

Desktop Study on
Assessment of Capacity Gaps and
Needs of South East Asia Countries
in Addressing Impacts, Vulnerability
and Adaptation to Climate
Variability and Climate Change



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REGIONAL CLIMATE CHANGE
ADAPTATIONKNOWLEDGEPLATFORM for Asia

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ABBREVIATIONS & ACRONYMS

9MP NINTH MALAYSIA PLAN

ACCCMAC ADVISORY COUNCIL ON CLIMATE CHANGE MITIGATION, ADAPTATION AND COMMUNICATION

ACIAR AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH

ADB ASIAN DEVELOPMENT BANK

ADPC ASIAN DISTASTER PREPAREDNESS CENTER

ADRC ASIAN DISASTER REDUCTION CENTER

AIACC ASSESSMENT OF IMPACTS AND ADAPTATION TO CLIMATE CHANGE

AIT ASIAN INSTITUTE OF TECHNOLOGY

APF ADAPTATION POLICY FRAMEWORK

ASEAN ASSOCIATION OF SOUTHEAST ASIAN NATIONS

ASLR ACCELERATED SEA LEVEL RISE

AUSAID AUSTRALIAN GOVERNMENT'S OVERSEAS AID PROGRAM

BMA BANGKOK METROPOLITAN ADMINISTRATION

CCAI CLIMATE CHANGE AND ADAPTATION INITIATIVE (OF MRC)

CCAM CONFORMAL CUBIC ATMOSPHERIC MODEL

CCCM CANADIAN CLIMATE CENTER MODEL

CCCO CAMBODIAN CLIMATE CHANGE OFFICE

CCDMS COMMUNE COMMITTEES FOR DISASTER MANAGEMENT

CDM CLEAN DEVELOPMENT MECHANISIM

CEDAC CAMBODIAN CENTER FOR STUDY AND DEVELOPMENT IN AGRICULTURE

CIA CENTRAL INTELLIGENCE AGENCY

CIDA CANADIAN INTERNATIONAL DEVELOPMENT AGENCY

CSIRO AUSTRALIA'S COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

CSRD CENTRE FOR SOCIAL RESEARCH AND DEVELOPMENT

DBM DEPARTMENT OF BUDGET AND MANAGEMENT

DCCS DISASTER COORDINATING COUNCILS

DDPM DEPARTMENT OF DISASTER PREVENTION AND MITIGATION

DENR DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DFID DEPARTMENT FOR INTERNATIONAL DEVELOPMENT

DID DID MALAYSIA DISASTER

DMP DEPARTMENT OF MINERAL RESOURCES

DNA DESIGNED NATIONAL AUTHORITY

DOE DEPARTMENT OF ENERGY

DOE DEPARTMENT OF ENVIRONMENT

DOM DEPARTMENT OF METEOROLOGY

DPA DEVELOPMENT PARTNERSHIP IN ACTION

DPWTCP DEPARTMENT OF PUBLIC WORK AND TOWN AND COUNTRY PLANNING

DRR DISASTER RISK REDUCTION

ECHAM4 ATMOSPHERIC GENERAL CIRCULATION MODEL ECHAM4 IS BASED ON THE WEATHER FORECAST MODEL OF THE EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS (ECMWF)

EEPSEA ECONOMY AND ENVIRONMENT PROGRAM FOR SOUTHEAST ASIA

EMP ENVIRONMENT MANAGEMENT PLAN

ENSO EL NIÑO SOUTHERN OSCILLATION

FABS FARM BUSINESS ADVISORS

FAO FOOD AND AGRICULTURE ORGANIZATION

FDPM FORESTRY DEPARTMENT OF PENINSULAR MALAYSIA

FRD FEDERAL RESEARCH DIVISION

GCMS GENERAL CIRCULATION MODELS

GDP GROSS DOMESTIC PRODUCT

GEF GLOBAL ENVIRONMENT FACILITY

GFDL GEOPHYSICAL FLUID DYNAMICS LABORATORY

GFDRR GLOBAL FACILITY FOR DISASTER RISK AND RECOVERY

GIS GEOGRAPHIC INFORMATION SYSTEM

GISS GODDARD INSTITUTE FOR SPACE STUDIES

GPRD GOVERNMENT PUBLIC RELATED DEPARTMENT

GPS GLOBAL POSITIONING SYSTEM

GTZ GERMAN AGENCY FOR TECHNICAL COOPERATION

IACCC INTER-AGENCY COMMITTEE ON CLIMATE CHANGE

ICEM INTERNATIONAL CENTRE FOR ENVIRONMENTAL MANAGEMENT

ICZM INTEGRATED COASTAL ZONE MANAGEMENT

IDE INTERNATIONAL DEVELOPMENT ENTERPRISES

IEC INFORMATION, EDUCATION AND COMMUNICATION

IFAD INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

IFAP INTERNATIONAL FEDERATION OF AGRICULTURAL PRODUCERS

ILO INTERNATIONAL LABOR ORGANIZATION

IPCC INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

IRRI INTERNATIONAL RICE RESEARCH INSTITUTE

ITC IRRIGATION TECHNOLOGY CENTER

IWMI INTERNATIONAL WATER MANAGEMENT INSTITUTE

IWRM INTEGRATED WATER RESOURCE MANAGEMENT

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

KOICA KOREA INTERNATIONAL COOPERATION AGENCY

LDC LEAST DEVELOPED COUNTRIES

LESTARI INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

MAFF MINISTRY OF AGRICULTURE, FORESTS, AND FISHERIES

MARD MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

MARDI MALAYSIAN AGRICULTURE RESEARCH DEVELOPMENT INSTITUTE

MDGS MILLENNIUM DEVELOPMENT GOALS

MMD MALAYSIAN METEOROLOGICAL DEPARTMENT

MOE MINISTRY OF ENVIRONMENT

MOEYS MINISTRY OF EDUCATION YOUTH AND SPORTS

MOH MINISTRY OF HEALTH

MOLMUP MINISTRY OF LAND MANAGEMENT, URBAN PLANNING, AND CONSTRUCTION

MONRE MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

MOST MINISTRY OF SCIENCES AND TECHNOLOGY

MOSTE MINISTRY OF SCIENCES, TECHNOLOGY AND ENVIRONMENT

MOSTI MINISTRY OF SCIENCES, TECHNOLOGY AND INNOVATION

MOWRAM MINISTRY OF WATER RESOURCES AND METEOROLOGY

MPI MINISTRY OF PLANNING AND INVESTMENT

MRC MEKONG RIVER COMMISSION

MSMA URBAN STORMWATER MANAGEMENT MANUAL

MTC MECHANICAL TRAINING CENTRE

NAFREC NORTHERN AGRICULTURE AND FORESTRY RESEARCH CENTER

NAFRI NATIONAL AGRICULTURE AND FORESTRY RESEARCH INSTITUTE

NAHRIM NATIONAL RESEARCH HYDRAULIC INSTITUTE OF MALAYSIA

NAPA NATIONAL ADAPTATION PLAN OF ACTION TO CLIMATE CHANGE

NCCC NATIONAL CLIMATE CHANGE COMMITTEE

NCCF NATIONAL CLIMATE CHANGE FUND

NCCO NATIONAL CLIMATE CHANGE OFFICE

NCDM NATIONAL COMMITTEE FOR DISASTER MANAGEMENT

NCEA NATIONAL COMMISSION FOR ENVIRONMENTAL AFFAIRS

NDCC NATIONAL DISASTER COORDINATING COUNCIL

NDMO NATIONAL DISASTER MANAGEMENT OFFICE

NDPCC NATIONAL DISASTER PREPAREDNESS CENTRAL COMMITTEE

NDPMWC NATIONAL DISASTER PREPAREDNESS MANAGEMENT WORKING COMMITTEE

NGOS NON-GOVERNMENTAL ORGANISATIONS

NGPES NATIONAL GROWTH AND POVERTY ERADICATION STRATEGY

NIO NORTH INDIAN OCEAN

NOCCOP NATIONAL OFFICE FOR CLIMATE CHANGE AND OZONE PROTECTION

NPRS NATIONAL POVERTY REDUCTION STRATEGY

NSAPCC NATIONAL STRATEGY AND ITS ACTION PLAN ON CLIMATE CHANGE

NSCCC	NATIONAL STEERING COMMITTEE ON CLIMATE CHANGE
NSDP	NATIONAL STRATEGIC DEVELOPMENT PLAN
NSEDP	NATIONAL SOCIO-ECONOMIC DEVELOPMENT PLAN
NSTS	NATIONAL STUDY TEAMS
NTP	NATIONAL TARGET PROGRAM TO RESPOND TO CLIMATE CHANGE
OEPP	OFFICE OF ENVIRONMENTAL POLICY AND PLANNING
ONEP	OFFICE OF NATURAL RESOURCES AND ENVIRONMENTAL POLICY PLANNING
OPP3	THIRD OUTLINE PERSPECTIVE PLAN
PAGASA	PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION
PCW	PANTABANGAN-CARRANGLAN WATERSHED
PEACE	PELANGI ENERGI ABADI CITRA ENVIRO
PET	EVAPOTRANSPIRATION
PMT	PROJECT MANAGEMENT TEAM
PRECIS	PROVIDING REGIONAL CLIMATES FOR IMPACTS STUDIES
PTFCC	PRESIDENTIAL TASK FORCE ON CLIMATE CHANGE
RAN-PI	NATIONAL ACTION PLAN ADDRESSING CLIMATE CHANGE
RCMP	RIVER CATCHMENT MANAGEMENT PLAN
RDCCS	REGIONAL DISASTER COORDINATING COUNCILS
REGHCM-PM	REGIONAL HYDROCLIMATE MODEL OF PENINSULAR MALAYSIA
RGC	ROYAL GOVERNMENT OF CAMBODIA
RUPP	ROYAL UNIVERSITY OF PHNOM PENH
SDC	SWISS AGENCY FOR DEVELOPMENT AND COOPERATION
SEA-CC NET	SOUTHEAST ASIA NETWORK OF CLIMATE CHANGE FOCAL POINTS
SRD	SUSTAINABLE RURAL DEVELOPMENT
SRES	SPECIAL REPORT ON EMISSIONS SCENARIOS
SRI	SYSTEM OF RICE INTENSIFICATION
START	GLOBAL CHANGE SYSTEM FOR ANALYSIS, RESEARCH AND TRAINING
TDRM	TOTAL DISASTER RISK MANAGEMENT
TEI	THAILAND ENVIRONMENT INSTITUTE
TKK	WATER AND DEVELOPMENT RESEARCH GROUP OF HELSINKI UNIVERSITY OF TECHNOLOGY
UKMO	UNITED KINGDOM METEOROLOGICAL OFFICE
UN-HABITAT	UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME
UNDP	UNITED NATIONS DEVELOPMENT PROGRAMME
UNEP	UNITED NATIONS ENVIRONMENT PROGRAMME
UNFCCC	UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE
UNFPA	UNITED NATIONS POPULATION FUND
UNICEF	UNITED NATIONS CHILDREN'S FUND

V&A	VULNERABILITY AND ADAPTATION
VASS	VIET NAMESE ACADEMY OF SOCIAL SCIENCES
VI	VULNERABILITY INDEX
WB	WORLD BANK
WFP	WORLD FOOD PROGRAMME
WHO	WORLD HEALTH ORGANIZATION
WREA	WATER RESOURCES AND ENVIRONMENT ADMINISTRATION (LAOS)
WRRCC	WATER RESOURCES COORDINATION COMMITTEE
WRTC	WATER, RESEARCH AND TRAINING CENTRE

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EXECUTIVE SUMMARY

INTRODUCTION

South-East Asia will be strongly affected by the impacts of climate change according to the Intergovernmental Panel on Climate Change (IPCC) Technical Paper VI entitled “Climate Change and Water” (IPCC, 2008). This is due to the fact that one of the most pressing environmental problems in this part of the world is the expansion of areas subjected to increasing water stress. In reference to the Special Report on Emissions Scenarios (SRES), it is estimated that in the next forty years, the number of people that will experience severe water stress will increase between 4 and 5 times (Arnell, 2004). Monthly precipitations are expected to decrease in number but increase in intensity. Dry seasons are expected to be more in number and longer in duration. Thus, the risks of flooding in the wet season and water shortage in the dry season are also highly increasing. The general reduction of the rivers’ flow and the rise in sea level will provoke the intrusion of saltwater in estuaries and eventually cause a general deterioration of surface and ground water stocks.

These phenomena will impact strongly in the Southeast Asian region, where 8 members of the Association of Southeast Asian Nations (ASEAN), namely, Vietnam, Thailand, Malaysia, Philippines, Indonesia, Lao PDR, Myanmar and Cambodia are given focus in this report. In these countries, the increasing water stress, the increasing intensity of precipitations and the consequent floods will provoke the general erosion of the land and, consequently, the general deterioration of land quality and productivity. These conditions, coupled with temperature changes and low water quality and availability impacts negatively on agriculture, in general, and livestock production and the aquaculture industry, in particular. It means that the vulnerability of the population will increase because the risks on water and food security are also increasing. Strategies need to be put in place in order for the general population to adapt to the changing physical and climatic conditions. And to enhance the resilience of the socio-economic systems in these countries, cooperation between local governments and international organizations is essential.

This desktop study is conducted based on a stocktaking analysis provided by the Regional Climate Change Adaptation Knowledge Platform for Asia (Adaptation Knowledge Platform) in the ASEAN member countries indicated earlier. The purpose of this study is to illustrate the current state of adaptation, its status and possibilities, of the region. It also investigates how these ASEAN countries can learn from each other and from the scientific community, in order to define some adaptation strategies as possible next steps and priorities in the status of water and agriculture management from a socio-economic perspective. The aim of the Adaptation Knowledge Platform is to verify the state of knowledge in the different countries, identify the gaps and to try to fill them up.

REGIONAL ANALYSIS OF ASEAN MEMBER COUNTRIES

Gaps in adaptive capacity for the water sector: improvement of knowledge

The analysis of existing studies on national and regional vulnerability and adaptive capacity underlines several problems from local and regional points of view. The research in the specific countries highlights:

- Lack of information and statistical analysis applied to climate and hydro-geologic changes
- Scarce connection between decision-makers and the scientific community
- Inadequate climate risk assessment methods
- Scarcity and inadequacy of technical instruments
- Scarcity of experience and financial capacity of governments in managing climate change studies, and
- Insufficient real-time information on rainfall and water level for operational schemes.

The analysis also identified principal gaps that the 8 ASEAN member countries have to address:

- No river basin system-based management
- Lack of a long run strategy in water management: different use of the water resource, such as hydropower, irrigation, fishing, are often conflicting with each others
- Insufficient coordination between agencies
- Low investments
- No clear regulation for rational use of land: deforestation and costal and river basin erosion
- Inefficient use of water, especially in agriculture, and
- Insufficient drought management.

This is exemplified by the scenario that even when river basins transcend the territorial jurisdictions of many countries, there is no strong coordination between national and international institutions among such countries. Intergovernmental cooperation in managing common resources such as river basins is insufficient. This has led to a very fragmented scientific research, consequently losing the opportunity of creating a common strategy to solve transboundary environmental issues. Until now, different countries act differently and independently in addressing problems, which could be efficiently solved or avoided by a shared action. The situation may be different among countries, however, the phenomenon of water stress caused by physical and climatic conditions encompass the region.

In coming up with adaptation strategies related to the water and agriculture sectors, the main problem that can be pointed out is the lack of basin system-based management, especially in the case of big river systems and wetlands like the Mekong that meander across different countries. The management of this resource should not be fragmented because mismanagement in one country could affect the others. In order to minimize problems related to this scenario, multilateral agreements have been signed by various countries that

put in place management systems for transboundary river basins. In 1957, an international agreement created the Mekong Committee, which, in 1995 was renamed as the Mekong River Commission. However, this agreement was not signed by China, which is the source of the Mekong and Myanmar, another country strategically located upstream of the river basin. While the original rationale of the agreement was to create a joint management system for hydro-power/hydro-electric production, irrigation, navigation, fishing and flood control/relief, the Mekong River Commission has, hardly eminently, a political role as it is not directly involved in the practical management of the basin. It also bears no strong decision-making power.

Another international agreement, the ASEAN-Mekong Basin Development Cooperation, was signed in 1996. Nevertheless, such agreement was mostly created for the economic development of the Mekong basin. Aside from Commissions such as these, it is hoped that the constitution of intergovernmental authorities, which have autonomous decision-making power and economic independence in cooperation with local political and scientific institutions, could directly manage the scientific research and infrastructural interventions in the different basins. A combination of political pressure and economic incentives may be used to encourage countries to cooperate. Local governments and river basin management organizations have to cooperate to achieve important aims such as:

- Advanced monitoring and statistical analysis of the basin
- Constant diffusion of information and strong interaction with local institutions
- Floods and river overflows forecasting and alert system
- Rational regulation of the use of water
- Scientific study of the infrastructure that have to be realized to regulate the river's flow during wet and dry seasons
- Study and realization of security basins which provoke controlled floods
- Efficient natural resource system management
- Efficient use of water resource
- Land use planning
- Geographical relocation of population that live in places strongly exposed to a high degree of risk
- Financial assistance, and
- Transparency in information management.

The list of strategies may be long and comprehensive and it needs a long-term timetable for an overall river basin management policy to be effective. However, for the short-term, interventions have to be coordinated by local governments in cooperation with international organizations.

Gaps in adaptive capacity for agricultural sector and food security: improvement of knowledge

Agriculture is the most important economic activity across the 8 ASEAN countries included in the study. Water resource dynamics, agriculture and food security are tightly linked. The analysis of the Adaptation Knowledge Platform on the state of the local scientific research underlines the following gaps and issues:

- General backward situation of the research's state
- Inadequate tools, knowledge and financial endowment
- Lack of infrastructure
- General difficulty in communicating knowledge to farmers, and
- Lack of a clear study on the long-term impact of climate change on food production.

It is possible to put forward as evidence some remarkable activities implemented by local institutions, however, they are often managed inefficiently. In Vietnam, for instance, the government is supporting research activities of agro-meteorology and rice seed development, but the lack of international networks to exchange research results hinders the effective application of significant findings and improvements throughout the region. The situation is not better in terms of typology of the policies and strategies that local governments are trying to adopt in the region. Some of these countries are actively working to pursue poverty reduction goals, food security and irrigation development. Unfortunately, there are times when these adaptation practices are badly influenced by institutional and socio-economic environments, especially at the local level. The stocktaking analysis outlines the following gaps and issues that need to be overcome:

- Insufficient financial resources
- Insufficient long-term perspectives
- Lack of integration among adaptation strategies in food security and development strategies
- Insufficient integration between institutions
- Insufficient intergovernmental cooperation
- General difficulties for farmers to access credit
- Lack of cooperation between farmers
- Poor infrastructure in some countries
- Lack of in-depth study on small and poor farmers' socio-economic conditions, and
- Partial exclusion of farmers from the diffusion of information and decision processes.

Nevertheless, there are cases wherein governments and institutions show their inability to address such situations. As such, farmers, especially the most advanced and developed, have already started to devise some adaptation strategies after having experienced the changes in production conditions. This is especially identifiable in culture shifting: more resistant crops, short-cycle rice varieties. Unfortunately, the fragmentation of production, the difficulty in accessing credit, the slow mechanization of production, and the general lack of education of farmers, do not demonstrate a tendency towards a method of production adapted to the impacts of climate change. In this case, production becomes inefficient.

There are several good initiatives led by international organizations and Non-Governmental Organisations (NGOs) in some ASEAN countries that need to be replicated in the others. These initiatives could be considered as an introduction of good measures to handle similar issues in other places with similar features. For instance, Food and Agriculture Organization (FAO) in the Philippines succeeded in improving rice yield from 4.5 tons per hectare to 8 tons per hectare by enhancing the efficiency of the production process. Analyzing some of the actions adopted by the governments could be useful in trying to delineate a series of actions to fill the gaps highlighted by the stocktaking analysis. For instance, the Ministry of Agriculture and Cooperatives of Thailand has carried out adaptation measures including community-level capacity building and research initiatives on drought-resistant plant and animal species. In recent years, the needed safeguards, especially during severe droughts and floods, have been developed under the concept of “sufficiency economy”. Another good example is provided by the Cambodian government on the occasion of the United Nations Framework Convention on Climate Change (UNFCCC). Their efforts were oriented to the improvement of capacity building at all levels, especially local, with several objectives. Their strategies were developed taking into consideration the following:

- An improvement of information systems to increase awareness on adaptation
- An integration of adaptation strategies for the water and agricultural sectors for the country’s sustainable development, with the realization of infrastructures and economic policies aimed at poverty reduction and food security
- A critical analysis of projects and policies in order to learn from good practices as well as mistakes and failures, and
- A wider scope of information dissemination to increase awareness on the realities and immediacy of climate-related issues.

