future, in the dry season the salt water intrusion into the Mekong Delta as a result of sea level rise will be exacerbated. (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 only the effect of anthropogenic climate change, because these events can 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, 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)

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)

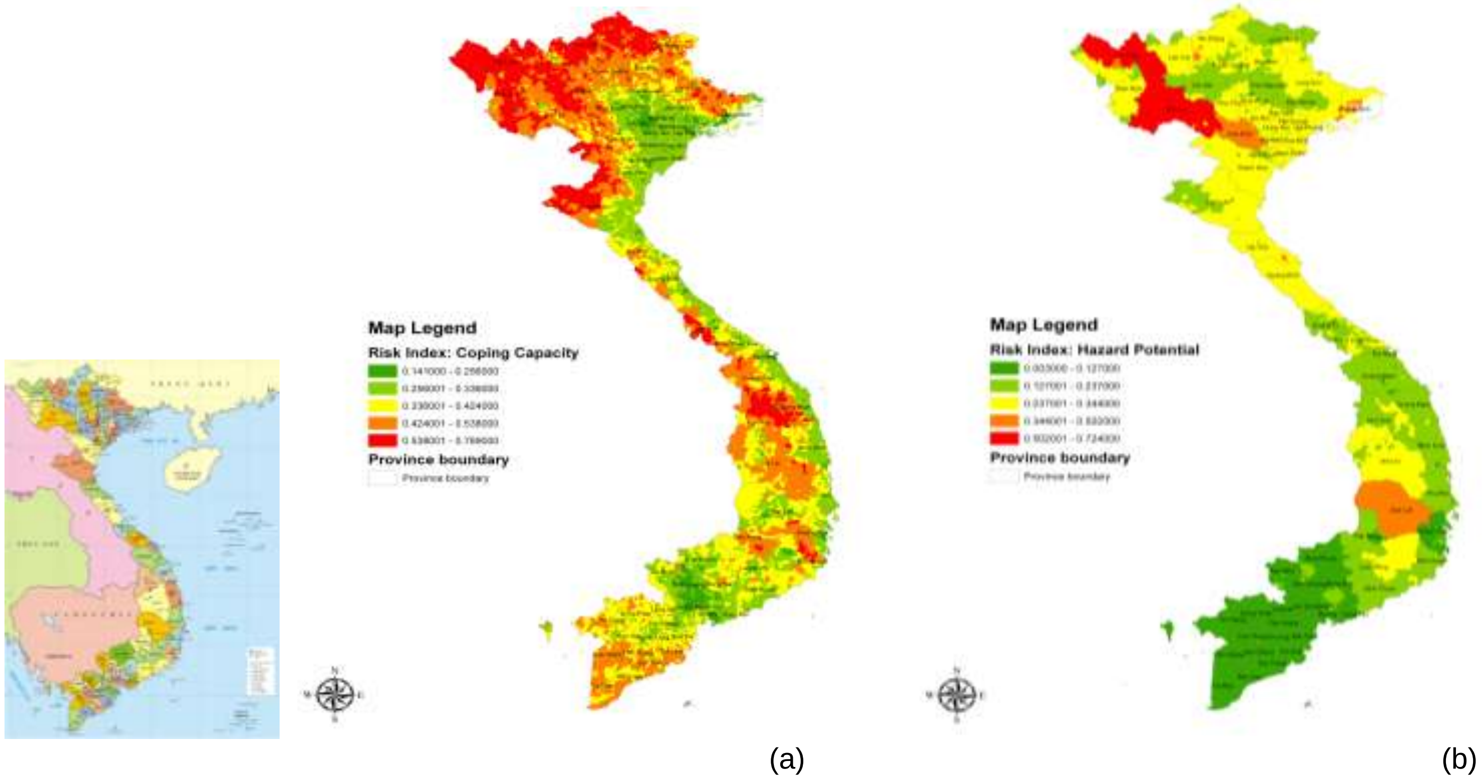
Settlement patterns, urbanization, and changes in socioeconomic conditions have all influenced observed trends in exposure and vulnerability to climate extremes. For example, coastal settlements, including the central coast region, the Mekong Delta and settlements in the Northern Mountains and Central 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.