These examples illustrate that there are some countries acting more efficiently than others – gaps clearly underlined by the stocktaking analysis on which this study is based. Learning from the gaps between countries as well as on international studies, it is imperative to outline a series of strategies and policies that could be proven to be effective and appropriate from a regional point of view. The application of such policies and strategies at the local level, though, has to take into consideration the different social, political and economic backgrounds and the uniqueness of each local setting. In order to enhance resilience and reduce vulnerability, coherent policies and coordinated strategies could be proficient on a medium-term basis. And in the long run, such actions would result in improved efficiency in the economic systems of the 8 ASEAN member countries, creating a virtuous circle that permits the internalization of adaptation costs.

Country Actions, Strategies and Perspectives

In all cases, the application of regional guidelines is always suggested. This section outlines the different policies and strategies that may be followed by each country.

Lao PDR

- Scientific coordination between international agencies and the hypothesized “Authority” with the local Water Resources and Environment Administration for the water sector.
- Integration of the Strategic Framework of the Northern Agriculture and Forestry Research Centre (NAFReC) with other regional and local research centres, as a way for the information acquired to be reproduced and replicated in other countries.
- Development of a better forecasting system, adding the consequences of climate change to the strategic framework.

Viet Nam

- Evaluation of the applicability of the policies adopted in disaster preparedness.
- Diplomatic pressure on the political system to adopt socio-economic subsidies that reduce the impact of adaptation strategies on the population.
- Application of projects for development and farmers’ assistance by micro-credit.

Philippines

- Study and implementation of the Water Balance model “WatBal”; reforestation.
- Introduction of urban wastewater recycling systems.
- Financial assistance to farmers; scientific assistance to research.

Indonesia

- Reforestation; introduction of urban wastewater recycling systems.
- Radical analysis and reformation of agricultural production systems.
- Improvement of communication systems.

Thailand

- Analysis and eventual implementation of measures adopted by the Bangkok Metropolitan Administration (BMA) as well as those recommended by the other studies.
- Rationalization of water consumption; improvement of the net efficiency of irrigation.
- Shifting cultivation; analysis of the studies of the Ministry of Agriculture and Cooperatives.

Cambodia

- Analysis, improvement and eventual adoption of the measures adopted for the water sector.
- Serious analysis and coordination of initiatives adopted in agricultural management.

Myanmar

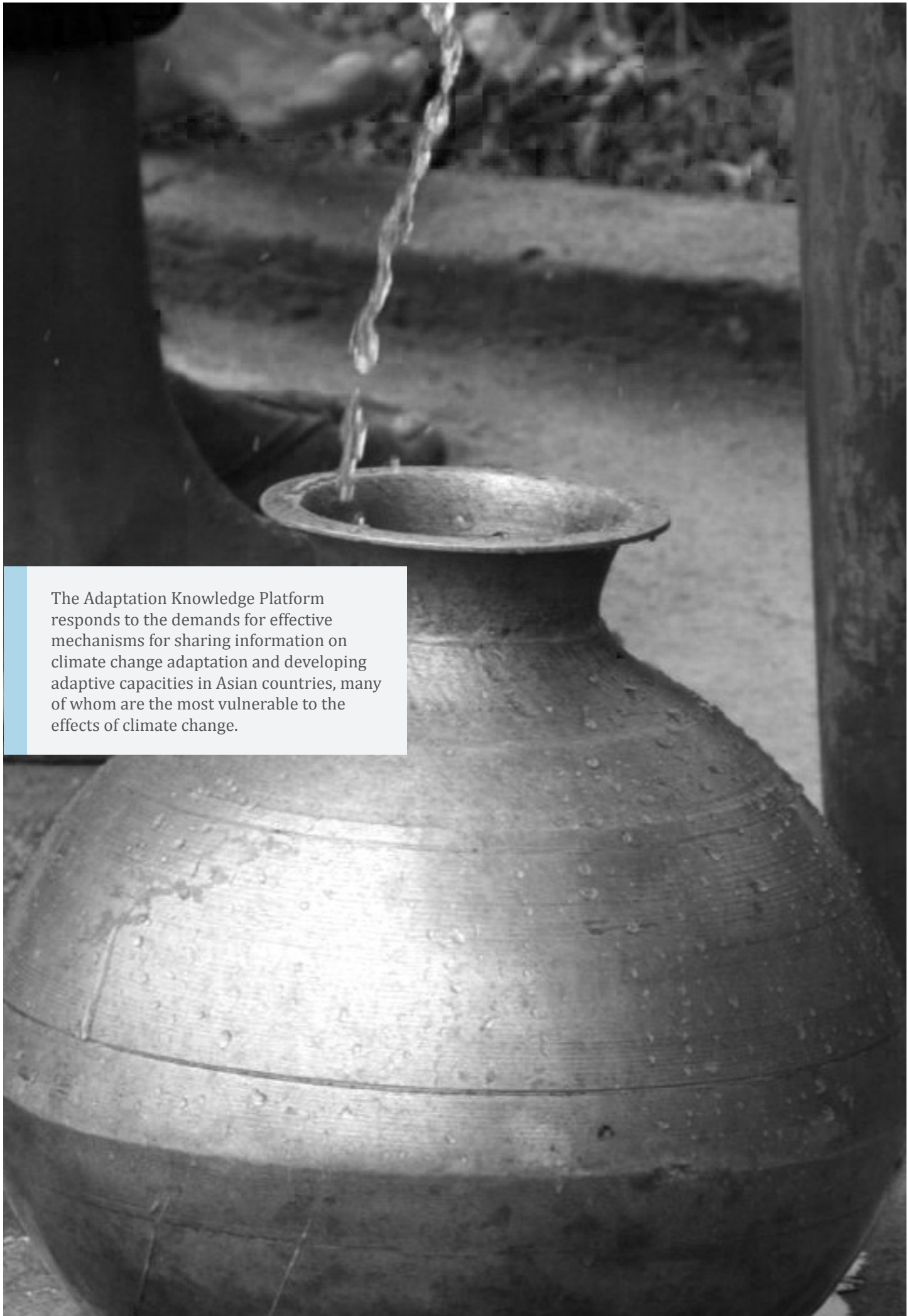
- Assistance to the local research institute and coordination of scientific studies on the Ayeyarwaddy River basin.
- Shifting cultivation and the enhancement of efficiency in agriculture.

Malaysia

- Regulation on water and land use; regulation of river flows through Ecosystem-based and engineering solutions
- Improvement of research activities
- Analysis, improvement and eventual adoption of the Integrated Pest Management
- Creation of long-term climate-conscious mindsets.

Conclusion

This study takes precedence from the research made by the Adaptation Knowledge Platform on the 8 ASEAN member countries and tries to provide some guidelines on the application of adaptation strategies. It also tries to specify country-specific strategies that could be adopted in order to enhance resilience through actions based on the combination of adaptation and development. The strategies and policies outlined above ensure that solutions to address the impacts of climate change are effectively managed, particularly those concerning the Water Sector, the Agricultural Sector and Food Security. Such strategies also overcome the gaps in coordination and communication at the regional and local levels and between national governments and international agencies. As the stocktaking analysis noted that governments act differently and independently, this study highlights the importance of creating unified policies and coherent strategies in order to enhance resilience and reduce vulnerability in the Water and Agriculture sectors in Southeast Asia.



The Adaptation Knowledge Platform responds to the demands for effective mechanisms for sharing information on climate change adaptation and developing adaptive capacities in Asian countries, many of whom are the most vulnerable to the effects of climate change.

INTRODUCTION

DESKTOP STUDY BACKGROUND

The Regional Climate Change Adaptation Knowledge Platform for Asia (hereinafter, referred to as the Adaptation Knowledge Platform) is a three-year program that supports research on climate change adaptation, policy making, capacity building and information sharing to help countries in Asia adapt to the challenges of climate change. The Adaptation Knowledge Platform responds to the demands for effective mechanisms for sharing information on climate change adaptation and developing adaptive capacities in Asian countries, many of whom are the most vulnerable to the effects of climate change.

The Adaptation Knowledge Platform is leading the desktop study in collaboration with the Southeast Asia Network of Climate Change Focal Points (SEA-CC Net). During the first SEA-CC Net meeting (Bangkok, 11-12 March 2009), key ASEAN member countries identified the need to review and analyze existing studies on national and regional vulnerabilities as one of the first priority in order to provide the stakeholders with firm background for informed decision making. In an effort to provide enhanced services to the countries of SEA, this study is carried out as a joint effort between the SEA-CC Net and the Adaptation Knowledge Platform.

The research study and synthesis is the findings on assessment of capacity gaps and needs of South East Asian Countries in addressing impacts, vulnerability and adaptation to climate variability and climate change.

The overarching objectives of this desktop study are to share up to date information on state of art methods, approach, technologies and status of adaptive capacity.

Further, it represents a synthesis of existing studies and reports on impacts, vulnerabilities and adaptation activities related to climate change in Southeast Asian countries. It has been elaborated with the immediate goal of identifying learning lessons for future capacity building actions.

GOALS AND EXPECTED OUTPUTS

The desktop study is aimed to provide information on the status of vulnerability at national and regional level in the countries of the Association of Southeast Asian Nations (ASEAN), which are among the world's most vulnerable to the impacts of climate change.

There are several common approaches, methods, toolkits, policies and research in water, agriculture and socio-economic sectors. This desk study intends to highlight overlaps and gaps in these specific sectors, which may exist in order to design capacity building and experience sharing activities among the member countries for south-south cooperation.

The output is an improved knowledge-base on existing data, information and knowledge in identifying country specific technical, institutional and functional setups and needs. This will form the basis for further decision-making processes, actions and mechanisms to respond to the needs of the countries in mainstreaming adaptation. Available

Figure 1: Member countries of the Association of Southeast Asian Nations (ASEAN), adopted from ASEAN (2009) (in black: countries considered in this study)



capacity at the regional level can be made available through networks and training programs to the national and provincial governments in order to enable them to improve climate change impact analysis and to adapt accordingly.

STUDY SCOPE AND APPROACH

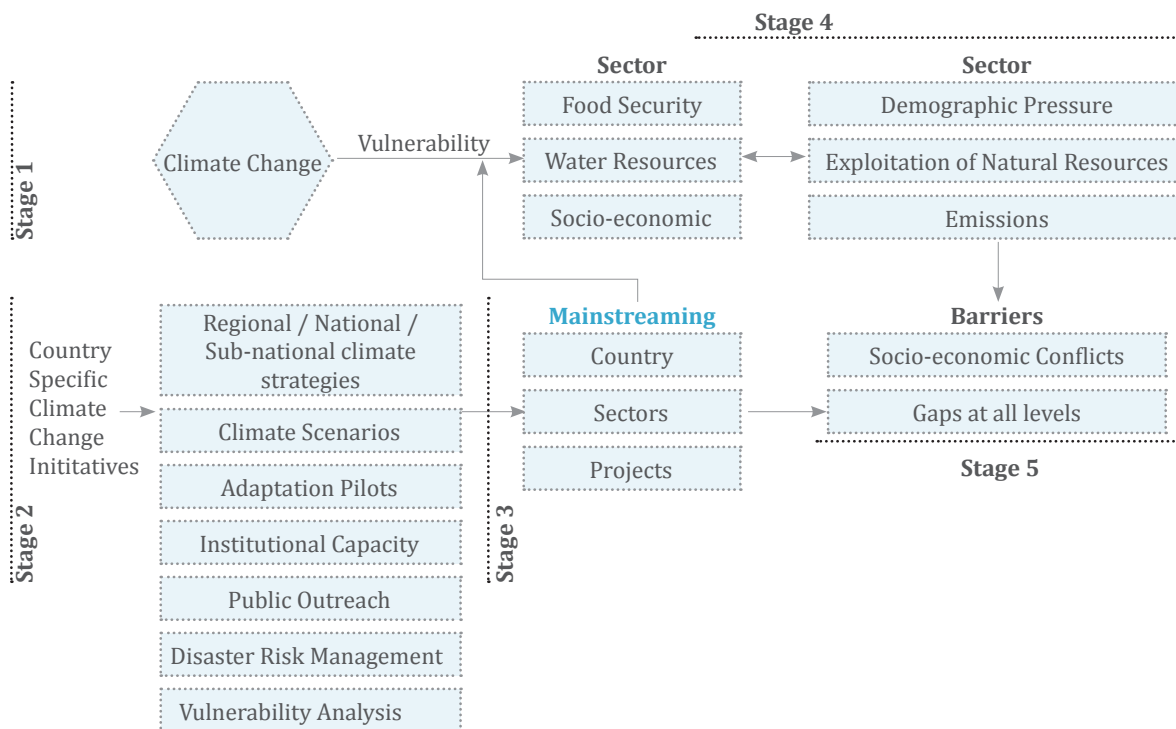
This study covers the eight selected countries, namely, Lao PDR, Viet Nam, the Philippines, Indonesia, Thailand, Cambodia, Myanmar and Malaysia (see Figure 1). The selection provides a representation of the Mekong River Basin and Delta countries with the land locked, low lying areas as well as countries in ASEAN with the long coastlines. While these countries' livelihoods and economies are agricultural and aquaculture driven, a great emphasis on water, agriculture and socio-economic sectors are given to compare, evaluate and assess the impacts of climate change.

In this study, a climate risk management approach is followed, assessing the threats and opportunities that result from both existing and future climate variability, including those deriving from climate change. Successful adaptation to future climate begins with successful coping with current climate variability (Noble, 2004). At the same time, a development perspective on adaptation is adopted, as adaptation to climate change is recognized as part of a development process. Thus, the adaptation process approach needs to be country driven with a focus on national needs and local priorities (Noble, 2004).

METHODOLOGY

The components included in the adopted methodology for the desktop study are to (i) take stock of existing studies on national and regional vulnerabilities and adaptation programs to climate change, namely in the water, agriculture and food security and socio-

Figure 2: National level synthesis on vulnerability and adaptation – an approach



Source: Authors of this report

economic sectors; (ii) identify the lessons learnt, to share among member countries for capacity building activities; (iii) highlight gaps in country level knowledge and capacity in the implementation of vulnerability assessments; and (iv) identify effective tools and methodologies, capacity building, and institutional support modalities for vulnerability assessments and adaptation activities.

A total of fifteen (15) key studies, each for Lao PDR, Viet Nam, the Philippines, Indonesia, Thailand, Cambodia, Myanmar and Malaysia, with a focus on water, agriculture and food security, and socioeconomic adaptation and climate change related impacts in the last decade were reviewed. . In order to exemplify the review/ or study process, a country level approach was followed to synthesize country level data, information and knowledge towards adaptation methods, technologies, best practices and mainstreaming approach to pave a way forward in the significant developmental endeavour of vulnerability and adaptation study. A three pronged process covering regional, country specific climate adaptation initiatives and local, sub-national and national levels were followed. The overall approach and processes pertaining to all these steps were embraced with external factors to keep the perspectives, while analyzing the data and information gathered. To conduct the synthesis, a five-stage process was followed.

Stage 1 in Figure 2 reviews the historical weather data that are analyzed to understand its significance in terms of climate change. Historical data are important as they are used to establish the change at sectoral levels such as water, agriculture and socio-economic. Impacts on these sectors are of varying degrees in terms of climate parameters such as, rainfall amount, number of rainy days, temperature, intense rainfall leading to floods and changes in tropical cyclone characteristics and frequencies.


Stage 2 focuses on the impacts of future climatic conditions under projected climate change scenarios through their vulnerabilities on food security, water resources and socio-economic sectors. Since, knowledge on uncertainty in climate predictions is yet to be proven, as seen from available information and knowledge, some aspects of downscaled climate data and scenarios are covered. While analyzing this top down process, where adaptation is imposed from outside without much consultation or interaction (and being science driven), an evaluation of external factors such as, anticipated implications of demographic pressure and exploitation of natural resources are reviewed to ground the sectoral approach for a reality check and to find a way and status of the countries from an autonomous adaptation to planned adaptation (or adaptive capacities).

Stage 3 recognizes the regional, national and local level studies and its significance of promoting climate change adaptation in building significant sectoral activities. Many of these pilot and research based studies are focused on technical assistance and knowledge management activities, whereas, some are meant to assess both social and economic aspects of the issues with and without climate change scenarios. Communication, public awareness and outreach efforts further underline the facts of institutional, policy, technical level gaps to the current factual state and future directions.

Stage 4 builds on stage 3 to further sectoral research and national climate change adaptation strategies, policies and regulatory framework to mainstream

the process as developmental agenda at country level in the five years developmental plans and beyond.

An analysis of stage 4 helps understand the current engagement process to assess the goals and contextualization of the issues among various stakeholder agencies to document expectations. Synthesizing this stage, a series of gaps emerged that are not climate impacts, but developmental challenges to build a sustainable process that includes adaptation. Therefore, through this exercise, in stage 5, prioritization of the issues are undertaken and challenges that need to be overcome in view of the formulation and implementation of a successful climate change adaptation activities are identified.



Lao PDR has a tropical climate dominated by the southwest monsoon, which brings high rainfall, high humidity, and high temperatures. The climate is characterized by high inter-annual variability and frequent occurrences of heavy precipitation leading to floods.

RESEARCH SYNTHESIS ON LAO PDR

COUNTRY CHARACTERISTICS

This section presents Lao PDR's geographic attributes, social, economic and climatic risks situation. Lao PDR's country profile overview is shown in Table 1.

Geographic Attributes

Lao PDR is located in the Mekong Region, bordering on China in the North, Thailand and Myanmar in the West, Cambodia in the South, and Viet Nam in the East (see Figure 3). From its total land area of about 236,800 km², approximately 80% are mountainous, located in northern Lao PDR in the eastern border, and in the south. The remaining land area mainly consists of flat floodplain along the Mekong River (Lao PDR, 2009a).

Socio-Economic Status

According to the 2005 census, the population of Lao PDR is 5.8 million inhabitants, resulting with 24 people per km² in the lowest population density of Southeast Asia (Lao PDR, 2009a). The growth rate of the Lao PDR population was about 2.4% and the crude birth rate was 33.7 per 1,000 people. Around 73% of the Lao population lived in rural areas. The country's poverty could be reduced, showing 38.6% of households living below the poverty line in 1992/93 and 28.7% of poor households in 2002/03. The adult literacy rate was 73% in 2005 and was estimated to be 77% in 2007. In the UN Human Development Index, Lao ranks 133rd out of a total of 179 countries in 2009. Regarding the economic activity, out of the in total US\$ 4,980 million Gross Domestic Product (GDP) in 2007, 40.3% were

Table_1 Lao PDR Country Profile Overview

Country information (Lao PDR, 2009a)	
Surface area (km ²)	236, 800
Bordering countries	China, Viet Nam, Cambodia, Thailand, and Myanmar
Population density, 2005 (persons/km ²)	24
Population growth rate, 2005 (%)	2.4
Mountainous land (% of total area)	80
Flat land (% of total area)	≈20
Agricultural land (% of total area)	8
GDP, nominal, 2007-08 (million US\$)	4,980
Contribution of agricultural sector to GDP, 2007 (%)	40.3
Contribution of industrial sector to GDP, 2007 (%)	34.1
Contribution of service sector to GDP, 2007 (%)	25.6
Percentage of population, 2005 (%) in - rural areas - urban areas	73 27
Poor population, 2002/03 (% of households)	28.7
Infant mortality rate, 2006 (%)	5.72
Adult literacy rate, 2007 (% of total population, estimate)	77
Access to water supply, 2007 (% of total population, estimate)	55

Figure 3: Lao PDR Location map (Lao PDR, 2009a)



provided through the agricultural sector, 34.1% through the industrial sector, and 25.6% through the service sector (Lao PDR, 2009a).

Climate Risks

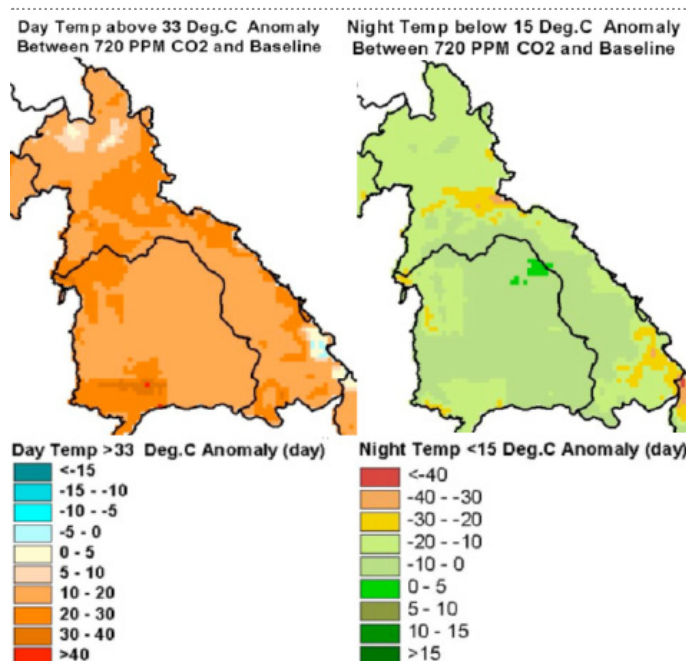
To assess Lao PDR-specific climate profile, current climatic conditions and projected climate scenarios are discussed.

Current Climatic Conditions

Lao PDR has a tropical climate dominated by the southwest monsoon, which brings high rainfall, high humidity, and high temperatures between mid-April and mid-October. The climate is characterized by high inter-annual variability and frequent occurrences of heavy precipitation leading to floods. Over the past four decades, there have been sixteen (16) major floods, each affecting 226,400 people on average and resulting in loss of life and property damage. According to the Lao Meteorology Department, the larger the area flooded and the longer the flood, the greater the impact on few leading sectors such as water resources, agriculture, and forestry, which leads to dampen the overall development and socio-economic conditions of Lao (ADB, 2009a).

Lao PDR's major climatic risks are floods, droughts, and storms (EM-DAT, 2009; GFDRL, 2009d). Flooding mainly occurs from May to September when Monsoon rains accumulate in the upper Mekong River Basin. Besides river basin flooding, flash floods are common in the northern mountainous region.

Figure 4: Numbers of annual hot day (>33 °C) and cool day (<15 °C) in Lao PDR (Snidvongs, 2006)



Estimations indicate that the south and central regions, that are home to about two thirds of the country's population, face 1.5 times the serious floods or droughts a year, at an average (GFDRL, 2009d). Table 2 gives an overview on further natural disaster statistics. The five top natural disasters in Lao PDR from 1980 to 2009 were all climate-related: three flood events in 1996, 2000 and 2001; one drought in 1988, and one storm event in 1995. Regarding the number of people affected by these natural disasters, 43% were affected by floods, 33% by storm, and 24% by drought (Figure 5). When it comes to all the events of climatic disasters occurring between 1980 and 2009 – i.e. five storm, four drought, and twelve flood events –, the flood events affected the highest number of people (56% of all people affected, see Figure 6), whereas storms were responsible for almost the entirety of the caused economic damage (93%, see Figure 7).

Climate Projections

Climate change is expected to have a range of impacts which include, increases in the annual mean temperatures by around 0.1-0.3°C per decade; a longer annual dry season; more intensive rainfall events; and more frequent and severe drought and flooding events (Srinetr et al., 2009). The 4th International Panel on Climate Change (IPCC) report (Cruz et al., 2007) indicates that the Mekong Basin is expecting increasing maximum monthly flows of 35-41% and decreasing minimum monthly flows of

Table_2 Overview on natural disasters in Lao PDR: 1980-2009

Top 5 Natural Disasters in Lao PDR: 1980-2009

Type of natural disaster	Date/year	No of people affected
Storm	Aug 1995	1,000,000
Drought	Dec 1988	730,000
Flood	Aug 2001	453,000
Flood	Sept 2000	450,000
Flood	Aug 1996	420,000

Total Natural Disasters in Lao PDR:1980-2009

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Storm	5	1,462,312	305,951
Drought	4	750,000	1,000
Flood	12	2,792,740	22,828

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain – Brussels, – Belgium.

17-24% over the course of this century, which will substantially increase flooding risks in the wet season and water scarcity in the dry season. The regional climate change scenario projects that hot periods with temperature higher than 33 °C will increase and cooler days with a temperature lower than 15 °C be reduced by 2-3 weeks a year (Snidvongs 2006) (see Figure 4).

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

This section focuses on reviews from existing studies and programs on adaptation issues in the three identified sectors, water, agriculture and food security, and socio-economic aspects. The section on further analyzes the methods used - a) study findings on the impact of climate change; b) the status of vulnerability and adaptation to climate change; c) identified gaps and d) a review on newly launched sector-specific projects to report about on-going policy and response related to climate change adaptation activities.

Water Sector

The Mekong River is one of the world's largest rivers, measuring about 4,900 km. The Mekong River flows through China and marks the border between Myanmar and Lao PDR, before it runs through Lao PDR, Thailand, Cambodia, and Viet Nam to the South China Sea. The Mekong River is of high relevance for Lao PDR, about 20% of the country's total land area being floodplains along the Mekong River and 50% of the Lao population living in these plain areas (Lao PDR, 2009a). Thus, it is essential to assess the implications of climate change on precipitation patterns and associated effects on the Mekong River and its tributaries.

Range of Studies Reviewed and Methods Applied

A range of studies and applied methods were reviewed for analyzing the Lao PDR's water situation in view of climate change.

Snidvongs (2006) from the South East Asia Global Change System for Analysis Research and Training (SEA START) Regional Centre has presented a number of methods and models in its study on extreme hydrological events and changes in water resources in Southeast Asia, including Lao PDR. To study climate change, a regional climate scenario was simulated with the Conformal Cubic Atmospheric Model (CCAM). This has been taking place at the level of the Lower Mekong River Basin, since downscaling had been proven to produce inaccurate results for local levels (Snidvongs, 2006). The CCAM has been specifically developed by the Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Atmospheric Research in Australia for the Australasian region (Lao PDR, 2009a). Recently, PRECIS¹ which is dynamically downscaling outputs from the coarser level ECHAM4 model to a resolution of 0.2° x 0.2° – has been calibrated for Southeast Asia by the

¹ PRECIS: PRECIS (pronounced as in the French *précis* - "PRAY-sea") is based on the Hadley Centre's regional climate modelling system. PRECIS was developed in order to help generate high-resolution climate change information for as many regions of the world as possible. The intention is to make PRECIS freely available to groups of developing countries in order that they may develop climate change scenarios at national centres of excellence, simultaneously building capacity and drawing on local climatological expertise. These scenarios were and can be used in impact, vulnerability and adaptation studies, and to aid in the preparation of National Communications.

Figure 5: Percentage of people affected
due to top 5 natural disasters:
1980-2009

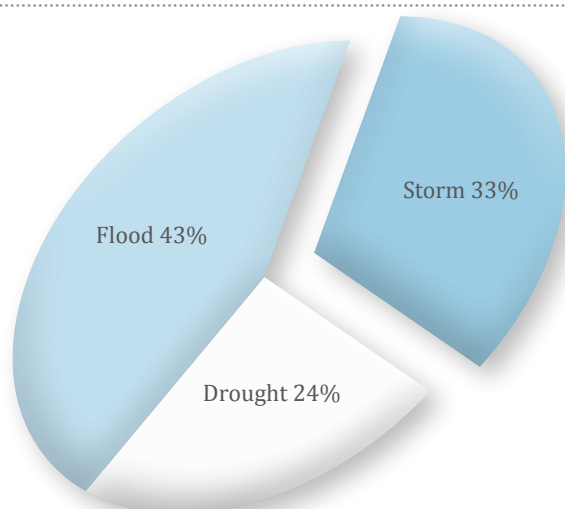


Figure 6 : Percentage of people affected
due to total natural disasters:
1980-2009

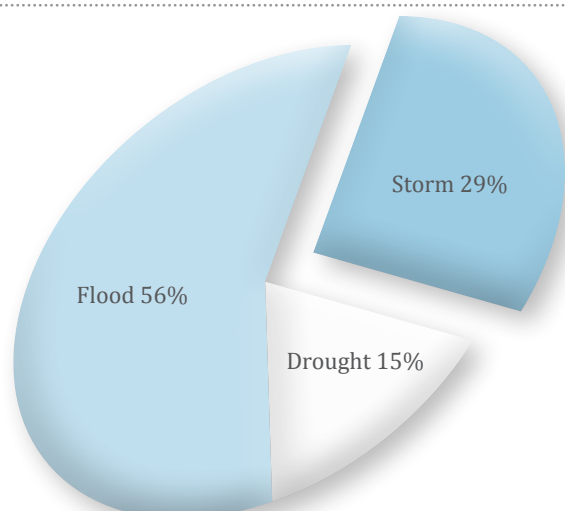
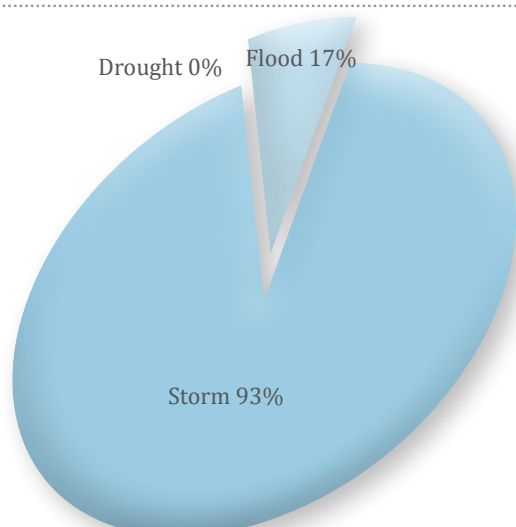


Figure 7: Percentage of damage (US\$)
due to total natural disasters:
1980-2009



Southeast Asia START Regional (Lacombe and Hoanh, 2009). For studying the climate change impact on the hydrological regime in the Lower Mekong River Basin, Snidvongs (2006) relied on the Variable Infiltration Capacity hydrological model. This model solves water and energy balances at the land surface-atmosphere interface, including parameters such as spatial variability of precipitation, land surface cover, infiltration, soil and vegetation characteristics.

Climate change projections for individual sub-basins of the Mekong River Basin were generated by Eastham et al. (2008) in their assessment of climate change impacts on water resources. They sampled the output of eleven Global Climate Models in order to reflect the uncertainty bounds of projections. Sub-basin level projections of rainfall and temperature for the A1B SRES² climate change scenario were obtained using statistical downscaling techniques (Lacombe and Hoanh, 2009).

For preparing the National Adaptation Programme of Action (NAPA) to Climate Change (see also chapter 2.3.1 b), the NAPA Working Groups compiled climate data and statistics for temperature and rainfalls from the Department of Meteorology and Hydrology (DMH) for the period 1995-2005 and regionally produced climatic data since 1980 and climate change predictions from Mekong River Commission (MRC) (Lao PDR, 2009a).

MRC has applied a couple of hydrological models on regional basin scale including Lao PDR (MRC, 2006). MRC uses the Decision Support Framework (DSF) to analyze impacts of adaptation strategies. The DSF consists of the Soil Water Assessment Tools (SWAT) as the hydrological model, linked with IQQM as the basin model, and ISIS as the hydrodynamic model. All together are used as Impact Analysis Tools, addressing both the spatial and temporal resolution of the modelling requirements (MRC, 2006). MRC carried out the impact analysis for both the ECHAM4 A2 and ECHAM4 B2 Scenarios for the Mekong Basin including Lao PDR to compute total flow, snow melt, mean annual peak, extreme peak, mean monthly flow, mean dry season flow and mean wet season flow for both present (1985 - 2000) and for future climate change scenarios (2010-2050) (MRC, 2009c). The study was accomplished through the Joint MRC-CSIRO Project on Climate Change Vulnerability in the Mekong River Basin (2007 - 2009) with support from AusAID on regional scale. The outputs, toolkit and

² SRES: In order to predict future climate change, a projection of how anthropogenic emissions of greenhouse gases (and other constituents) will change in the future is needed. A range of emission scenarios has been developed by the IPCC). In this study, A1F, A2 and B2 were referenced as used in different countries.

know-how for these are available with MRC but not with the Lao Government department or institutions (Srinetr et al., 2009).

In a recent study, Lacombe and Hoanh (2009) analyzed the impacts of climate change on rainfall and temperature in the Greater Mekong Sub-region. They used the PRECIS regional climate model data (scenarios A2 and B2), produced by SEA START, and considered over the period 1960 - 2049.

Impacts on the Water Sector

“As much as climate change mitigation is about energy, climate change adaptation is about water”, states the policy brief of the project called Water and Climate Change in the Lower Mekong Basin Project (TKK and Southeast Asia START Regional Center, 2009). The reason for the major relevance of water in climate change adaptation, according to the project implemented by the Helsinki University of Technology (TKK) and the Southeast Asia START Regional Center, is based on the severe impact of climate change on ecosystems and people’s livelihoods through changed water cycles (TKK and Southeast Asia START Regional Center, 2009).

Climate change impacts due to extreme hydrological events and changes in water resources in Southeast Asia – including Lao PDR – were assessed by Snidvongs (2006). Also, rain-fed farmers’ vulnerability and adopted adaptation approaches have been analyzed. According to the applied climate change model, significantly longer hot periods in future summers and shorter cold periods (see Figure 4) as well as increasing precipitations must be expected, especially in eastern and southern Lao PDR. As a consequence on water resources, climate change is likely to increase water levels in most of the Mekong River’s tributaries, which will enhance the risk of flooding (Snidvongs, 2006). The findings of the study concerning vulnerability and adaptation measures of rain-fed rice farming in view of climate variability are presented in chapter 2.2.2 on agriculture and food security.

Eastham et al. (2008) also investigated climate changes in the Mekong Basin by 2030 and their potential impacts on water resources. The results of the projections indicate that the annual basin runoff is likely to increase by about 21%, mainly due to increased runoff as a consequence of increased precipitations during the rainy season. As a consequence, Eastham et al. (2008) estimate that the current water availability will be maintained or increased, despite potentially increased water

withdrawals. However, increased flooding is likely to affect the whole basin, with the greatest impact to be expected in downstream catchments due to the cumulative effect of the increased water runoff. Concerning the dry season precipitation, climate change is expected to have a decreasing effect in Central and Southern Lao PDR, but is expected to increase the dry season precipitation in Northern Lao PDR (Eastham et al., 2008).

The results from Lacombe and Hoanh (2009) differ from those of Eastham et al. (2008), indicating that the total annual rainfall in Lao PDR is not predicted to change significantly (Lacombe and Hoanh, 2009; Roth, 2009). However, Lacombe and Hoanh (2009) show that the clearest tendency for the Lower Mekong Basin is a decrease of light rainfall and of rainy days during the dry season in the Southern part of the catchment. Furthermore, Lacombe and Hoanh’s results indicate a 2-day shift in onset and end of the wet season every ten years of the study period (Roth, 2009).

Vulnerability and Adaptation in the Water Sector

Vulnerability

The sustainability of water resources has been recognized as a critical factor for Governments’ objectives to reduce poverty and foster economic growth in the past years (ADB, 2004). According to the WFP (2007), 46% of Lao PDR’s rural population are vulnerable to drought, most of them being located in the Southern lowlands and the majority of them being farmers, especially in rain-fed agriculture.

Vulnerability to changes in water resources may be exacerbated due to the existence of interest conflicts between different water uses such as agriculture and hydropower, posing a high challenge of coordinating the management of water resources (ADB, 2004). General water-related adaptive responses and institutional changes are presented here.

Adaptation

The Lao Government has implemented several institutional and legislative measures in order to foster efficient and effective water resources management (ADB, 2004). An important first step was to promote an integrated water resource management (IWRM) approach for reinforcing links and synergies between water, land use, environment and sustainable development. Also for this purpose, the Water Resources Coordinating Committee

(WRRCC) has been established in 1998. Still, however, insufficient coordination among the total 22 central agencies and provincial departments or related to the water sector is stated as a remaining institutional problem in the water sector. Although the problem still exists, yet this could be seen as a step towards increased priorities to reduce the vulnerability associated to water sector not just in physical forms but also to overcome the barriers in formulating adaptation strategies at first and then build a mechanism for effective implementation. Continued efforts of the government and others are trying to strengthen the water sector institutions. The institutionalization and integration of the IWRM approach at central as well as provincial levels has been identified as one of the main long-term objectives in the water sector (ADB, 2004).

The MRC is an essential institution at regional level in terms of the management of water resources. Besides research activities about climate change and implications on hydrology, vulnerability and adaptation in the Lower Mekong Region, the MRC also sets the climate change agenda for the Lao National Mekong Commission (Resurreccion et al., 2008). More recently, the MRC has launched a Climate Change and Adaptation Initiative (CCAI) for the Mekong River Basin (see section e).

Gaps Identified in Programs and Studies

The NAPA report states that assessments, analyses or predictions concerning the potential future impacts of climate change have to date only been done to a very limited extent at the national level (Lao PDR, 2009a). Although climate change phenomena such as longer dry seasons and unusual flood events are experienced by the population, hardly any data for confirming such perceptions and even less for assessing future climatic conditions are available. It is mainly due to a general lack of capacity and resources that the Lao government and institutions have not been conducting their own climate change research and studies, is stated in the NAPA (Lao PDR, 2009a). Indeed, the forecasts available are mainly short-term and based on monthly weather monitoring, or are provided by external and regional sources such as data from the Global Telecommunication System linked from Bangkok or data from the MRC or the South East Asia START Regional Centre (SEA START) (Lao PDR, 2009a).

An exhaustive review of various research papers, reports and policies reveal the gaps pertaining to the water sector in Lao PDR:

- Advanced statistical analysis of historical climate and hydrological data is not available and should be undertaken to determine the characteristics of vulnerability at provincial and local scales. MRC (2009b), for example, identified capacity building programs aimed at increasing climate change awareness, and scientific knowledge as a major priority for the CCAI. A package of climate change modelling and assessment tools are to be provided by MRC to the designated agencies in Lao PDR (MRC, 2009b).
- The range of climate uncertainty and variability using observed climate data before using the Global Climate Model Projection data for Lao PDR to be made available.
- Application of hydrological or water balance model by the line departments and national institutes or universities is not available. Some analysis with this respect has been made and was undertaken by international or regional consultants using donor funded resources.
- A national strategy for addressing the multipurpose use of water – including water supply, hydropower, irrigation, and fishery – is not available and it's development could serve as a basis for comprehensive adaptation strategies in view of water-related extreme events such as, floods and droughts (MRC, 2009b)

Recent Projects in the Water Sector

Listed here are a few recent initiatives in the water sector, related with the adaptation to climate change. They include projects at regional, national and at the provincial level.

The MRC-GTZ Watershed Management Project is a pilot study for mainstreaming integrated watershed management (GTZ and MRC, 2007). It aims at exploring the 'opportunities of climate change adaptation on the watershed level', meaning that impacts on natural ecosystems and the complex hydrological regime of the Mekong are easier to be addressed within the same watershed than within administrative units. As a first step, a field study in Nam Ton Pilot Watershed Area in Vientiane Province has been undertaken to define the physical climate change impacts perceived and adaptation measures taken at the local level. The response from the local people indicate trends in climate change, such as warmer temperature, heavier rain, change in the rainy season schedule in the form of delayed onset of monsoons, longer and drier dry seasons, and more flooding. Current adaptation measures were

stated to follow the nature, and is looking up for the better local governance (GTZ and MRC, 2007). The MRC-GTZ Watershed Management Project is in its current phase is expected to bring a comprehensive watershed management plans of action for each of the pilot areas (MRC and GTZ, 2008). The evaluation team recommends that the next phase of project should include climate change adaptation issues as priorities, in their project plan (MRC and GTZ, 2008). MRC's Climate Change and Adaptation Initiative (CCAI) for the Mekong River Basin, is technically supported by the International Water Management Institute (IWMI), Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and SEA START (MRC, 2009a). The initial phase was implemented in July 2008, with the Regional Climate Change Forum as one of the first activities for fostering dialogue and consultation among the concerned stakeholders of the Lower Mekong Basin (MRC, 2008). A major goal of the CCAI is to improve the understanding of how the Mekong River environmental systems will be threatened by climate change. Also, the potential vulnerability will be intended to be reduced by establishing adaptation frameworks and mechanisms (MRC, 2008).