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



There is evidence from observations gathered 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 further 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 has decreased rapidly in the last decade. The number of **hot days** increased in most observation stations, especially in the North-East, Northern Delta, and the Central Highlands, but decrease was observed in some stations in the North-West, South Central and the Southern regions. (Chapter 3, Section 3.3.1)

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 future 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 penetrates 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 21^{st} 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)

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 some downstream of the Red River and Thai Binh River, where decreases are 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 downstream 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 currently 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 are growing, coastal tourism and industrial zones, transport infrastructure and aquaculture are growing in zones where those 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 whereas 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 the 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 may be moved again because the new place does 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 DRM requires integration of DRM and climate change adaptation into national social-economic development strategies and plans, as well as sectoral plans and put strategies and plans into action for 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 risks and 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 disaster risk management 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 water enters the Mekong Delta is often affected by floods and 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 also 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. Socioeconomic inequalities and for example health-related differences and 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 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 to the temporal and spatial dynamics of exposure and vulnerability is important given 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, but 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, although 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 observed number of hot days and number of heat waves tend to 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; 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-4, SPM-5).

Figure SPM-4. Number of heat waves observed in the country

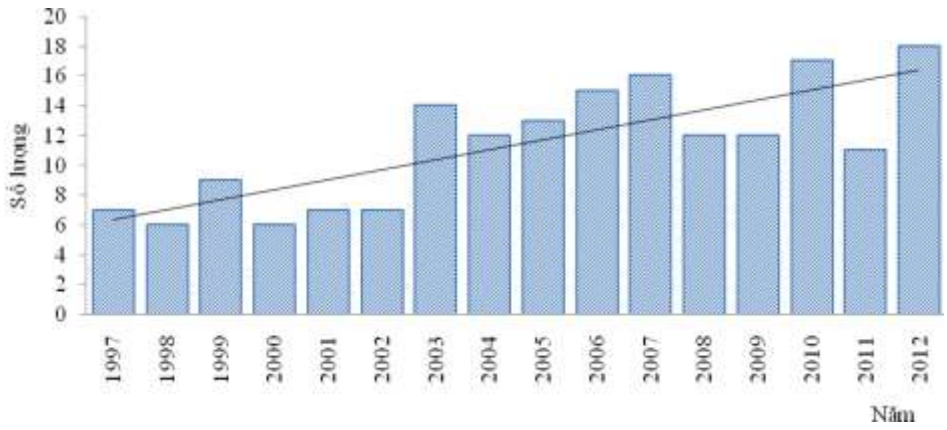
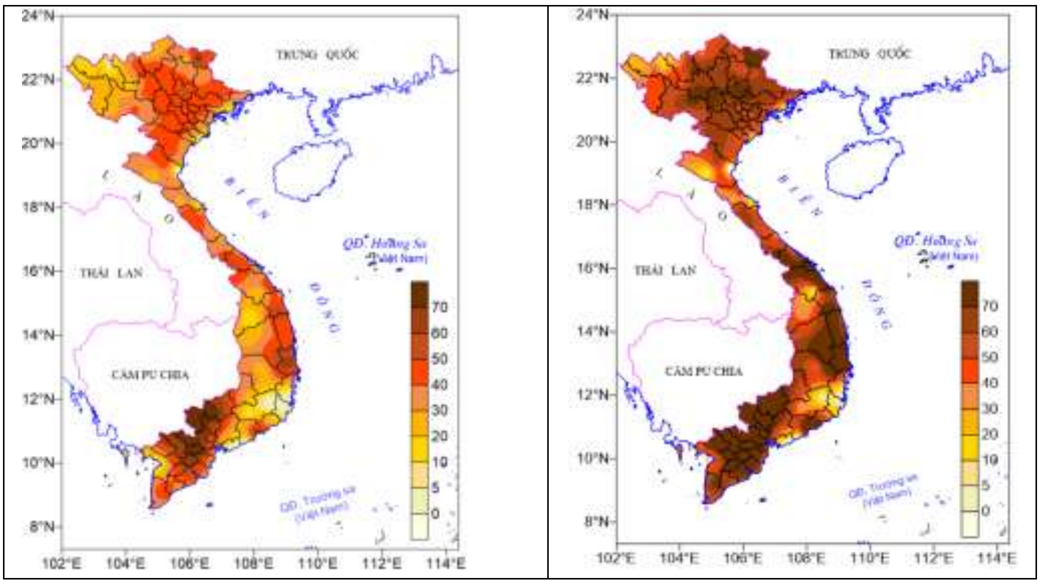