At the national level, an integrated water resource management (IWRM) supported program was launched in October 2009 (Vientian Times, 2009a). The initiative is intended to help the Water Resources & Environment Administration (WREA) with the implementation of IWRM issues, such as the development and mainstreaming of river basin plans, sustainable use of ground water, and large-scale water resource development projects. The program, being implemented from 2010 to 2012 is supported by the Asian Development Bank (ADB), the Australian Government's Aid Program- AusAID and the Lao government (Vientian Times, 2009a).

Also relevant to the water resources sector, especially with respect to adaptation to climate change, a technical assistance project will be undertaken from 2010 to 2012 (Vientian Times, 2009b). It is funded by the ADB and the Nordic Development Fund (NDF) and is led by the WREA. The project was launched in November 2009 and includes adaptive capacity development of WREA officials to cope with climate change, promoting climate resilient development of the country, and to strengthen access to financial instruments such as the Least Developed Country Funds. Climate change adaptation pilot activities will adopt approaches of "learning by doing" and "ecosystem-based adaptation" while addressing the priority sectors like agriculture, water and forestry (Vientian Times, 2009b).

At the provincial level, five southern provinces of Lao PDR are currently case study sites to assess the impacts of climate change on water resources. The technical assistance work is funded by ADB and includes the modelling of the impact of climate change on probabilistic flood risks, carried out by RMSI (2007), a consulting firm based in India (ADB, 2009a).

Agriculture and Food Security Sector

Lao PDR's agriculture sector represents the country's most important source of income, providing 40.3% to the total GDP in 2007 (Lao PDR, 2009a) and is also a critical factor towards Lao PDR's food security.

Range of Studies Reviewed and Methods Applied

Snidvongs (2006) presents a number of methods and models in the study on, "Extreme hydrological events and changes in water resources in Southeast Asia". To study climate change impacts on rain-fed agriculture, the Decision Support System for Agro Technology Transfers (DSSAT version 4.0) is used for crop modelling to simulate future potential yield of rice vulnerability. Data considered in the modelling includes parameters such as range of temperature, precipitation and solar radiation. The potential impact of increased floods due to climate change, however, was not included (Snidvongs, 2006).

Chinvanno et al. (2006) studied the farmers' strategies for adapting to climate variability through household surveys and focus group meetings in selected study sites in Lao PDR, Thailand and Viet Nam.

In 2006, the World Food Programme (WFP, 2007) undertook a comprehensive analysis of food security and vulnerability in Lao PDR. The data collection took place through a key informant questionnaire that was distributed to the village head in the selected villages (in total 398) and a household questionnaire administered to sampled households (in total 3,926). This primary data was complemented by the secondary data such as food security literature from Lao PDR (WFP, 2007).

A study led by the ADB reviewed the situation of the rice sector in Lao PDR, by reviewing existing studies and data (Bestari et al., 2006).

The strategy framework reports of the National Agriculture and Forestry Research Institute (NAFRI) and Northern Agriculture and Forestry Research

Center (NAFReC) (NAFRI, 2008b) reviewed the institutional responses in the agricultural sector.

Impacts on Agriculture and Food Security Sector

Snidvongs' (2006) has undertaken a study on climate change impacts due to extreme hydrological events and changes in water resources, including crop modelling for assessing the impact of climate change on rice productivity in Southeast Asia. Study findings indicate that the rain-fed rice production in Lao PDR, more specifically in Savannakhet province – shows tendency to be only slightly reduced under the modelled climate change scenario, taking into account longer hot and shorter cold periods (see also chapter 2.1.3 and Figure 4). However, it is to be noted that potential impacts due to more frequent and intense floods have not been assessed in this study. Indeed, discussions with farmer communities in Lao PDR have shown concerns among the farmers in view of an increased possibility of floods in future due to climate change (Chinvanno et al., 2006). Already, climate variability has been affecting Lao farmers, due to which adopting adaptation measures is necessary. The adaptation measures have evolved over the years, mainly because of the increasing variability in the dates of onset and end of the rainy season, changes in the wind direction, changes in rainfall distribution pattern throughout the season, and an increase in thunderstorm activity. Further, occurrence of these climatic events have increased in frequency throughout the rainy season, namely midseason dry spell after that rice seeds are sowed and occurrence of floods before the crop has been harvested have posed significant threats to farmers' livelihoods (Chinvanno et al., 2006).

Vulnerability and Adaptation in the Agriculture and Food Security Sector

Vulnerability

The country has seen a significant reduction of poverty due to the economic growth during the past two decades and despite the fact that the agriculture sector is the population's predominant economic activity, insufficient food security is still affecting an important part of the Lao population (WFP, 2007). One main reason is that the country is predominantly mountainous – about 80% of the total surface (Lao PDR, 2009a) – making significant portions of the land not accessible by road and/or not cultivable (WFP, 2007). Especially in rural areas, chronic malnutrition is alarmingly high, with 50% of the children being affected. This indicates that Lao's food security has not improved over the past decade. The

study highlights that 13% of Lao's rural population faced food insecurity at the time of the studied period during the post-harvest season and more than 50% were at risks to becoming food insecure because of floods and droughts (internal shocks) or oil price peaks (external shocks). This means that in total, two thirds of the rural population is effectively or potentially affected by food insufficiency. The study identified droughts as the biggest threat to the food insecurity, potentially affecting 46% of the rural population.

Adaptation

Farm households in Savannakhet Province have developed considerable ability to adapt to existing climate variability and hazards, states Snidvongs (2006) and the working report of Chinvanno et al. (2006). Chinvanno et al. (2006) and Snidvongs (2006) assessed the vulnerability and the adaptation of farmers to climate change. The results of the field survey indicate that the farmers' vulnerability varies from place to place, depending on the degree of climate impact, socio-economic as well as the area's physical conditions. At the same time, the socio-economic situation strongly influences the adaptation measures undertaken by the rain-fed farmers. Farmers in less developed socio-economic conditions in Lao PDR tend to rely mostly on simple farm level measures being implemented with limited financial and other resources, the food security of the household being a major focus. Adopted farm level measures include raising livestock and harvesting for increased food resources and changes in seed varieties, timing and methods of cultivation. Farmers in Lao PDR tend to rely on the natural eco-system for improving their livelihood. Farmers in more developed conditions such as in Thailand, on the other hand, show the tendency to adopt measures such as seasonal migration to urban areas for diversifying the income and show a higher dependency on improved technologies and financial resources. Due to the limited extent of adaptation measures at national and community levels to date, the study identifies the adaptive capacity at the individual farm levels as key limiting factor for managing climate risks in Lao PDR. The implementation of an early warning system together with accurate risk communication techniques reaching the affected population could improve the performance of on-farm adaptation measures, but constraints include the precision of climate forecasts and the reliability of communication networks. Also, the lack of suitable seed types, dependency on rice, consumption preferences and lack of financial knowledge and other resources impose limits to

develop more climate resilient rice varieties or switch to alternative crops (Snidvongs, 2006).

Also in 2006, a study lead by the ADB reviewed the situation of the rice sector in Lao PDR (Bestari et al., 2006). The study states that the rice industry has seen a tremendous progress in the last two decades, with the rice production and per capita rice availability having increased. The country will need to accelerate the growth of rice productivity, however, if Lao PDR shall maintain its self-sufficiency in rice, in view of population growth and the associated increasing demand. Furthermore, although the food security could be improved at national level, rice availability is still not fully sufficient for farm households in remote areas or with limited incomes. Insufficient funding for developing agricultural institutions and research systems is mentioned as a current constraint to face challenges in rice production (Bestari et al., 2006). It has to be noted that this study is – although being recent – not mentioning the challenges posed by climate change on the rice sector.

Institutional responses

The National Agriculture and Forestry Research Institute (NAFRI) – implemented in 1999 – acts as a leading research agency in the agricultural and natural resource sectors (NAFRI, 2008a). It used to focus on technical research, but shifted to provide information for national debates on poverty alleviation and sustainable development, as well as for emerging issues such as climate change and associated opportunities and constraints (NAFRI, 2008a). It has to be noted that although NAFRI mentions the issue of climate change in its strategic plan for 2007-2012, the strategy paper addresses only bio-fuels as energy sources, carbon sequestration and trading, and does not mention the potential impacts and adaptation needs due to climate change.

In 2011, NAFRI established the regional center NAFReC (Northern Agriculture and Forestry Research Center). According to the strategy framework report of NAFReC (NAFRI, 2008b), radical changes in agricultural production are going on in Northern Laos: Farmers are replacing semi-subsistence production and shifting cultivation to permanent, new cash-crops such as maize, cassava, soybeans and rubber. This massive change has been introduced without accurately assessing the suitability of these crops to agro-environmental conditions and their impacts on the sustainability of land use and food security, according to the report (NAFRI, 2008b). The newly established NAFReC aims to respond to the

needed scientific knowledge for adequately adapting the new agricultural system to the local conditions as well as to consider emerging issues such as climate change. One proposed activity for the NAFReC is that the institution shall help research centers in the preparation of data regarding best practices, market trends, and agro-meteorological data in order to understand the climate change impacts and its implications for the suitability of new crops (NAFRI, 2008b). Lessons learnt in the NAFReC are intended to be used in the development of a southern regional center, the SAFReC (NAFRI, 2008a).

Gaps Identified in Programs and Studies

Snidvongs (2006) in its study on, “on-farm and off-farm adaptation measures”, assessed the limiting factors and effectiveness. Constraints include achieving satisfactory precision of climate forecasts and reliable communication for making the implementation of an early warning system work. The lack of suitable seed types, dependency on rice, consumption preferences and lack of financial, knowledge and other resources represent limits to develop more climate resilient rice varieties and thus, making it difficult to switch to alternative crops (Snidvongs, 2006).

The WFP study (2007) on, “food security” identified several reasons for the current food insecurity of Lao PDR’s population. These include constraints such as (1) lack of accompanying measures for mitigating the effects of policies affecting food security, such as the bans on shifting cultivation and opium production; (2) deficit of net rice production especially in the Northern provinces, which is currently not encountered with a sufficient extent of rice imports; (3) major dependency of rural households on rice and on the own production; (4) limited access to domestic and export markets due to poorly developed transport infrastructure; (5) limited access to other food items than rice, e.g. vegetables and fruits, due to seasonality; (6) limited access of households to wild animal and fish proteins; and (7) less healthy food consumption patterns due to lower levels of education and literacy. The study includes a range of recommendations to improve the Lao population’s food security (WFP, 2007).

Stated here is an observation made in view of the revised studies is that, although the NAPA has identified agriculture and forestry as most vulnerable sectors – together with the sectors health and water resources – NAFRI does not mention climate change in its Strategic Framework for

the Center for Agriculture and Forestry Research Information 2009 - 2013, published in December 2008, and limits to bio-fuels as energy resources and carbon sequestration in the strategic plan for 2007 - 2012 (NAFRI, 2008a). In the NAPA, it is stated that no adequate tools and equipments are available to the NAFRI for developing and promoting animal species and crop varieties that are adapted to the local natural hazard conditions (Lao PDR, 2009a). This gap is intended to be tackled by NAPA's project number 6. Another example is project number 13, that addresses the lack of capacity of technical staff for researching on and developing biological fertilizers in order to improve the agricultural production (Lao PDR, 2009a).

Lao PDR being majorly a rice crop based economy, there is a need for both direct and indirect assessment of climate change impacts on rice value chain. However, this appears to be off the radar at this point of time in the government or various donor agencies being in the strategy and planning process. Moreover, in order to assess the direct biological impacts of climate change, an application of crop growth model is needed. Lao PDR is yet to exercise such models or risk management approaches in this context. Furthermore, in order to understand the potential impacts of water shortage, groundwater depletion and its implication to livelihood or income generation, a basic modelling toolkit such as water balance model, input-output optimization and maximization methods and practices are important that is unavailable for informed decision making processes.

Recent Projects in the Agriculture Sector

In August 2009, the GEF submitted a project proposal from the UNDP to the Least Developed Countries Fund (LDCF), intended to improve the resilience of the Lao agricultural sector to climate change impacts (GEF, 2009). The project aims to fulfil the implementation by 2014, including the components of access to climate risk information, policy analysis and capacity building, community-based climate risk reduction, and adaptation learning.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

Data and information on socio-economic implications of disasters has been reviewed from the International Disaster Database (EM-DAT, 2009) and the Global Facility for Disaster Risk and Recovery (GFDRR, 2009a).

The Lao PDR NAPA report (Lao PDR, 2009a) and food security and vulnerability analysis of the WFP (2007) provides information on Lao PDR's vulnerability regarding socio-economic aspects.

Regarding adaptation strategies, Brahmi and Pounphone (2002) conducted a study on local coping mechanisms in disaster management through a survey in nine Lao villages of different geographical and ethnical ranges.

Socio-Economic Impacts

The most recent major natural hazard – number nine out of the top ten regarding the number of affected people in the period 1980-2009 – was a flood in August 2008 (EM-DAT, 2009). It is estimated to have affected more than 204,000 people, damaged 50,000 ha of arable land and caused an economic loss of over US\$ 9 million (EM-DAT, 2009; GFDRR, 2009d). The GFDRR notes that because of high degree of poverty in rural areas, even natural disasters of low intensity affect rural farmers (GFDRR, 2009a).

A key issue regarding socio-economic impacts is that climate change is likely to increase food and forestry trade, with developing countries becoming more dependent on food imports (Easterling et al., 2007). The expected impacts of climate change on countries GDPs depend on the scenario and region. However, poor countries are likely to suffer damages in all climate scenarios. A recent study projects that by 2100, the poorest quartile of the world's nations – including Lao PDR and Viet Nam – will suffer significant damages in percentage of GDP, across all scenarios, while the richer quartile will benefit in all but one scenario (Mendelsohn, 2006).

Vulnerability and Adaptation in the Socio-Economic Context

Vulnerability

Poverty in Lao PDR could be reduced over the past years: 39% of households were living below the poverty line in 1992/3, whereas the percentage was 29% in 2002/3 (Lao PDR, 2009a). But still, Lao PDR is – beside Cambodia, Myanmar and Timor Leste – one of the four Least Developed Countries (LDCs) in Southeast Asia: The per capita income in 2005 was US\$491 and in 2004, 71% of the population had less than US\$2 available a day for supporting their livelihood (WFP, 2007).

Laotian's livelihoods depend strongly on Lao PDR's natural resources – namely 80% of the population –, which makes the country highly vulnerable to

climate change impacts on the natural ecosystems (UNDP and WREA, 2009). Effectively, Lao PDR's socio-economic development has seen significant adverse effects due to climatic extreme event such as floods and drought occurring in past years (Lao PDR, 2009a). Especially, the agricultural sector, being affected by climate change, is a major contributor to the economy of Lao PDR and the livelihood of its people. Besides the income, employment, and food security affected, water and forestry resources as well as public health are other socio-economic aspects are influenced by climate change. Indeed, climate change seems to cause an exacerbation of already existing man-made environmental risks such as environmental degradation as well as of natural disasters (Lao PDR, 2009a).

Also, socio-economic conditions and food insecurity of Lao's rural population appear to be strongly related: According to the WFP-study (2007) on Lao PDR's food security situation, people affected by food insecurity tend to be farmers that are lowly educated, illiterate, from non-Lao-Thai ethnic groups, practicing farming in upland and highly sloped areas, and living in villages with poor sanitary and infrastructural conditions.

Adaptation

In the Lao Province of Attapeu, a vulnerability assessment of climate risks was carried out under the Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme in 2005 (ADPC, 2005). The study recommended enhanced livelihood options to being less vulnerable to severe flooding and droughts. Options to diversify activities in an agrarian economy include agro-processing, eco-/agro-tourism, and the promotion of traditional handicrafts. The availability of credit systems for village communities is proposed as another option for supporting sustainable livelihoods (ADPC, 2005). A study on local coping mechanisms in disaster management has been published in 2002, focusing on how rural poor in Laos are applying coping mechanisms in response to shocks to their livelihoods caused by disasters (Brahmi and Pounphong, 2002). The study revealed that there is a considerable gap between the perception of the government and most development practitioners, on the one hand, and the perception of the poor population, on the other hand, with respect to the definition of a 'disaster'. The latter can be distinguished between a 'big disaster' and 'ongoing disasters'. The investigation revealed that recurrent seasonal human diseases constitute the greatest threat to the people's livelihoods, since human labour constitutes the essential resource

for the provision of food through hunting, fishing, and agriculture. In the case of illness, the level of subsistence cannot be sustained besides disasters bring varying degree of coping scope. Also, the study shows that currently ongoing economic, socio-cultural and environmental changes in Laos significantly impact the indigenous coping capacity of the poor's livelihoods. The critical changes include rapid population growth, expansion of the market economy, and the relocation of communities from forested mountains to valleys, which leads to the incapacity of populations to adapt the food production to unfamiliar environment and market conditions, and to withstand lowland diseases and climatic conditions. The access to market, for instance, seems to have affected the use of kinship and solidarity as coping mechanisms in the case of disasters. The recommendation formulated in the study is that disaster management must be mainstreamed into rural development programming. According to the study, there is already some evidence that disaster management programs in Laos are already increasingly focusing on addressing the causes of the population's vulnerability to disasters for mitigating their effects (Brahmi and Pounphong, 2002).

Institutional Responses

Poverty reduction is a key goal of the Lao PDR government and constitutes the basis for the Government policies formulated in the National Growth and Poverty Eradication Strategy (NGPES) in 2003, aiming at overcoming Lao PDR's status of a LDC by 2020 (Lao PDR, 2009a). Also, thanks to education development plans, progress in the education level of the population could be achieved, with the adult literacy rate rising from 73% in 2005 to 77% in 2007. Overall, Lao PDR has improved its position in the Human Development Index of the United Nations from rank 141 (out of 173) in 1993 to the rank 133 (out of 179) in 2009 (Lao PDR, 2009a).

In 2006, the Sixth National Socio-Economic Development Plan (NSED) 2006-2010 was published (Lao PDR, 2006). This Plan aims at supporting the achievement of the goals that were outlined in the Ten-Year Socio-Economic Development Strategy (2001-2010), including the establishment of a fast and stable development. The Plan's targets and indicators mostly coincide with the Millennium Development Goals (MDGs) and the Brussels Programme of Action for Least Developed countries (2001-2010) (Lao PDR, 2006). It has to be noted, however, that the NSED does not address the threat posed through climate change to the country's development.

Gaps Identified in Programs and Studies

Brahmi and Poupphone (2002) concluded in their study that the media coverage as well as the relief funds and development assistances mainly focus on big disasters such as floods affecting densely populated . These regions are rice-producing areas of the country and relatively the 'well off' section of the society, having access to fertile paddy land and infrastructure. The majority of the poorest communities and often ethnic minority groups are living in remote forests or mountainous regions and are not considered under the financial economic and technical support programs (Brahmi and Poupphone, 2002).

Although, the high importance of water for the socio-economic development is recognized (ADB, 2004; Lao PDR, 2009a), the NAPA observes that the institutional framework for the management of water resources is still considered weak (Lao PDR, 2009a). In order to cope with growing demands on and limited supply of water resources – especially, in view of the need to adapt to climate change – a high priority project for strengthening institutional and human resource capacities in the water sector is proposed in the NAPA (Lao PDR, 2009a).

Furthermore, farm level applications in both water and food security sectors are necessary to understand the adaptive capacity of a household or farmers and to explain the socio-economic status of communities in Lao PDR for appropriate measures.

Recent Projects in the Socio-Economic Sector

A project titled, 'Climate Impact and Adaptation Sectoral Strategy for Rural Infrastructure in Lao PDR' has been introduced by the ADB (ADB, 2009a). This is a nine months pilot study under the ADB's Small Grant Facility (SGF) and its Climate Change Adaptation in Asia and the Pacific program. The project is being currently implemented by the consulting firm, RMSI and will investigate the impact of climate change on irrigation infrastructure and other agricultural infrastructure, and ensuing policy implications (flood risk assessment). The project is undertaken in the Southern provinces of Savannakhet, Saravane, Sekong, Attapeu and Champassak. The resolution of the risk assessment modelling will be at district and sub-basin levels. If successful, the project is seen as a precursor to a larger regional initiative. The main objective of this ADB SGF Study is to reduce climate change-induced flooding impacts on rural infrastructure and agriculture in Southern Lao PDR.

Activities include the collection of data and the application of a hydrological model, climate impact flood hazard-mapping for the Southern river basin, national and provincial strategies workshops, and the dissemination of Geographic Information System (GIS)-based flood risk maps (ADB, 2009a).

In October 2009, a project on the northern rural structure development, funded by the ADB, was approved (ADB, 2009b). The project aims to enhance and diversify livelihood opportunities for rural communities in Northern Lao PDR through investment in rural, agricultural productivity and market access. With relevant to climate change adaptation, the project provides the basis for mainstreaming climate change considerations into rural infrastructure investments and to implement cost-effective climate proofing measures in order to ensure the long-term protection of infrastructure (ADB, 2009b).

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Two domains are identified as cross-sectoral institutional settings-climate change and disaster risk reduction.

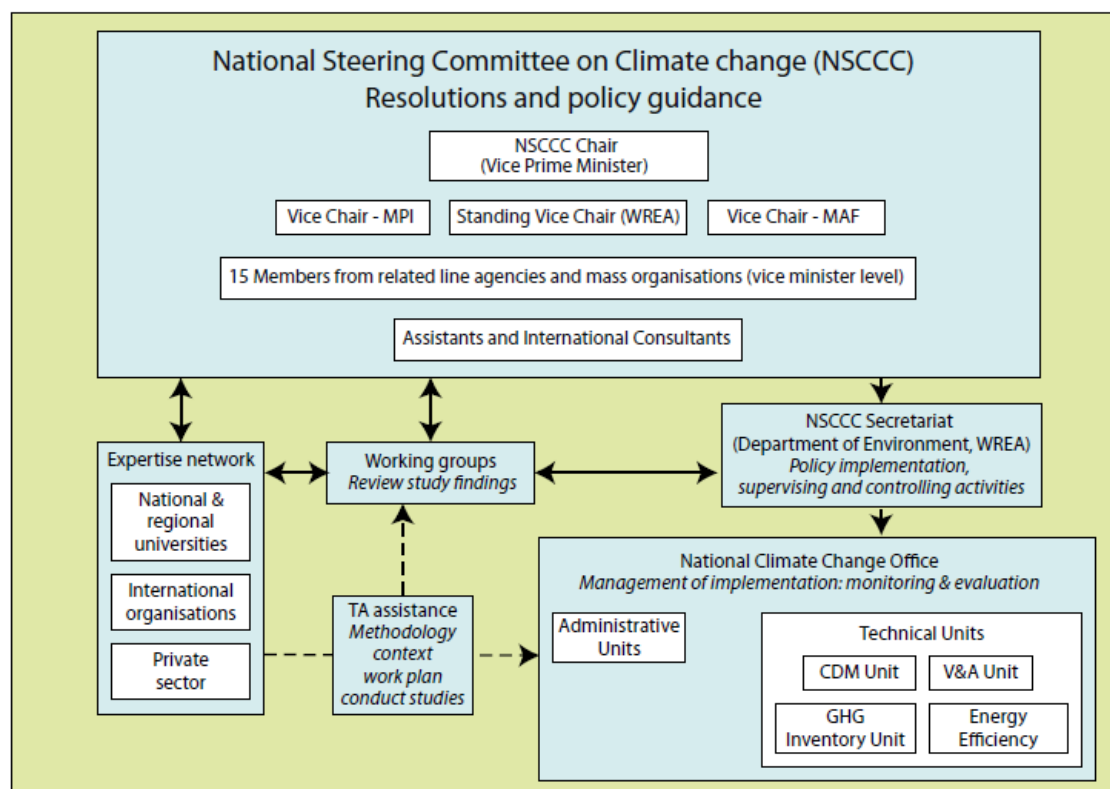
Climate Change

Climate change has only in recent years become a high priority policy issue in Lao PDR (Roth, 2009). Lao PDR begun its climate change journey in 1995 with the ratification to the United Nations Framework Convention to Climate Change (UNFCCC) and by joining the Kyoto Protocol in 2003 (UNDP, 2009b).

To deal with the increased challenges posed by climate change, the Department of Environment (DoE), WREA, has been appointed as the UNFCCC national focal point for the country's climate change actions and initiatives (Roth, 2009). In 2008, the Prime Minister established the National Steering Committee on Climate Change (NSCCC) (Lao PDR, 2009b). The NSCCC has drafted the National Strategy and its Action Plan on Climate Change (NSAPCC). In 2009, the WREA published the National Adaptation Programme of Action to Climate Change (NAPA). National Steering Committee on Climate Change (NSCCC).

In 2008, the NSCCC and the Climate Change Office were established with the goal to coordinate the development of national strategy to manage climate change and its impact, and to establish an action

Figure 8: Institutional climate change arrangements in Lao PDR (MRC, 2009)



plan on programs to be undertaken (UNDP, 2009b). The NSCCC is chaired by the Deputy Prime Minister, the Director General of the DoE as the secretary and includes members from all concerned sectors (Roth, 2009). An overview of the new institutional settings in Lao PDR concerning climate change is presented in Figure 8.

One of the first assignments undertaken by the NSCCC was to form the following seven Technical Working Groups lead by representatives from various line agencies (MRC, 2009b):

- Food and livelihoods security and agricultural productivity (Ministry of Agriculture and Forestry),
- Forest and land management to reduce emissions from deforestation and degraded landscapes (Ministry of Agriculture and Forestry and National Land Authority),
- Energy Management including export of electricity to neighbouring countries (Ministry of Energy and Mines),
- Hydrology assessments to predict variability and vulnerability to water resources (WREA),
- City infrastructure resilience and efficient building design (Ministry of Public Works and Transport),

- Economic management to ascertain the implications of climate change impacts on growth targets poverty reduction goals and attaining the country's 2020 vision (Ministry of Planning and Investment),
- Financing instruments economic incentives and benefit sharing arrangements (under the clean development mechanism or successor arrangements).

These Technical Working groups were established to study and assess the respective climate change impacts for the period 2009 - 2020. The DOE, in collaboration with the Technical Working Groups and based on their impact studies, drafted the documents: (i) National Climate Change Strategy for 2020; (ii) Interim Action Plan for 2009 - 2011; (iii) First National Action Plan for 2011 - 2016, in accordance of the 7th National Socio-Economic Development Plan (MRC, 2009b).

National Strategy and its Action Plan on Climate Change (NSAPCC)

The NSAPCC is currently due completion and is expected to provide the framework for the development of Lao PDR's climate change adaptation and mitigation activities (Lao PDR, 2009b).

The NSAPCC will be implemented in three phases in the period 2009 to 2020 (Lao PDR, 2009b), pursuing the following structure of implementation. During Phase I (2009-2010), the focus is on (i) building climate change awareness; (ii) mainstreaming climate change; (iii) strengthening policies and institutional capacity; and (iv) expanding the knowledge base. Phase II (2011-2015) will pursue (i) the implementation of the thematic priorities initiated in the first phase; and (ii) in the meantime, start the implementation of the adaptation and mitigation actions, some on a pilot basis. Phase III (2016-2020), will aim for full-fledged implementation of all the actions (Roth, 2009).

Early this year, the NSAPCC and the new climate change office have been able to launch the strategy for the country. However, the implementation of this is tentatively planned in a three-pronged manner. While the Phase-I has begun, the allocation of money for all these phases is still open. Nonetheless, the government officials in Lao PDR with limited skilled human resources are trying to cope with various multi and bilateral donor agencies to streamline the funding sources to undertake some of these planned developmental measures to combat climate change (ADB, 2009a).

National Adaptation Programme of Action to Climate Change (NAPA)

The National Adaptation Programme of Action (NAPA) to Climate Change, approved by the government in 2009 has identified four priority sectors for the adaptation to climate change: agriculture, forestry, water, and health (Lao PDR, 2009a). Across all sectors, forty five priority project proposals were prepared for implementing adaptation activities in four main sectors - agriculture, forestry, water and water resources, and public health. Twelve of these projects are of high priority, followed by the remaining thirty three projects. The following are the proposed adaptation projects of high priority (Lao PDR, 2009a):

Agriculture

- Strengthen the capacity of the National Disaster Management Committees
- Promote secondary professions for farmers in order to improve the livelihood of farmers affected by natural disasters induced by climate change

Forestry

- Continue the slash-and-burn eradication program and permanent job creation program

- Strengthen capacity of village forestry volunteers in forest planting, caring and management techniques as well as the use of village forests

Water resources

- Raise awareness on water and water resource management
- Mapping of flood-prone areas
- Establish an early warning system for flood prone areas, and improve and expand meteorology and hydrological networks and weather monitoring systems
- Strengthen institutional and human resource capacities related to water and water resource management
- Survey underground water sources in drought prone areas
- Study, design and build multi-use reservoirs in drought prone areas

Health

- Improve systems for the sustainable use of drinking water and sanitation with community participation in flood and drought prone areas
- Improve knowledge and skills of engineers who design and build water and sanitation systems

No further prioritization has been done within these defined priority actions. The WREA has been assigned to be the central institution for disseminating the NAPA plan throughout the country, to mobilize funds, and to take the lead in collaborating with the main sectors (Roth, 2009).

Recent Projects: Development of the Second National Communication to the UNFCCC

A very recent project concerns the development of the Second National Communication for Lao PDR, the initiative being approved by the WREA in November 2009 (UNDP, 2009a). It aims at supporting the Government in the development of a "comprehensive and consolidated response to national climate change challenges", by the end of October 2011. WREA is the implementing partner, while funds are provided by GEF, UNDRRO and the government. The first planned project objectives and activities include (i) the development of a National Circumstances Report assessing Lao PDR's sectoral policies, national strategies and plans, and the capacity for climate change mitigation and adaptation; (ii) strengthening of capacities for realizing climate change vulnerability, mitigation, and adaptation assessments; (iii) developing a set

of recommendations for mainstreaming climate change issues into environmental, social and economic policies and for awareness raising; (iv) establishment of a climate change coordination mechanism; and (v) supporting the development of Lao PDR's National Climate Change Strategy (UNDP, 2009a).

Addressing the challenges of climate change is expected to contribute to the achievement of the MDGs and to the enhancement of the livelihoods of Lao PDR's poor, vulnerable and food insecure population (UNDP, 2009a).

Institutional Settings Concerning Disaster Risk Reduction

National statistics on disasters such as those from the Department of Meteorology and Hydrology show an increased severity and frequency of floods and droughts during last three decades (Lao PDR, 2009a). Such extreme climatic events have been causing damages to the country and the livelihoods of its people, as a consequence of which the government of Lao PDR has started to develop activities that "prevent damage from, and strengthen adaptation to, climate change", as stated in the NAPA (Lao PDR, 2009a).

Disaster Risk Management

In 1999, the National Disaster Management Committee was created in order to take a lead role for an effective implementation of emergency activities in the case of disasters and extreme events, with the National Disaster Management Office (NDMO) as its secretariat (GFDRR, 2009d). Examples of past activities to adapt to climate change include, the building of embankments for flood protection, water drainage channels, water gates along the Mekong River and its major tributaries, and the installation of water pumps and irrigation systems for combating drought (GFDRR, 2009d; Lao PDR, 2009a). Also, flood and drought prevention and response projects, such as the Anti-Disaster Preparation Project with the organization Concern Worldwide, and the Disaster Risk Reduction Project with Oxfam Australia, have been undertaken (Lao PDR, 2009a).

The government introduced a Strategic Plan on Disaster Risk Management (SPDRM) in 2003. It defines immediate objectives to establish District Disaster Management Committees in all districts, to establish warning and information dissemination systems all over the country, and to integrate knowledge about disaster management and environmental protection

into development programs (Lao PDR, 2009a). It is not noted in the NAPA whether climate change impacts and adaptation are explicitly addressed in the Strategic Plan. By 2010, the NDMO, supported by UNDP is preparing a Strategic National Action Plan for disaster risk management (GFDRR, 2009d).

The GFDRR (GFDRR, 2009d) assessed the disaster risk profile of Lao PDR. It stated that significant progress in the disaster risk assessment has been made in recent years, with increased proactive disaster risk planning, systematic management of disasters, and towards reducing population's vulnerability by reducing poverty and improving rural farmers' living conditions (GFDRR, 2009d).

Gaps Identified

Of late, the linkages between disaster risk reduction (DRR) and climate change adaptation have provided a boost for climate adaptation as a point of departure, especially in the least developed countries. Some DRR measures that are linked with the agriculture sector include river embankment, protection of dams, seed stocking during floods, and maintenance and rehabilitation of irrigation canals that play a pivotal role for the rain-fed rice production in the country (ADB, 2009). Nonetheless, greater need for the National Disaster Management Office and Climate Change Office to collaborate closely to advance DRR components has been identified (GFDRR, 2009d). Also, although some risk mapping has been funded under donor projects in selected communities and districts, no country-wide hazard or risk mapping exists, to date. Furthermore, in the case of disasters, the information flow from local to national level is slow: There is lack of available capacity and resources for data collection and dissemination at the local disaster management level. The NDMO also lacks capacities for carrying out a comprehensive disaster information management system. A need to train school teachers on DRR issues has also been identified by the government (GFDRR, 2009d).

Recent Projects Concerning Disaster Risk Reduction

GFDRR is currently supporting the Lao PDR government in the reduction of natural hazard risks from floods and droughts through six components: (1) analysis of the government's existing institutional capacity of disaster risk reduction; (2) operationalization of the 2003 Strategic Plan on Disaster Management (SPDM) through the identification and prioritization of flood and drought prone provinces and the preparation of provincial and district disaster preparedness

plans; (3) strengthening of the early warning system through measures such as to improve the capacity in forecast modelling; (4) institutionalization of a replicable disaster risk reduction training program; (5) integration of disaster risk reduction into sectoral economic development strategies, the next NESDP, climate change initiatives, and other strategy documents; and (6) strengthening of the government's damage, loss, and needs assessment capacity (GFDRR, 2009a). The DRR program of the GFDRR is the first that involves line ministries in the disaster management and therefore, identifies the need for extensive coordination. The implementation of the program was planned for end of 2009 (GFDRR, 2009a).

Within the support of the GFDRR for improving Lao PDR's DRR, several projects are currently ongoing, such as, "Operationalizing Strategic Plan for Disaster Management" (GFDRR, 2009b), and the project GFDRR Country Programming for EAP (GFDRR, 2009c). The former aims at operationalizing and implementing the national strategic plan for disaster management, whereas, the latter supports the preparation of the participating countries' –Lao PDR, Viet Nam, Cambodia and the Philippines – disaster reduction action plans.

Furthermore, a new ASEAN cooperation project was introduced in April 2009 under a JAPAN-ASEAN integrated fund, focusing on the utilization of satellite images for disaster management (GeoInformatics Center, 2009). The project's five modules will include: (1) introduction of the project to local agencies that work on disaster risk reduction; (2) locally conducted technical trainings for skills development; (3) development of support materials in local languages; (4) seminars for planners and managers; and (5) regional workshops (GeoInformatics Center, 2009).

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Donors funding in climate change issues in Lao PDR is low (Roth, 2009). Few donors, ADB, WB, FAO, GTZ, AFD, SDC, JICA and KOICA are supporting agriculture, rural development and natural resource management. Traditionally, there is a tendency to support poverty alleviation and food security, mainly in the upland and northern regions of Lao PDR. A key example of support for climate adaptation is the UNDP's support of the Lao PDR NAPA process

(Roth, 2009). Also, other interventions may be relevant for improving climate resilience. However, a fresh review of such programs is needed to enforce adaptation as a developmental issue to harness far reaching impacts.

Limited institutional capacity and the lack of coordination and cooperation within the different sectors is one of the major constraints for implementing adaptation efforts. Reasons are lack of accurate information, data and in-depth studies at national level and a central agency that would act as a common interface for dealing with climate change (Lao PDR, 2009a). The institutional situation is weak due to lack of personnel resources – in quantity and quality, adequate tools and equipments, such as manuals and guidelines about climate change adaptation, as well as available budget (Lao PDR, 2009a). Despite the recent introduction of the NSCCC, the institutional capacity still needs to be strengthened.

As of today, public awareness on climate change issues is low at all levels: decision and policy makers, academic institutions, communities and the public.

National climate and hydrological research for providing data and projections are not available or yet generated and hence, there is a need to undertake studies to determine the vulnerable characteristics at provincial and local scales. Capacity building programs to increase scientific knowledge is identified to be of highest priority and further, there is a need for climate change modelling and assessment tools.

Furthermore, the following issues and challenges are to be addressed, in view of the formulation and implementation of climate change adaptation activities:

- To strengthen and expand the work on institutional development and technical assistance in climate change as a basis for progress on climate change adaptation issues.
- While better understanding of climate trends and projected impacts are essential, adaptation will continue with a certain degree of prevailed uncertainty and move towards adaptive capacity.
- Mainstreaming of climate adaptation would need provincial and local level policies too, and is required to work in tandem with national level policies and strategies.
- Ecosystem and climate change adaptation activities at regional scale is not a concern for

Lao PDR. Regional agencies, like the MRC are better placed for regional scope of activities.

- Vulnerability analyses must be undertaken at provincial level to highlight the hotspots and to overcome the lack of data on existing impacts and corresponding strategies need to be tackled with climate change, this being a tactical issue.

Regarding the three different sectors that have been analyzed, the conclusions that can be drawn from the review of the sectoral studies and programs, are:

Water Sector

- The high importance of adaptive capacity in the management of water resources must be recognized and implemented, such as in the Water Sector Strategic Plan.
- A sufficient level of coordination among the central and provincial agencies and departments related to the water sector must be achieved, especially in view of a successful implementation of an IWRM approach for the management of water resources.
- A national strategy for addressing the multipurpose use of water – including water supply, hydropower, irrigation, and fishery needs to be developed to serve as a basis for comprehensive, cross-sectoral adaptation strategies in view of water-related extreme events.
- Regional efforts such as the CCAI or the MRC-GTZ Watershed Management Project of the MRC must be made use of for fostering the adaptation of water resource management to climate change at national and local levels.
- In order to define vulnerability and adequate adaptation actions at national, provincial and local level and for long term –, the capacity to provide climate and hydrological data must be established.

Agriculture and Food Security Sector

- Institutions such as the NAFRI and studies on food security such as the one on rice lead by ADB (Bestari et al., 2006) do not sufficiently take into account the important climate change risks posed on agriculture and food security issues, hence, major awareness raising efforts are called for. This especially in the view that the agricultural sector is identified as being the most vulnerable sector to climate change.
- Limitations in existing studies' and methods not considered for potential climate change impacts on rice yields due to increased flooding (see Snidvongs, 2006) have to be overcome by

a meaningful assessment of vulnerability to climate change and corresponding adaptation strategies.

- In view of the identified gaps for improving the adaptive capacity in agricultural production – such as the lack of suitable seed types or lack of resources, measures explicitly addressing these gaps must be undertaken through research.