Figure SPM-5. Estimated change in number of hot days by the middle of the 21st century (left) and the end of the 21st century (right) compared to the 1980-1999 average



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 show a rising trend 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, 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).

The expected future change in rainfall and temperature is such that there may be 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 will affect the peak discharge. Floods in the country appear to become increasingly frequent, severe, unusual, and with wider impact, sometimes covering a large area, even a region of the country. (Section 3.5.4)

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

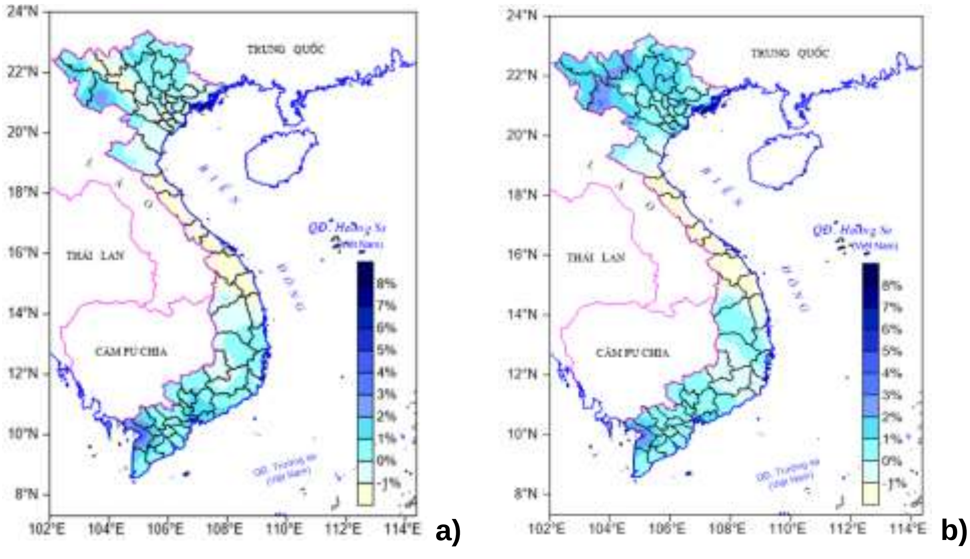
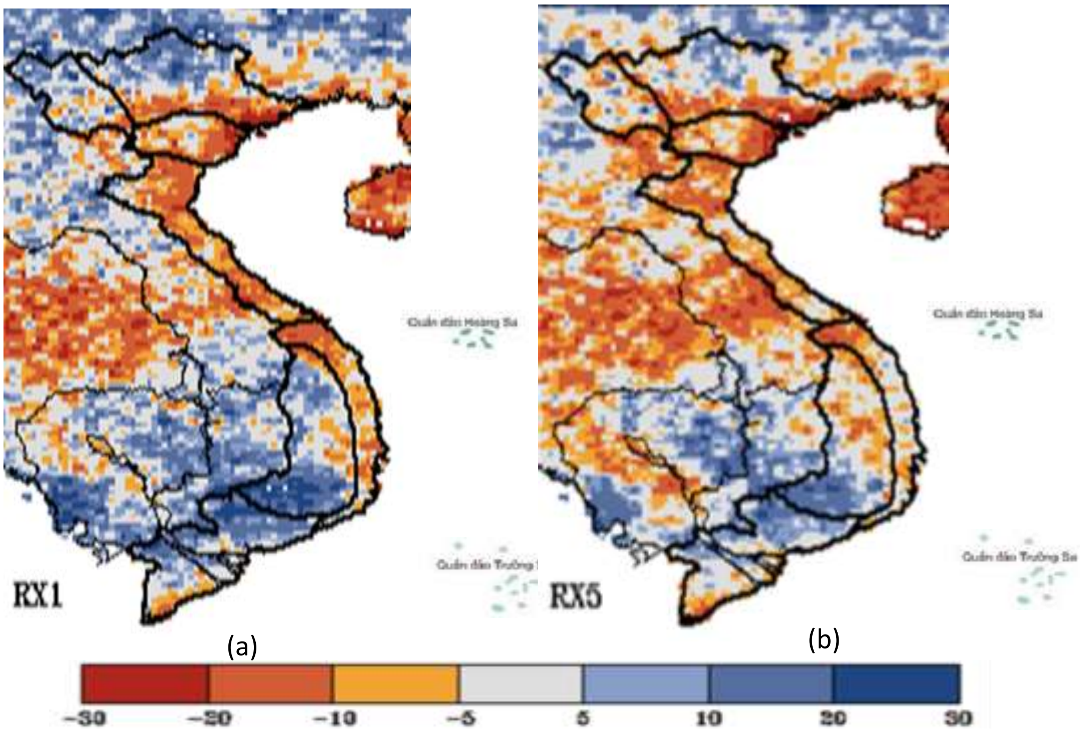