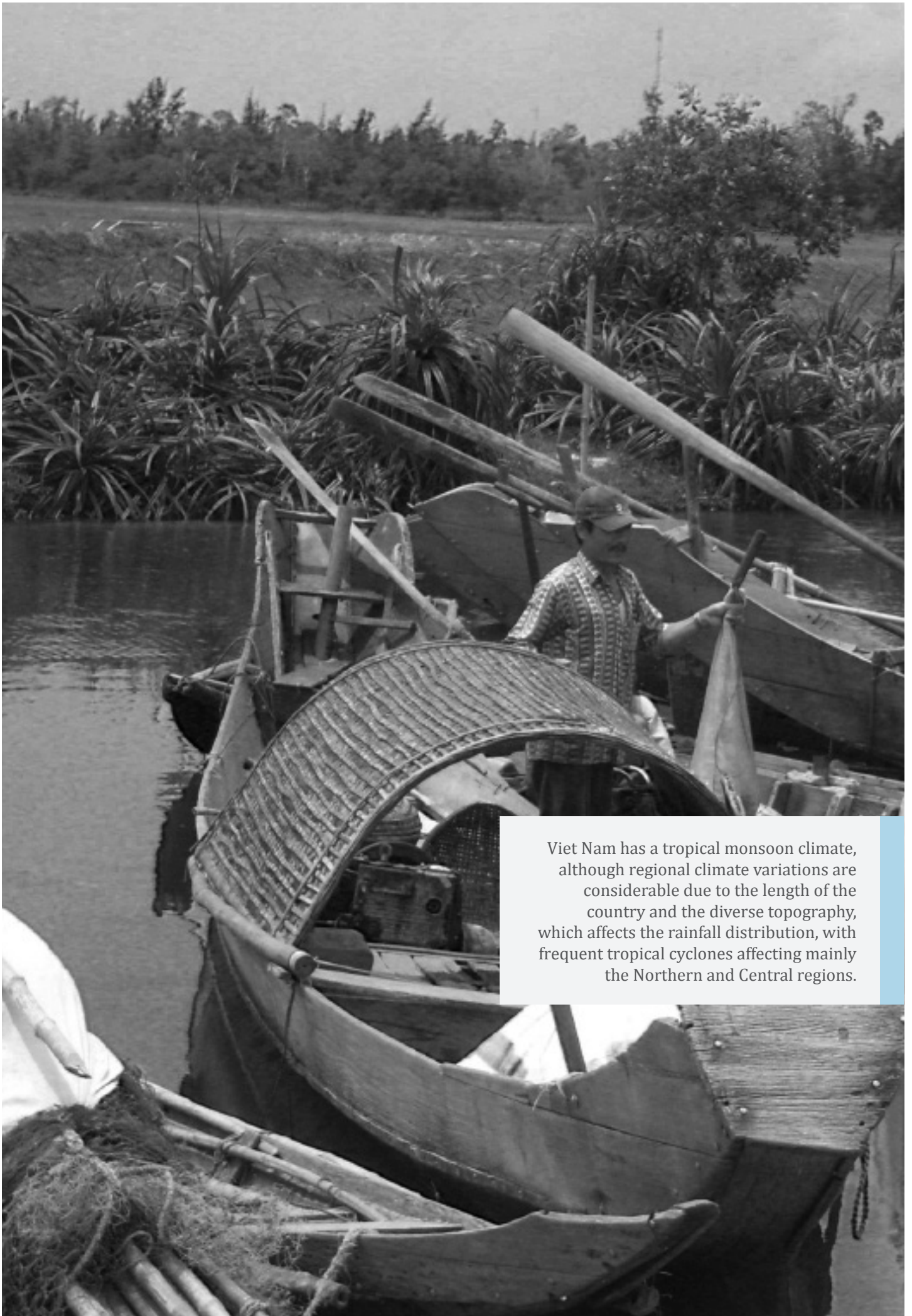
Socio-Economic Sector

- The socio-economic adaptation to climate change depends to a large extent on the adaptation status of the agricultural and the water sectors, due to their preponderant importance for the socio-economic development. Besides, efforts in reducing poverty also lead to enhanced capacities to respond to environmental changes, namely to natural disasters and their impacts on people's livelihoods. As a consequence, a more integrated and comprehensive development and climate change approach is appropriate for making use of synergies between climate change adaptation, disaster risk reduction and development.

Disaster Risk Reduction

- Although there is an increased awareness of the linkages between natural disasters and climate change, synergies must be increased. The newly created Climate Change Office offers a facilitated cooperation and coordination between climate change institutes and the NDMO. The Strategic Plan for Disaster Risk Management to be developed in accordance to the climate change (adaptation) efforts.
- The approach to involve line ministries in disaster risk reduction is new and therefore, needs an increased focus on extensive coordination.
- While disaster risk reduction in the past was mainly limited to engineering and technical measures, such as the construction of embankments, however, institutional efforts such as the mainstreaming of disaster risk reduction into sectoral strategies are needed for coping with future disaster risks.

Overall, a major infusion of resources is required in view of a general lack of fund and resources for the implementation of the NAPA. Also, capacity building is essential and a three-pronged approach is needed at national, provincial and local capacities in priority sectors.



Viet Nam has a tropical monsoon climate, although regional climate variations are considerable due to the length of the country and the diverse topography, which affects the rainfall distribution, with frequent tropical cyclones affecting mainly the Northern and Central regions.

RESEARCH SYNTHESIS ON VIET NAM

COUNTRY CHARACTERISTICS

The country characteristics cover information on Viet Nam's geographical, social, economic and climatic risks. An overview of the country's characteristics is provided in Table 3.

Table_3 Viet Nam Country Profile Overview

Country Information (World Bank, 2008; Chaudhry and Ruysschaert, 2007; Undata, 2009b)	
Geographic area	331,690 km ²
Population	87,375 million
Pop. density (person/km ²)	263.4
Borders	China, Lao PDR, Cambodia
Hills and Mountains (% to total area)	75
Plains land (% to total area)	25
Suitable for agriculture (% to total area)	8
GDP (million US\$)	71,174
Agricultural GDP (%)	22
Industry GDP (%)	39.9
Service GDP (%)	38.1
Population distribution	
- rural areas %	73
- urban areas %	27

Geographic Attributes

Viet Nam is located in the lower Mekong Region, bordering with China in the North and Lao PDR and Cambodia in the West. The land covers 331,689 km² (UNdata, 2009b) and has a coastland of 3,260 km (Chaudhry and Ruysschaert, 2007). Its mountains and highlands hold 3/4 of the total area, with elevations between 100 and 3400m, and the mountain system extends from the Northwest border to the eastern side of the South, with 1,400 km in total length. The remaining land area mainly consists of flat floodplain area corresponding mainly to delta regions: total length of all rivers in Viet Nam is 41,000 km with total flow of nearly 300 billion m³ of water, and 3,100 km of canals. The Red River has 510 km on Viet Nam territory and its delta surface is 15,000 km²; the Mekong River has 220 km on Viet Nam territory and its delta surface is 40,000 km².

Socio-Economic Status

Viet Nam's population is 8.7 million inhabitants (2007), distributed as 51% female, 49% male, 27.2% aged between 0 - 14 years (2008), and 17.2% older than 60 years. Population growth rate between 2005 and 2010 as percentage per annum is 1.3 and population density is 263.4 people per km² (2007) (UNdata, 2009b). The lowlands are extremely fertile and densely populated, and most of Viet Nam's agriculture and industry are concentrated there. The Urban population in 2007 was 27.3% and has a growth rate of 3.1% every year. On 2009, the United Nations Development Programme (UNDP) in Hanoi released a human development report, which reflects statistics for 2007. According to the report, Viet Nam ranks 116/182 nations on the Human Development Index (UNDP, 2009d). Referring to economic data, Viet Nam is a low-income country,

Figure 9: Viet Nam location map
(UNdata, 2009b)



with a GDP of 71174 million US\$ (UN data, 2009), but has recently made spectacular progress in terms of both economic growth and poverty reduction. The official poverty rate has fallen from 58.1% in 1993, to 16% in 2006. The high growth and rapid poverty reduction were accompanied by only very modest increases in inequality. The Gini coefficient, for example, rose from 0.34 to 0.37 between 1993 and 2004 and declined to 0.36 in 2006 (World Bank, 2008).

Climate Risks

Current Climatic Conditions

Viet Nam has a tropical monsoon climate, although regional climate variations are considerable due to the length of the country and the diverse topography, which affects the rainfall distribution, with frequent tropical cyclones affecting mainly the Northern and Central regions. The country is generally divided into three regions: North, Central, and South, and annual mean temperature in the different regions ranges from 8 to 29 °C. The monthly mean of the coldest month is about 13 - 20 °C in the North, while in the South, it is 20 - 28 °C. Annual rainfalls range from 600mm to 5,000 mm, with as much as 90 % of rainfall concentrated in the rainy season (ADPC, 2003; Chaudhry and Ruyschaert, 2007).

Viet Nam has a long history of coping with climatic variability and natural disasters. For the last 40 years climate has experienced some changes,

such as an observed annual temperature rise of 0.1 °C per decade between 1931 and 2000, and of 0.5 - 0.7 °C in the last 50 years (1958 - 2007). The localized intensity and unpredictability of the rainfall has increased, although the annual volume has remained stable, causing severe floods. There have been more droughts in the south in recent years, which have tended to last longer. On average for the whole country, the rainfall over the past 50 years decreased by about 2%. The sea level has risen between 2.5 to 3.0 cm per decade in the last 50 years, but with regional variations. Between 1993 and 2008, it has risen at a rate of 3 mm/year, which is comparable to the global tendency, according to the Ministry of Natural Resources and Environment (MoNRE, 2009). Typhoons have reduced in number in the last four decades, but they have become more intense and are tracking southwards. El Niño/La Niña weather events have become more intense in the last 50 years, causing more typhoons, floods and droughts (Oxfam, 2008).

In Viet Nam, the most destructive disasters are typhoons, storms and whirlwinds as well as floods, flash floods, landslides, storm surge and salinity intrusion. The midland and coastal areas in the North, the Central Provinces and the South are the most affected areas by flash floods and whirlwind. Due to its close location to the typhoon center of the South China Sea, on an average it is hit by 4 to 6 typhoons per year. In the recent years, there have been more typhoons with higher intensity affecting the country. They have also moved towards Southern latitude. Typhoons raise sea levels and send storm surges up estuaries to inundate valuable croplands. Furthermore, the most severe erosion-affected areas are the downstream banks of the Red River, the Tien and the Hau Rivers, and along the entire coastline of Viet Nam. Although the country is in the tropical region and enjoys an abundance of water resources, drought and forest fires are a risk that impacts the South Central Region, Highlands, and the coastal areas of Quang Tri, Ninh Thuan, and Binh Thuan Provinces, which will undergo desertification because of lack of water (ADPC, 2003). Table 4 presents statistical details on the situation of natural disasters in Viet Nam. It highlights that people affected by the top five natural disasters between 1980 and 2009 were hit by storms, namely 70%, of all the people affected (see Figure 10). The remaining 30% are affected by floods. When all the natural disasters occurring between 1980 and 2009 in Viet Nam are considered, storms are reported to have more impacts. They account for most of the events (73 in number), affecting the highest number of people (59%, compared to 32% affected by floods

Table_4 Overview on natural disasters in Viet Nam: 1980-2009

Top 5 Natural Disasters in Viet Nam: 1980-2009

Type of natural disaster	Date/year	No of people affected
Storm	Sep 1980	9,027,174
Drought	Jul 1980	6,624,710
Flood	Jul 2000	5,000,004
Flood	Oct 1989	4,635,762
Flood	Oct 1999	3,504,412

Total Natural* Disasters in Viet Nam: 1980-2009

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Storm	73	41,048,908	4,015,405
Drought	5	6,110,000	649,120
Flood	55	21,825,602	2,758,525

*not considered are epidemic, wet mass movement, and wildfire

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain – Brussels, – Belgium.

and 9% by droughts, see Figure 11), and cause the highest economical loss (54%, compared to 37% due to flood and 9% due to drought, see Figure 12).

Climate Projections

Climate change impacts may include changes in storm intensity and frequency, rainfall patterns and other meteorological changes. Inland areas of Viet Nam, which includes the Northwest, North, and the Tay Nguyen Highland, may experience the highest increases of 2.5°C by 2070, while the coastal area temperatures of the Central and Mekong Regions may rise by 1.5°C. Projections for precipitation are less certain than temperature. The IPCC Third Assessment Report highlights that rainfall may increase in intensity; however, this may occur in a shorter period, leading to flash floods and greater run off. Also the Ministry of Natural Resources and Environment concludes that the total annual rainfall and rainy season's rainfall would increase while dry season's rainfall would decrease. More predictable is the increase of sea level that is expected to rise about 100 cm in 2100; in Viet Nam, if sea level rises by 5 meters, then 16% of area, 35% of population and 35% of GDP will be affected. It is reported that most of the impacts are in the Mekong and Red River Deltas (Dasgupta et al., 2007). According to

this study, Viet Nam is among the countries that are hardest hit by climate change and sea level rise.

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

This section focuses on adaptation issues in Viet Nam in the three identified sectors- water resources, agriculture and food security, and the socio-economic aspect. This section also includes reviews of existing studies and programs on the three identified sectors and analyses of methods used.

Water Sector

Viet Nam is situated in the tropical monsoon region. Its total annual run-off is 843 billion m³ (approximately), of which 323 billion m³ are originated in the Viet Nam territories, it also has

a groundwater resources reserve of 1,500 m³/s. However, all this resources are unevenly distributed in area and time. The 70 - 75% of the total annual flow is concentrated in the three- to four-month monsoon season while only 5 - 8% of the total annual flow is available during the three-month dry season. Therefore, natural disasters such as drought, flooding and inundation occur more frequently (Trung, unknown), and changing rainfall pattern also affects, thus, obstructing water supply and causing water use conflicts.

Range of Studies Reviewed and Methods Applied

The Initial National Communication under the United Nations Framework Convention on Climate Change for Viet Nam reviews development by the Ministry of Natural Resources and Environment on the assessments of climate change impacts and adaptation measures. The assessment uses the outputs of CSIRO Mark 2 global climate model based on the global greenhouse gas emission scenarios (IS92a and IS92b) for Southeast Asia; in which the earth surface average temperature will increase from 1.5°C to 2.5°C and rainfall variation will be from -5% to 10%. In order to assess the impacts of climate

Figure 10: Percentage of people affected
due to top 5 natural disasters:
1980-2009

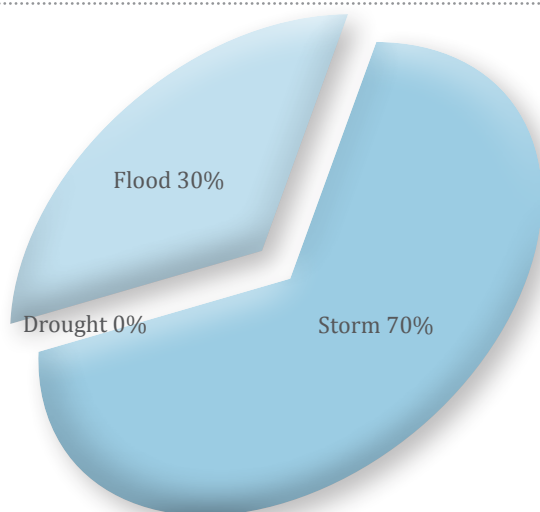


Figure 11: Percentage of people affected
due to total natural climatic
disasters: 1980-2009

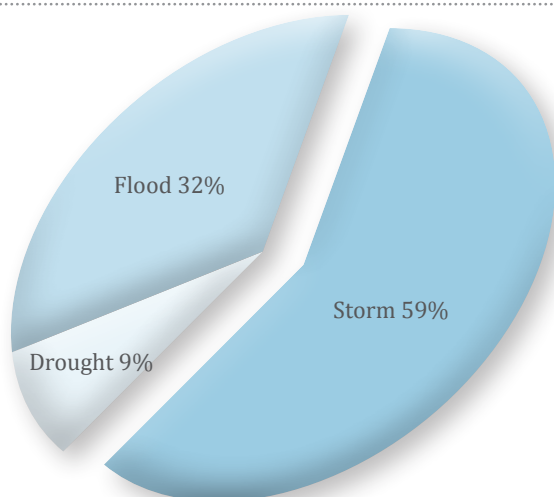
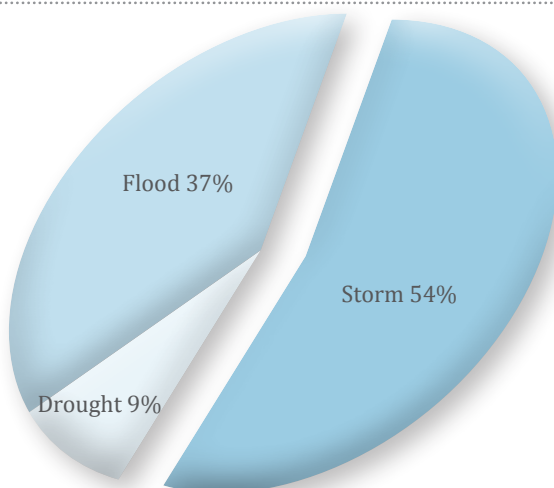


Figure 12: Percentage of damage (US\$)
due to total natural disasters:
1980-2009



change on coastal zones, the scenario of sea level rise of 1m by 2100 was used. In the report, the potential evapotranspiration was calculated using the modified Penman formulae and the models RRMOD and SSARR were used for calculating and assessing the variation of annual run-off, low flow and flood flow according to the respective scenarios. However, this vulnerability and adaptation assessment is largely qualitative, and hence, the results should only be regarded as preliminary.

The Sea level rise scenarios for Viet Nam are done by the MoNRE under the National Target Program for climate change response. The methodology used are MAGICC / SCENGE 5.3 software and statistical downscaling methods and criteria: plausibility of global climate change scenarios, level of details of climate change scenarios, inheritability, local appropriateness, completeness of scenarios and possibility for self updates. To develop the climate change scenarios, the study used three different greenhouse emission scenarios, low emission scenario, intermediate emission scenario of the medium scenario group and intermediate emission scenario of the high scenario group. Also, the temperature and rainfall scenarios are developed for seven different climate zones: North West, North East, North Delta, North Central, South Central, Central Highlands and South.

Some of the other studies reviewed are Trung's study, which focuses on the strategic plan for integrated water resources management of the Vu Gia-Thu basin organization (Trung, unknown); the Climate Change and Human Development Report in Viet Nam (Chaudry and Ruysschaert, 2007); the World Bank series for environmental monitoring 'Adapting to Climate Change'; and the ADAPTS program about adaptive water management at a local scale in Viet Nam (My et al., 2008).

Impacts on the Water Sector

According to the Human Development Report (Chaudry and Ruysschaert, 2007), the temperature has been increasing 0.1°C per decade since 1990, and is expected to increase from 1.4-1.5°C by 2050 and 2.5-2.8°C by 2100. As to rainfall, and compared to changes recorded since 1990, it is expected to increase in the range 2.5 - 4.8% by 2050 and 4.7 - 8.8% by 2100, especially in Northern Viet Nam and less in Southern plains.

The results described in the Sea Level Rise Scenarios for Viet Nam gives a prediction for the medium emission scenarios similar to the data described in

the HDR. By 2050, the temperature will increase (relative to period of 1980 - 1999) between 0.8 - 1.5°C and by 2100 between 1.6 - 2.8°C with the minimum in the Central Highlands and the maximum in the North Central zone. For the same scenario, in rainfalls, it gives an increase of 0.7 - 3.9% (relative to period 1980 -1999) by 2050 and 1.0 - 5.2% by 2100. The less affected areas in 2050 and 2100 would be Central Highlands and South while the most affected would be the North Delta.

The Initial National Communication states that for the Mekong River and the Red River, climate change would have profound impacts on surface water resources: annual run-off varies from +4% to -19%, peak discharge, with an increase in evapotranspiration. Because of the daily rainfall increase (12 - 19%), the peak discharge increases significantly with a decrease in the return periods. The flood peak, which earlier had a return period of 100 years, would now be only 20 years. The flood peak, which previously had a return period of 20 years, would only be five years now; flood episode frequency would be higher. For medium rivers and small rivers, the highest decrease of annual run-off was recorded in the East of South Viet Nam (29 - 33%), Central Viet Nam (23 - 40.5%), North Viet Nam and North of Central Viet Nam (2 - 11.5%), and the highest increase was in extreme South of Central Viet Nam (49%), Central Highland (6 - 16%) (MoNRE, 2003). Drought will also intensify by 3% in coastal areas and by 8% in inland areas, due to variation in rainfall and temperature, which will affect evapotranspiration (ICEM, 2009).

Groundwater resources will be affected in the coastal zones because of sea level rise and seawater intrusion. In the Central Highlands region, a decrease in the groundwater level is another potential and important effect in the area.

Important water security changes are expected to be associated with changes in temperature and precipitation, and also, associated with sea level rise, coastal storms, and saltwater intrusion changes in the delta regions of major river basins. Some of the threats that will be faced because of climate change related water security issues are:

Although precipitation will increase in general, an uneven distribution of resources is projected. The complex interaction of precipitation and temperature changes could result in less runoff to streams in several regions. This could cause increased water stress, prolonged droughts, and increase in water

conflict. Hydropower production could drop as a result of the reduction in river flows in the long term. Water supplies for drinking, agriculture, and industry could also be threatened by reduced river flows and reduced groundwater recharge. For example, in the Mekong Basin: Sea level rise and coastal intrusion could have substantial impacts on delta area productivity and sustainability. Coastal cities such as Ho Chi Minh City could be impacted significantly. (World Bank, 2007)

Another important impact to be expected is sea level rise. According to the results of the temperature and the rainfall scenarios provided by the Sea Level Scenarios for Viet Nam report, by mid 21st century, sea level may rise by 28 to 33 cm (considering the three scenarios described) and by 2100 would be about 65 cm to 100 cm relative to the base line period of 1980-1999 (MoNRE, 2009). Due to the difficulties and the limited understanding of climate change, together with other uncertain factors such as economic or social development, "the most harmonious scenario is the medium scenario which is recommended for ministries, sectors and provinces/cities to use as an initial basis in climate change and sea level rise impact assessments and in the development of action plans to respond to climate change", mentions MoNRE (2009). According to this scenario, by 2050, sea level may rise 30 cm and by 2100, 75 cm.

Considering these predictions, the sea level rise will significantly affect deltas, islands and could have strong impacts on coastal ecosystems and communities. All this could be aggravated by the sinking of delta land, coastal degradation, and loss of coral reefs. Viet Nam has been classified as one of the five most vulnerable countries to sea level rise due to its long coastal line.

Also, sea level rise, in combination with increased coastal storms and inland hydrologic changes, could impact the water security of coastal areas. This could be manifested as seawater inundation of productive land areas, seawater intrusion into coastal aquifers, and resulting water scarcity in these coastal areas. In small islands, there is a special threat from these changes to the small freshwater lenses that are vital to island communities (World Bank, 2007).

Vulnerabilities and Adaptation in the Water Sector

Viet Nam, because of its geographical locations, creates great potential in hydro-electricity, and water storage but also poses increased risks of flood and

land erosion. Additionally, water resources appear to be degrading and suffering negative impacts from deforestation and pollution (Trung, unknown). Also, the most populated areas and where the main economic activity is taking place are those with high flood risks, increased salinity of water resources and other hazards related to water resources.

The Initial National Communication lists suggestive measures for adaptation to climate change impacts (MoNRE, 2003):

- Building reservoirs with the total additional capacity of 15 - 20 billion m³ for containing flood water to mitigate losses caused by floods, and to regulate water during low-flow season. High priority should be given to the eastern parts of South Viet Nam, central highland and mountainous areas in North Viet Nam;
- Upgrading and raising the scale of drainage systems, the existing sea and river-mouth dykes, and building new sea dykes;
- Controlling population growth rate in vulnerable areas and organizing new resettlement areas to avoid the effects of sea level rise;
- Reclaiming areas, especially in hilly midland areas in the North Viet Nam, for agricultural production;
- Use of water effectively with special attention to increased run-offs during low-flow season, which is regulated by reservoirs upstream;
- Sustainable use of water sources;
- Conducting studies in long-term water resources prediction, seasonal, inter-annual predictions of water sources for planning rational and safe use of surface water sources.

The MRC on its Climate Change Adaptation in the Lower Mekong Basin Countries Report lists ongoing activities, such as : upgrading and raising the level of drainage system; limiting population growth rate and redistribution of residential areas; cooperation for efficient water use; conducting studies in long-term water resources prediction; and implementation of the strategy “Living with Flood”.

Other adaptation activities are being implemented as part of the National Strategy and Action Plan for Disaster Mitigation and Management in Viet Nam 2001-2020 and the MRC Strategy on Flood Management and Mitigation. The National Strategy stresses the notion of living with the floods. This includes various fixed requirements for flood safety and security in residential areas. Also, there is a program for house foundations to make them

more flood secure. Low-level dyke systems already control saltwater intrusion and early flooding, and water management in the Mekong Delta, focusing on irrigation water supply and prevention of saline water intrusion (ICEM, 2009). Thus, in the northern region, the emphasis is more on ‘positively prepare for and prevent flood’, and in the central part, it is on ‘positive preparedness, mitigation, and management’.

Gaps Identified in Programs and Studies

Currently there are policies, laws, programs and projects related with water resources protection, but there are still some weaknesses in water resources management. This could be summarized as the need of a long-term strategies on national and regional scales; that water resources have not been managed according to basin system; that the provision on the protection, utilization and management of water resources have been insufficient, including suitable management instruments on water quality standards and the limits for underground water utilization for each region; and finally, low investment for irrigation works having imperfect works as a result.

Recent Projects in the Water Sector

The Institute for Environmental Studies, ACACIA Water started the ADAPTS project, undertaking the Adaptive Water Management at the Local Scale – a Viet Nam case study in 2008. The overall aim of ADAPTS is to increase developing countries’ adaptive capacities by achieving the inclusion of climate change and adaptation considerations in water policies, local planning and investment decisions (My et al., 2008). The project is being implemented in six river basins around the world; and in Viet Nam, it is the Huong River Basin. Around 800,000 people live in the Huong River Basin. Their livelihoods, small-scale agriculture and fisheries, depend on the river and the lagoon into which the river drains. The local partner Centre for Social Research and Development (CSR D) aims to take climate change and adaptation into account in their work and support local adaptation measures. CSR D also aims to facilitate dialogue between communities, researchers and government authorities on climate change and adaptation in the basin, and supports the establishment of a platform on Climate Change in Central Viet Nam.

According to the matrix of climate change activities elaborated by the World Bank in collaboration with the Government of Viet Nam, donors and NGOs (World Bank, 2009b), here are some of the projects identified under the water sector: (i) Impact of

Climate Change on water resources and adaptation measures, implemented by MoNRE-IMHEN with Denmark/ODA funds, focuses on identifying impacts of climate change on water resources and suggested mitigation measures; (ii) Impact of Climate Change on Rural Water and Sanitation, implemented by East Meets West and funded by Ford Foundation which aims to identify climate change impacts on rural water and sanitation services and facilities, and develop improved technical designs. It is associated with a World Bank Global Partnership on Output Based Aid project on rural water supply and sanitation; (iii) The Report on impacts of climate change and sea-level rise on water resource use, funded by the MARD and implemented by MARD and Institute of World Economics and Politics, uses downscaling models and estimates provided by the IMHEN. While physical impacts have been identified, these impacts have not yet been monetized into economic damages; (iv) The Water Sector Review, implemented by the ADB and co-financed by the Netherlands, Australia and Denmark, aims to help the Government and its development partners to adopt better management approaches based on integrated water resources management (IWRM) principles, in line with the objectives of the National Water Resources Strategy (NWRS); (v) The World Bank project Economics of Adaptation to Climate Change (EACC) - Agriculture and Water sector study in Viet Nam, focuses on the economic impacts of CC on a small number of critically important crops and it is being carried out jointly with a number of Viet Nameese institutions; (vi) finally implemented by Monash University, VNU, and MONRE and funded by Australia /AusAID, is the project, developing integrated catchment management strategies for sustainable water use in response to climate change that will build multi-disciplinary capacity in integrated catchment management and develop cost-effective adaptation strategies (World Bank, 2009b)

Agriculture and Food Security Sector

The agriculture and livelihood options, important for the economy will have to adapt to the conditions linked to water resources impacts, temperature and rainfall changes.

Range of Studies Reviewed and Methods Applied

The Initial National communication Under the United Nations Framework Convention on Climate Change for Viet Nam reviews impacts and adaptation measures for agriculture in Viet Nam.

A study contained in the Final Report for Assessments of Impacts and Adaptations to Climate Change developed by START (Snidvongs, 2006), uses a crop model to simulate potential future yield of rice productivity in the region under different climate scenarios. The crop model used is Decision Support System for Agro Technology Transfers (DSSAT version 4.0) crop modelling software with daily climate data from climate scenario. By using daily climate data for the simulation process, this study is able to capture the impacts of climate change on rain-fed rice production not only in terms of the change in degree of intensity of each climate parameter (increase or decrease in rainfall or temperature), but also change in temporal aspect too (shifting of the onset or changing on the length of rainy season or change in the pattern of mid-season dry spell period, etc.).

The World Bank study also gives information about impacts Viet Nam will suffer due to the sea level rise (Dasgupta, 2007), and the Asian Disaster Preparedness Centre (ADPC) does so in its study about agriculture and adaptation for the Mekong Delta (ADPC, 2003).

Impacts on the Agricultural and Food Sector

According to climate change simulation, the length of the period with air temperature lower than 20°C would decrease 20 - 30 days by 2050 and 30 - 50 days by 2070. On the contrary, the length of period with air temperature above 25°C would increase 15 - 45 days by 2050 and 30 - 80 days by 2070 (MoNRE, 2009). In the mountainous and midland areas of North Viet Nam and Central Highland, the sum of temperature would increase much more than other areas. Meanwhile, absolute minimum temperature would also increase with the same rate of average temperature.

Climate change has significant impacts on growth and productivity of plants, affecting cropping seasons, and may induce pestilent insect. Climate change would also affect growth and reproduction of livestock, increase risk of pathogenesis and spread of dangerous diseases. Due to warming over the country, the adaptable time for tropical plants will be longer, while for the sub-tropical plants will be shorter (MoNRE, 2008b). The planting boundary of tropical trees/crops would move towards northwards and higher mountainous region. On the other hand, the adaptation area of subtropical plants would become less. By 2070s, the mountainous tropical trees would be able to grow at the altitude 100 - 550

meters higher and move 100 - 200 km northwards in comparison with present. Due to abnormal changes of rainfall intensity, flood inundation and drought would occur more frequently. Significant cultivation areas in Mekong and Red River deltas would be under salt water due to sea level rise. The Central Highlands region may also be affected on agricultural productivity because of the increase of severe weather events. The economy of the Central Highlands region of Viet Nam is based on forestry and agriculture in which the main products of the area includes coffee, rubber, pepper and other cash crops (ICEM, 2009).

According to the results from the simulations, the period of inundation will be prolonged during the rainy season impacting the productivity of rice farming. As a rough estimation of the effects of the inundations, at least 25% of the lands of the delta will be inundate in next decades, reducing the production by 3 million tons of rice (ADPC, 2003).

The Snidvongs study (2006) contains the Study of Impact of Climate Change on Rain-Fed Rice Productivity which argues that change in climate pattern will affect agriculture system directly, especially the rain-fed system. This study focused on the study of climate change impact on rain-fed rice cultivation as it is considered as the most important food crop of the Southeast Asia region. It says that in Lower Mekong River region, in Viet Nam, where farmers grow two crop cycles in a year, the simulation result of the study shows different climate impacts: the winter-spring crop will get slight impact from climate change as the yield will increase slightly from baseline year under climate conditions at atmospheric CO₂ concentration of 540 ppm, but will drop slightly from baseline year under climate conditions at CO₂ concentration of 720 ppm; the summer-autumn crop tends to be severely impacted by climate change. The simulation shows significant decline productivity by approximately 8 - 12% under climate condition at CO₂ concentration of 540 ppm and would sharply drop up to almost 50% in some areas under climate condition at CO₂ concentration of 720 ppm.

Due to salinisation, climate change is also expected to narrow down area of agricultural land. A significant fraction of agricultural land in the coastal plain, the Red River Delta and the Mekong River Delta will be exposed to salt water intrusion as a result of rising sea level if no responding method is applied (MoNRE, 2008b). Dasgupta's study (2007), shows that a 1-metre rise in sea level would affect

approximately 5 % of Viet Nam's land area, which would impact 7% of agriculture, and reduce GDP by 10%. Along with the short rainy periods will come longer dry seasons which will compound the salinisation problems that already exist. In 2003, the 42% of the delta was affected by salinity intrusion, which is the main limiting factor in agricultural production. Drinking shortages are also a problem for local people, so measures are needed to prevent further salinity intrusion; the increase of run-off in rainy season leaves less freshwater for the dry season (ADPC, 2003).

Vulnerabilities and Adaptation in the Agriculture and Food Sector

Coastal districts of Viet Nam concentrate nearly a quarter of the total population, though only covers 16% of land surface. Approximately, 58% of coastal zone livelihoods are based on agriculture, fishing and aquaculture (Chaudhry and Ruysschaert, 2007). Agriculture, forestry and fishery contribute 28.7% to the GDP. The agricultural land is 7.37 million hectares; gross output of food crops in rice equivalent is 26.2 million tons (MoNRE, 2003).

Listed below are measures described in the Initial National Communication for adaptation to climate change:

1. Development of crop patterns suitable to climate change.
2. Effective use of irrigation water.
3. Upgrading of irrigation system for agriculture.
4. Development of new varieties that could stand against severe environmental conditions.
5. Reserve and storage of local crop varieties, establishing crop seed bank.
6. Development of farming techniques appropriate to climate change.

Adaptation of rain-fed farmer to climate change results

The evidence is clear: adaptation measures begin at local scale. In the case of rain-fed rice farmers in Viet Nam, indigenous adaptation measures are practiced at the household level. Community and national level measures play limited role in reducing their climate risks. Community level measures in Viet Nam are very limited and have low effectiveness. Farmers consider measures implemented at the national level as moderately effective. The farm-level solutions are mainly efforts and investments to increase and sustain the productivity (construction and maintenance of small-scale irrigation systems or embankments to protect their farmland from

flood). Using an alternative strategy, some farmers in the study carried out by START, have adapted to floods by accepting them as part of the ecosystem, adjusting their crop calendar, getting benefits from nutrients being deposited to enhance soil fertility and pollutants being washed from their farmland. In addition, use of alternate crops and seed varieties are also common adaptation measures of the farmer in the Mekong River delta in Viet Nam (Snidvongs, 2006).

Some farmers are changing the variety of rice grown, both seasonally as a response to climate forecasts and semi-permanently, even though they are commercial farmers and grow rice to match market demand. The national government supports research and development of seed varieties and provides financial support for investment in farm sector infrastructure, but other measures by the national government reported by farmers are limited. In the Mekong River delta, farmers have some financial resources and benefits from a longer rainy season. The availability of short-cycle rice varieties that are suitable for growing on their farms and are accepted by the market also gives them greater flexibility to vary their rice cultivar and crop calendar, if the season is expected to be unusually short or dry. Choices of farmers are alternative cultivation practices to reduce the risk of damage or loss to the rice crop and investments to improve the productivity and resilience of their farms (Snidvongs, 2006).

Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector

The Ministry of Agriculture and Rural Development (MARD) has developed an Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector, period 2008-2020. Its general objective is to enhance the capacity of the Government about adaptation and mitigation to minimize the adverse impacts of climate change, focusing on security of city's residents (especially at the Cuu Long river deltas and the central mountainous areas), food security, and the maintenance of infrastructure for disaster prevention. It also shows clear efforts to link the disaster management activities, which were mainly under the mandate of MARD, with climate change adaptation activities.

It also describes seven specific objectives, which can be summarized to create policies to integrate climate change into development plans, define responsibilities, develop an Action Plan that support policies and human resources for implementing

policies, strengthen research, impact projections and international cooperation (to get technical and financial assistance), and to enhance awareness. The Action Plan does not identify specific adaptation measures but contains main tasks to allow development of such measures as part of its implementation. The main tasks of the action plan are defined according to specific objectives, which are further broken down in detailed activities, role of implementing agencies, outputs and the implementing duration. The main tasks are to disseminate knowledge and experiences to achieve awareness of climate change impacts and greater knowledge of adaptation among government officials, staff and communities; develop human resources and studies to provide adaptation solutions, to include climate change issues in sectoral developing programs through policy systems; encourage international cooperation to seek funding, promoting relationships, mobilizing and using aid, etc.; and finally prioritizing activities for implementing adaptation and mitigation policies.

Gaps Identified in Programs and Studies

In order to improve the research capacities, a network focusing on agricultural issues is needed in the Southeast Asia Region. Also, more local research capacity needs are to be developed, forums to exchange research results and to develop further joint activities that may lead to further policy implementation (Snidvongs, 2006).

Also improved tools and data are important for future study in climate change. Among various tools and data needed are high resolution climate scenarios, local ability to run climate model at high resolution, with ability to fine tune the simulation to match specific requirement of impact analysis in each area of study.

It is considered important to improve knowledge transfer and capacity building; transfer in form of training to local researcher at least in the initial stage. The study on climate change and its impact as well as vulnerability and adaptation need to be conducted on many other systems and sectors in many other aspects to produce information that can support policy making. In order to do this, institution capacity as well as researchers still needs to be further developed and expanded.

Finally, and referring to the scale, there are big differences between objectives and limiting factors, and the prevalence and effectiveness of different

measures in the different levels of implementation. The differences demonstrate the strong influence that the local context has on climate risk management. The measures that are used and their effectiveness are place and time specific, but all these actions are developed into what is done at community and national levels. Farmers and local level do not have a comprehensive evaluation of national policies and programs. At national level, measures, which farmers are aware, do not take part in the national strategy process for managing climate risks. The actions are not coordinated and typically are not designed specifically to combat climate risks. Also, investment costs and limited financial capacity of farmers to implement their measures to fight against climate change, limits wider use of these measures.

Recent Projects in the Agriculture and Food Sector

In addition to the efforts that the Government is doing, tasking the MARD and the MoNRE with the policies and programs to address climate change issues, NGOs, community groups and other civil society organizations are working directly with the grassroots level and play an important role for minimizing the negative impacts of climate change. In accordance with this, Sustainable Rural Development (SRD), a development agency supporting poor rural communities, is implementing projects focused in sustainable agriculture and livelihoods in mountainous areas affected by climate change, integrating climate concerns at the local level projects. SRD projects on rice seed conservation are the System of Rice Intensification, Participatory Land Use Management, and Integrated Pest Management; all have contributed to the adaptation of the rural communities to the risk of climate change and the minimization of the harmful effects (SRD, 2009).

The World Bank's matrix of climate change activities (World Bank, 2009b) also provides a list of projects related with the agricultural sector; some of these are: (i) The project Economics of Adaptation to Climate Change (EACC) - Agriculture and Water sector study in Viet Nam, that has already been described in the water sector; (ii) Australia/AusAID is funding the project "Helping poor farmers in rice-based systems in the Mekong delta of Viet Nam adapt to climate change" which is being implemented by ACIAR and that supports targeted research and development collaboration between Viet Nam agencies, Australian organisations and international agricultural research centres to improve adaptation to climate change for small farmers in the Mekong Delta (World Bank, 2009b).

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

A World Bank Policy Research Paper studied the consequences of a sea level rise of 1 - 5 meters on 84 developing countries, including Viet Nam. The method adopted included the use of GIS software, overlaid with spatially-disaggregated global data sets on land, population, agriculture, urban extent, GDP, and wetlands, obtained from various public sources such as the Center for Environmental Systems Research and the World Bank (Dasgupta et al., 2007).

Chaudry and Ruysschaert (2007) edited the Human Development Report 2007/2008 and provided the most relevant study reviewed regarding the socio-economic vulnerability and adaptation strategies undertaken. Chaudry and Ruysschaert (2007) addressed the topic of climate change and human development in Viet Nam through studying existing reports and data from literature.

The Viet Nam Academy of Social Sciences (VASS, 2007) constituted a national source of information regarding Viet Nam's poverty conditions. The report used findings from literature research and analyzed data from the Viet Nam Household Living Standards Surveys in 1993, 1998, 2002 and 2004.

Finally, a recently published report of Oxfam (2008) assessed the situation of the poor population and their adaptation strategies through a field study in the two provinces of Ben Tre and Quang Tri in May 2008.

Socio-Economic Impacts

Climate change is considered to be a 'real threat' to further pursuing socio-economic development of Viet Nam, in view of an increase in the variability in rainfall, higher temperatures and intensity of extreme weather events, and sea level rise (Dasgupta et al., 2007).