Figure SPM-7. Projected change in (a) one day highest rainfall (RX1), (b) 5 days highest rainfall (RX5), by the end of the 21st century under an high greenhouse gas concentrations scenario - RCP 8.5 (%)



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 according to 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)

The projected number of typhoons in the East sea that affect Vietnam in the mid and late 21st century shows no clear trend and is uncertain. The frequency of storms could reduce but intensity could increase. **The number of strong tropical storms is likely to increase.** The typhoon season is expected to end later and the path 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 type of anomalies of ocean surface temperatures in the equatorial central Pacific region are likely to increase (Section 3.4.3).

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 spell including a record cold spell has appeared with fairly low temperatures. Ice and snow occurred with greater frequency in the higher mountains in the North such as Sa Pa, Mau Son .... Data trends from 1981 to 2009 showed that frost appears later and ends earlier; the trend in the number of frost days is to decrease and decrease rapidly in recent decades (Section 3.5.5).

It is very likely that the 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 the maximum wind speed of tropical storms, 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 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 5, 6, 8)

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)

Although receiving the support from international and regional mechanisms and policies, the implementation of DRM and adaptation to climate change in the world and in Viet Nam are also barriers as well as opportunities for 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, in order to make suitable policies and integrate them into strategies, planning and development plans is critical. DRM is coordinated in Viet Nam by the Central Committee for Flood and Storm Control, with a permanent agency is the Ministry of Agriculture and Rural Development. Meanwhile, the agency and the focal point for responses to climate change was handed by the Government to the Ministry of Natural Resources and Environment. In the coming period, the DRM and climate change adaptation policy should be integrated into policies and development 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 in the case of Viet Nam is not benefiting from the larger portion of adaptation funding allocated under the Support Programme to Respond to Climate Change (SPRCC). (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. There is a national Community Based Disaster Risk Management (CBDRM) programme. Community-based adaptation and especially disaster risk management is being supported by NGOs and UN agencies in Viet Nam. Local analysis of responding to the changing climate, particularly extreme climate events, can demonstrate existing capacity within the community and current shortcomings. 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. Effective risk communication builds on exchanging, sharing, and integrating knowledge about climate-related risks among all stakeholder groups. Among individual stakeholders and groups, perceptions of risk are driven by psychological and cultural factors, values, and beliefs. (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 communities, 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 the content of sustainable development**. At the micro level, development projects, poverty reduction, natural resource management and biodiversity conservation should apply 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 were summarized, namely: (1) The strong commitment of the Government to disaster risk reduction and adaptation to climate change; (2) To raise awareness and mobilize community participation in disaster risk reduction and adaptation to climate change; and (3) Combined, to mobilize resources for international cooperation. (Chapter 8; Table SPM-1)

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 different chapters of 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		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
Inundation related to extreme local rainfall	The main cause of flooding in Hanoi is prolonged or heavy local rain on in the wider Hanoi area, or a combination of those, while the drainage system does not meet the requirements for rapid drainage. Research results 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. The highest 5-day precipitation (RX5day) shows that increases can be expected notably in the southern Central Highlands. Estimating future extreme rainfall is very difficult because it depends	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 – Maintenance of drainage system – Improving early warning systems – Local micro-insurance and risk-sharing mechanisms Examples of general adaptation are: – Development of the national economy to become more independent of climate, less reliant on natural resources. – Adaptive management with repetitive learning from the experiences (success and failures). – Continue resettlement programs with a focus on developing livelihoods to not only reduce the level of exposure, but also reduce

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	
		on many different factors and processes; thus the projected results remain uncertain. (Section 3.3.2; Table 3.9 to 3.15).		the vulnerability. (Section 5.6.3, 9.2.4.4)
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 has killed about 300,000 people. The recorded data show that the biggest surge caused by storm DAN in 1989 was 3.6 m. Storm surges appeared 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 through the banks into suburbs, causing widespread flooding. Some flood protection works are not effective.	**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 the East Sea increased by about 4.7 mm / year between 1993 and 2010. The annual highest sea levels include tides, storm surges, high wave 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 in the range of 78 cm to 95 cm, modelled with the high emissions scenario A1FI. Within that, the areas with the highest 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 it cannot adequately assess the impact of changes in storm surges. (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 vulnerabilities and adaptation measures; – Raising community awareness about the dangers; – Improving early warning systems, including an important role for forecasting; improving the local systems for communication, alerting, alarming – Mangrove conservation, restoration, and replanting – Reducing vulnerability to high-risk areas (migration from coastal areas, build storm, 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		Options for risk management and adaptation
		Observed (from 1961) and projected (to 2100) changes	Scale of risk management	
	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 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	The flooding in the Mekong Delta is unique, so although the residential area and the range is very large impact, duration of effect lasts for several months, but the impact is not as fierce floods in Central and the Northern Delta.	Recognizing the problem, we have invested in a basic system with measures to ensure adaptation, actively living with floods, to mitigate losses. The primary motto to prevent flooding in the Mekong Delta is to adapt, prevent and partially limit the impact of flooding through structural and non-structural measures. Overall planning area is necessary. The construction of levees in many cities and towns should consider that changing flood levels throughout the region and the possible increase of flood levels of the area cannot be protected by the current dyke system. (Section 9.2.2.3)

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	
		downward trend. (Section 3.5.3, Figure SPM-7).		
Flash floods in the mountains	Heavy rain causes high intensity flash floods in mountainous provinces in Viet 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. A 8/2012 flash flood event in August 2012, also in Lao Cai killed 11 people and injured 9. (Section 9.2.3, Table 9.3)	**Observed:** Mountainous, sloping terrain is extensive and flash floods are a common and form of natural disaster and is increasingly risky because of heavy rainfall events and land use changes **Projected**: Increased extreme rainfall is increasing the future risk of flash floods. However, there are many ways to reduce vulnerability the degree of exposure to the hazard. (Section 3.3.2)	Flash floods appear in local, 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)	Low-regret options that reduce exposure and vulnerability to flash floods in the mountains, are: – 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 – Mapping the risk of flash floods – Mapping vulnerabilities and adaptation measures; – Link the 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 take the mitigation of climate change into account.	**Observed**: In 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 tropical depressions is increasing,	More than 3,000 km of Viet Nam's coastline is exposed to the risk of typhoons and tropical	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

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	
	Many resettlement areas do not ensure sustainable livelihoods and the living environment is not stable under the impact of natural disasters and therefore may be moved again. For example, in Quy Nhon the 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)	the number of average level typhoons is decreasing, but the very strong typhoons are on the increase. The typhoon season in recent years ends later and the path of the storms is shifting southward. **Projected**: Model results show that, in the mid and late 21st century, the number of typhoons East Sea and impacts on Viet Nam does not show a clear trend and is uncertain. The climate projections suggest a decreasing frequency but increasing 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)	depressions, especially in the central region. All coastal settlements, especially in big cities, need to carefully consider these risks in of socio-economic development planning.	– Improving capacities for forecasting and for operating early warning systems – Local, provincial and national scale risk-pooling – Consider future risks and strengthen the provisions for planning, design and construction of infrastructure, housing and public works 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 include age, health status, level of outdoor activities, and socio-economic factors such as poverty, social isolation, adaptation and urban infrastructure. A typical example is 2 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 Northern Delta and the North Central region temperatures	**Observed:** Studies of recent monitoring 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	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: – Early warning systems that reach particularly vulnerable groups (e.g., the elderly, children, people with chronic illnesses ...) – Mapping vulnerability and adaptation measures – Information supply to the community about the measures to prevent and deal with heat waves – Using social care networks to reach vulnerable groups

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	
	reached up to 40-41 °C, and in some places up to 42 °C. In addition, heat waves and damaging economic and agricultural production. In the Northern region, the heat waves occur in the summer, causing water shortages and affecting life, seriously affecting health and increased energy consumption for pumping for irrigation and cooling. In the South and Central Highlands regions frequent hot, dry periods occur 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)	region. (see Figure SPM-4) **Projected:** The number of hot sunny days (above 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 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; and in the remaining regions the increased will be 2 to 6 events. (Section 3.5.1) (Figure SPM-5)		Specific adjustments in strategies, policies, and measures informed by trends in heat waves include awareness raising of heat waves as a public health concern; 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 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 the drought in 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	**Observed:** Drought appeared more severe in many areas, especially in the 2000-2007 period. **Projected:** Droughts may occur more often and longer in most climatic regions of Viet Nam. Drought is increasing during the 21st century, with an high rate in regions with many droughts such	Winter droughts occur mainly in the North, South and Central Highlands; summer drought is common in the North Central and South Central	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, and livelihood

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	
	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)	as the South Central region, the Central Highlands, with more severe droughts lasting longer.	regions. Measuring equipment and monitoring data have improved, but information dissemination to at-risk people is still limited.	diversification – Increasing use of drought-tolerant crop varieties – Maintain and upgrade irrigation and water supply systems to minimize losses – Encourage the use of water saving, alternating sprinklers, reduce water pollution – Appropriate Early warning systems integrating seasonal forecasts with drought projections, and involving extension services – Develop integrated plans for water resource development in river basins and key areas. Plan exploitation, rational use of water resources for localities and sectors; – Planning of water resources development, including structural and non-structural measures; associated with the 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)

References

IPCC, 2012a: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC) [Field, C.B., V.Barros, T.F.Stocker, D.Qin, D.J.Dokken, K.L. Ebi, . Cambridge University Press, Cambridge, UK, and New York, NY, USA, Cambridge.

IPCC, 2012b: Summary for Policymakers., in: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A S. pp. 1–19.

Wisner, B., Blaikie, P., Cannon, T., Davis, I., 2004: *At Risk: natural hazards, people's vulnerability and disasters*. Second edition.

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