For Viet Nam the consequences of sea level rise are 'potentially catastrophic' (Dasgupta et al., 2007). Among the 84 studied developing countries, Viet Nam shows the highest percentage of the population that would be affected by a sea level rise of 1 meter, being 10.8%. With a projected sea level rise of 5 meters, the impacted population would even amount to 35%. A sea level rise of 1 meter is expected to reduce Viet Nam's GDP by approximately 10% (35% in the case of 5 meter), impact the urban extent by

about 11% (41%), the agricultural extent by 7% (24%), and wetlands by 29% (87%). Inundation and saline water intrusion due to the projected sea level rise pose threats to the agricultural production, which in turn endangers agricultural exports such as rice, of which Viet Nam is the second largest exporter in the world. Climate change impacts are also likely to occur on the fishery and aquaculture sectors' incomes, since the numbers of sub-tropical fish of high commercial value is expected to decrease. Furthermore, Viet Nam's economic sea production capacity is estimated to be reduced by at least one third due to degenerated coral reefs and decreased plankton, resulting in reduced fish masses. Also, aquaculture farms will be impacted due to the need of relocations as a response to seawater level rise (Dasgupta et al., 2007).

Natural disasters particularly affect the coastal zones. Upland areas are affected by flash floods such as heavy rainfalls associated with typhoons. River floods, on the one hand increase soil fertility and bring wild fish stocks, but they also devastate infrastructure and cause important losses in crop yields (Chaudhry and Ruysschaert, 2007). Due to a rise in temperatures, higher typhoon activity and intensity of storms is expected in northern Viet Nam, with mainly the coastal zones suffering more intense typhoons and having infrastructure, agricultural production, and people's livelihood threatened (Chaudhry and Ruysschaert, 2007). Today, it is estimated that up to 80 to 90% of Viet Nam's population is affected by typhoons (Socialist Republic of Viet Nam, 2007). In the years, 1980 - 2009, storm affected a total of 73 events, more than 41 million people and damages of more than US\$4 billion (see Table 4).

Vulnerabilities and Adaptation in the Socio-Economic Sector

Vulnerability

Inequality between the growth poles of Ho Chi Minh City and Hanoi, on the one hand, and the remote areas, on the other hand, is increasing, which may significantly reduce Viet Nam's long term capacity to collectively respond to climate related vulnerabilities: In 2004, the poverty rate was of 5% in the region of Ho Chi Minh City, whereas it amounted to about 26% in the central coast region that is typhoon and drought prone (Chaudhry and Ruysschaert, 2007). The country-wide rural poverty rate was 25% in 2004, whereas the urban poverty rate was as low as 4% (VASS, 2007). Besides poverty being a mainly rural phenomenon, also regional

disparity can be observed: The three regions northern mountains, north central coast and central highlands are together home to 57% of the country's poor people. All three regions have a poverty rate that is higher than 30% (VASS, 2007).

Rural poor are considered those who face the most immediate challenges to cope with and adapt to climate change impacts since their incomes and food security heavily depend on agriculture, aquaculture and fisheries (Chaudhry and Ruysschaert, 2007). Furthermore, the poor's vulnerability to drought, floods or typhoons is increasing since 'safety nets' existing under centrally planned economic conditions have been removed. The reason for that is that since 1986 – the start of the so-called renovation process –, Viet Nam is undergoing the transformation from a centrally planned, command economy to a market-based economy. As a consequence, the state is losing its central role in collective security. Poor households lack the capacity to individually cope with disaster risks and have seen an increasing vulnerability to shocks such as the curtailment of access to common property resources. Mangroves, as an example, have been disappearing as a consequence of the increasing privatization of coastal lands. Mangroves, at the same time, are especially vital for aquaculture, sustaining the poor's food and livelihood, as well as to protect the coastal zone from storm surge. Furthermore, the poor's vulnerability to climate change has been increased due to the development of commercial aquaculture that is restricting the access of the poor to the resources (Chaudhry and Ruysschaert, 2007). The Ninh Thuan province is the one of the poorest provinces in the south central coast and is the one most affected by drought, typhoons and floods (Chaudhry and Ruysschaert, 2007; Oxfam in Viet Nam, 2007). Recent research has shown that rainfall variability is increasing in this region and that women, old people and children are most at risk due to malnourishment and extreme heat. The increasing human demand on environmental services is further exacerbating climate change impacts. Examples include substantial groundwater extraction for increased agricultural production such as of maize, deforestation, and an increase in aqua-cultural production (Oxfam in Viet Nam, 2007). Another threat on land and water resources in the Ninh Thuan region comes from projects of national interest such as the long term plan to develop a nuclear power plant (Chaudhry and Ruysschaert, 2007).

Experience shows that children are especially vulnerable to natural disasters: The majority of the

almost 500 people killed in the devastating floods in 2000 and 2001 were children (Chaudhry and Ruysschaert, 2007). As a lesson learned between the two disasters, a measure undertaken for reducing child fatalities was to build new schools that were flood proof. The problem continued, however, since many of the poorest children were not attending the school during the flood period, since they had to work in fishing and agriculture and thus still resulted to be highly vulnerable. Already after the flood in 2000, day time child care with women volunteers were established and aid organizations distributed boats for means of transports and for fishing. After the 2001 flood, however, such response programs were developed with a focus on the poor people (Chaudhry and Ruysschaert, 2007).

As a consequence of the floods in 2000 and 2001, the Government also launched a program of safe settlement areas, including the home relocation above flood levels, in order to being able to pass on evacuations, according to the policy slogan 'living with the floods' (Chaudhry and Ruysschaert, 2007). Besides children, also women have been considered to be especially vulnerable to natural disasters. According to Oxfam (2008), women are especially hit by natural disasters since they often cannot swim and have limited opportunities for employment away from home in the case of threatened livelihood due to destroyed crops. However, women have been shown to be very effective in the mobilization of local involvement and implementation of community-level responses. The Oxfam-study also shows that local level disaster risk management programs, such as implemented in Quang Tri, are able to significantly reduce vulnerability to flooding. A recommendation drawn from that is that community-based planning should be used to scale up to provincial and national responses, drawing on people's personal experiences at perceptions at local level (Oxfam, 2008).

While the cyclone intensity shows the tendency to be increasing over time, not only the vulnerability of rural communities but also of urban areas has increased (Chaudhry and Ruysschaert, 2007). Families that improved their housing through own efforts run the risk of housing loss and damaging since they do not apply the rules of a storm resistant construction. Also, the urban houses tend to have very flat roofs that show a high risk of damage (Chaudhry and Ruysschaert, 2007).

Adaptation

For over 1000 years, Viet Nam has been developing an extensive system of dykes for the physical

protection from typhoons and sea level rise (Chaudhry and Ruysschaert, 2007). Today, the dyke system includes 5,000 km of river and 3,000 km of sea dykes. Building and maintenance of the dykes used to be done through collective mobilizations of household labor. Nowadays, the collective labour has been replaced by a tax and hired labor, since better-off households were not willing or able to bear the lost income due to the spent days of labor. There is the perception that sea defense infrastructure overall could be improved due to increased wealth and infrastructure development in past years, at least for the better-off households (Chaudhry and Ruysschaert, 2007).

Besides dykes, another important and highly effective measure of protecting the coastal zone from storm surges is coastal mangrove plantation. Coastal communities with the support of NGOs and international donors have undertaken successful projects of mangrove restoration (Chaudhry and Ruysschaert, 2007).

As a response to the increased vulnerability of housing damages to storm, an initiative supported by the European Commission Development Workshop promotes the application of ten principles for achieving storm resistance in new and existing housing in Central Viet Nam. The principles include for instance to build the house with a simple shape, to choose a location without full wind or flood force, and to construct the roof in an angle of 30° - 45° (Chaudhry and Ruysschaert, 2007).

Since vulnerability to climate change is closely linked to poverty, crucial long-term adaptation measures are considered necessary to reduce poverty, such as the diversification of incomes, respect of common property rights, and promotion of collective security (Chaudhry and Ruysschaert, 2007). In an approach of systematic integration and mainstreaming, risk management, poverty alleviation and sustainable development need to be considered in combination and across all the development sectors in view of planning for climate change (Oxfam in Viet Nam, 2007).

Besides, a key response to climate related disaster risks is Viet Nam's development of disaster early warning systems. Viet Nam has been supported by UNDP in improving early warning, collecting and reporting damage and hydrometeorological data, and providing more readily and widely available information. Today, the government is undertaking efforts to upgrade the disaster early warning

capacity, including the new support of data from Viet Nam's own satellite (Chaudhry and Ruysschaert, 2007).

Institutional responses

A National Target Programme on Poverty Reduction during 2006 to 2010 has been set up with the goal to reduce the poverty rate from 22% in 2005 to 10 or 11% in 2010 (Viet Nam News, 2009). A national report presented in October 2009 by the Ministry of Labour, Invalids and Social Affairs indicates that Viet Nam is on target to achieve a 10% reduction already by the end 2009, the poverty rate being 12.8% (2.2 million people) at the end of 2008. The funds of the program are used for building infrastructure in most disadvantages coastal and island areas, providing the poor with credit loans and reduced fees for vocational training, health insurance, houses, as well as free legal aid. However, the report also concluded that more people are becoming poor due to Viet Nam's socio-economic context, which leads to an inaccurate assessment of the number of poor households, due to insufficient administrative capacity of the involved agencies, which makes further efforts necessary (Viet Nam News, 2009).

Gaps Identified in Programs and Studies

Viet Nam could achieve important progress in its disaster early warning systems in the past years, including a national typhoon warning system, broadcast via media and loudspeakers, and a continuous monitoring of dykes during the typhoon season (Chaudhry and Ruysschaert, 2007). Nonetheless, large losses are still occurring. Overall, collection and communication of information within the disaster early warning system still need to be improved (Chaudhry and Ruysschaert, 2007).

Also, whereas the better-off households have seen a reduced vulnerability to disaster risks through improved sea defence, the poor population still remains extremely vulnerable due to their livelihoods' dependency on agriculture and fishery and the inability to individually cope with disaster risks due to the lack of alternative economic opportunities (Chaudhry and Ruysschaert, 2007). Furthermore, the national report recently published on the mid-term review of the National Target Program on Poverty Reduction puts forward that due to insufficient administrative capacity of the agencies involved in the program, not all households living below the poverty line have been listed as poor (Viet Nam News, 2009). Besides the need for capacity building for the involved administrative agencies, it

is proposed to consider a variety of criteria in the regularly to be updated list of poor households, not only the income level (Viet Nam News, 2009).

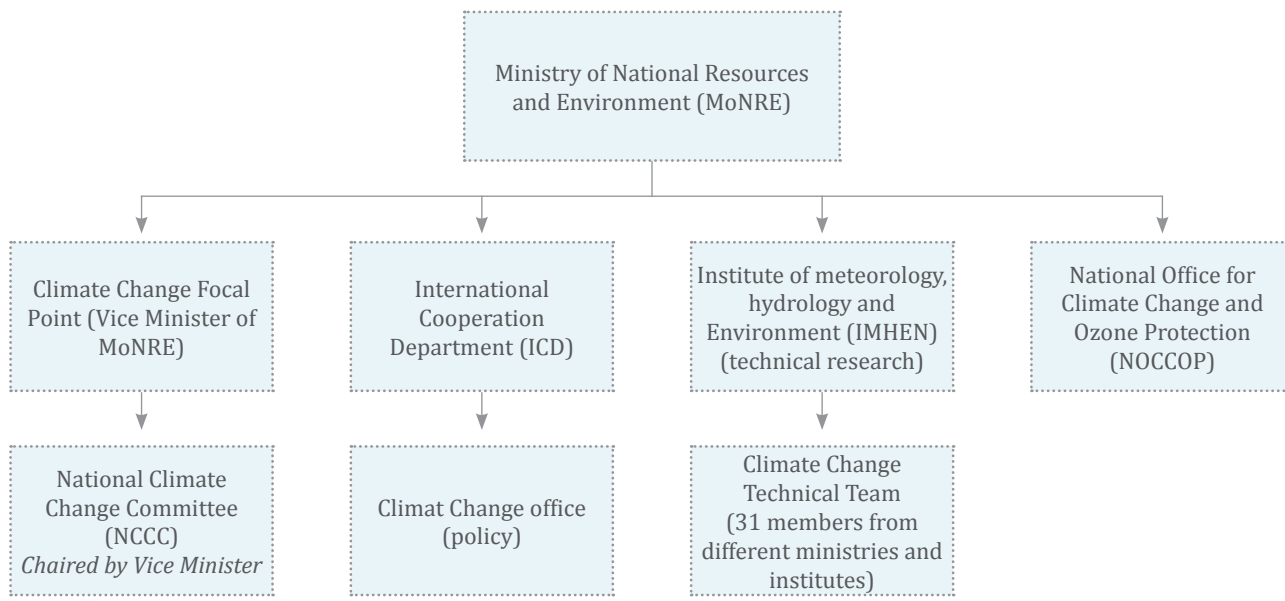
Chaudhry and Ruysschaert (2007) identified that the government's home relocation program faces barriers such as delays in the realization of the large scale program as well as resistance from the part of the concerned population. The new settlement locations limit the access to the people's fields and canals, not only in flood but also in non-flood times, which curtails the people's fishing activity that is a critical livelihood strategy. In general, resource rights and opportunities are unequally allocated between well-off households and the poor, which represents a primary constraint for the poor to effectively adapt to climate change. Overall Viet Nam's population that is most at risk from climate change is the rural poor in the most affected province. For those, there is still insufficient information, financial and technical support for climate change adaptation (Chaudhry and Ruysschaert, 2007).

Although the threat of climate change has started to be acknowledged, information and awareness are still insufficiently developed (Chaudhry and Ruysschaert, 2007). Potential impacts and adaptation needs are to be made known to Viet Nam's population beyond the experts and development workers and some agencies. Communication needs to be strengthened and long-term research on potential impacts on Viet Nam's economy and development goals, especially concerning poverty reduction, as well as projections regarding climate refugees due to sea level rise are needed (Chaudhry and Ruysschaert, 2007).

Recent Projects with Socio-Economic Sector

According to the matrix of climate change activities elaborated by the World Bank (2009b), the following projects were identified for the socio-economic sector: (i) Evidence Based Natural Disaster Risk Management, An Empirical Application from Viet Nam, is being funded by GFDRR and implemented by MARD. Among its objectives are, estimating the welfare and economic growth costs associated with different natural disasters and developing a disaggregated vulnerability map reflecting the percent of people likely to fall below a certain poverty threshold in the future; (ii) carried out by UNDP (with MoNRE), the Scoping research on Climate change and the Poor in Viet Nam project is a technical study of the linkage between climate change and poverty; (iii) the UNDP has also the project Climate change and Gender study, that studies the implications and

Figure 13: Government Institutional Arrangement for Responding to Climate Change
(Chaudhry and Ruyschaert, 2007; UNEP-SEI, 2009)



impact of climate change, with linkages to gender issues; and, (iv) Economics of Adaptation to Climate Change implemented by the World Bank is funded by Great Britain, Netherlands, and Switzerland, and its objectives are to identify and evaluate the expected impacts of climate change in developing countries under different climate change scenarios, identify good practice in project, program and policy design and financing, identify and rank plausible adaptation pathways, assessing their social and economic returns, integrate adaptation options into sector policies, and inform the development of effective international financial mechanisms for adaptation (World Bank, 2009b).

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Viet Nam recognizes the threat of Climate Change by ratifying international agreements like the UNFCCC in 1994 and the Kyoto Protocol in 2002. Up to date, the Government has focused more in reduction of greenhouse gases emission than in adaptation strategies.

Climate Change

Viet Nam, has been implementing in the past years strategies, plans and policies concerning to climate change focused in mitigation and adaptation. The country has configured national structures according to the UNFCCC and the Kyoto Protocol,

building national capacities following international commitment.

Organisations

The MoNRE is the focal agency in charge of climate change related activities; its structure can be seen in Figure 13. Technical resources and researches have been mobilized to implement climate change programs and projects; also, adaptation measures are included, like in the National Strategy for Environmental Protection (2005) that describes measures for sea level rise impacts.

The Institute of Meteorology, Hydrology and Environment has been coordinating projects related with climate change since 1990 and was restructured in 2003 to be a scientific functional organization under the MoNRE. Its mandate is to research and develop on meteorology, climatology, agro-meteorology, hydrology, water resources, oceanography and environment.

The Institute of Policy and Strategy on Natural Resources and Environment should be empowered to coordinate the activity of the different agencies related with climate change adaptation. It is in charge of climate change responsibilities and to hold the existing National Office for Climate Change and Ozone Protection (NOCCOP), which includes the national coordination of work on climate change, the construction of national policies, and international cooperation. It should conduct the vulnerability and adaptation assessment, analysis of climate change

impacts and adaptation measures, share research and coordinate to apply policy development within the MoNRE and MARD. However, it is not strong enough to deal with all task related to climate change because of the staff capacity related with climate change, so it may not be able to develop the National Program on Climate Change within the MoNRE.

The International Cooperation Department helps with the draft of the Framework of National Program on Climate Change assessing about the status of Viet Nam dealing with climate change. It is relevant for the definition of the National Program because it relates solutions and measures for mitigation and adaptation.

Initial National Communication Report to the United Nations Framework Convention on Climate Change (UNFCCC)

The Initial National Communication to the UNFCCC (MoNRE, 2003), as a Party to the Convention, Viet Nam has participated in many activities to implement it and this First National Communication is one of those activities, that has the financial and technical support from the Global Environment Facility (GEF) and the UNEP. As it can be seen in the structure in the following paragraph, it only explores climate change impacts and necessary adaptation measures in a preliminary and qualitative way; from the assessment of the sectors described some adaptation options were identified, but socioeconomic analysis was excluded, and they have not been followed by specific programs yet.

The Communication has 7 chapters. The first one describes the general features of geographical, climate and socio-economic conditions of Viet Nam in 1994. Chapter 2 gives the results of the National Greenhouse Gas Inventory done in 1994, and estimated national greenhouse gas emissions to 2020. Chapter 3 is devoted to analyze of greenhouse gases mitigation options in energy, agriculture and forestry sectors. Assessment of the potential impacts of climate change on some major economic activities and response measures are developed in chapter 4. Next chapter describes the climate observation and monitoring system and results of research into climate change and tendency in Viet Nam. Chapter 6 is based on education, training and strengthening of public awareness on climate change. Last chapter gives the main orientation to mitigate greenhouse gases through economic development plan of energy, agriculture, and forestry sectors. Also, a list of projects on climate change was also presented in

this Communication (MoNRE, 2003 and Chaudhry and Ruyschaert, 2007).

The Second National Communication to UNFCCC, which should be completed by the end of 2009, is developing a policy framework for implementing adaptation measures, and it goes more deep into vulnerability and adaptation assessments.

Second National Communication to the UNFCCC

The Government assigned MoNRE to be in charge to be the National Focal Point, and the ICD has to provide support to the ministry in the activities related with UNFCCC, Kyoto Protocol and Clean Development Mechanisms. At the same time the MoNRE sets up the National Climate Change Committee (NCCC), whose main responsibility is to assist the Minister with the activities that came up from the UNFCCC, Kyoto and CDM. The NOCCOP has taken the lead with the project "Viet Nam: Preparation of the Second National Communication to the UNFCCC" (2006-2009) with the support of UNEP/GEF. The areas covered are: development of national greenhouse gas inventories, identification of adaptation measures to climate change and preparation of the Policy Framework of implementing adaptation measures for key socio-economic sectors and determination of climate change mitigation measures (UNEP-SEI, 2009).

The National Target Program to Respond to Climate Change

The Government of Viet Nam, aware of the importance of climate change impacts, early ratified the UNFCCC (November 16th, 1994) and the Kyoto Protocol (September 2002). Since the UNFCCC and the Kyoto Protocol were ratified the Government, ministries, regions, etc. have launched some projects to study climate change impacts and trends focused on natural resources and socio-economic development, as well as some adaptation measures. The Government, considering that efforts still were effectiveness for the urgency of response to climate change risks, has requested (2007) to develop a National Target Program to Respond to Climate Change (NTP), focused on four specific sectors, which are considered the most vulnerable: agriculture and food security, water resources, public health, and habitat, that has been approved by the Prime Minister on 2nd December 2008.

As it is detailed in the NTP, there are five main guideline principles that can be summarized into a response to climate change carried out on the principle of

sustainable development and integration, with clear focuses for short and long-term impacts (projects must be immediately implemented), climate change issues and the response to it is the responsibility of all the stakeholders (politics, society, communities, etc.) and must be integrated into all strategies and planning at all sectors and levels. Finally, according to the principle of “common but differentiated responsibility” Viet Nam is willing to receive funding and technology transfer from developed countries and international organizations.

The general objective as described in the NTP is to “assess climate change’s impacts on sectors/areas and regions in specific periods and develop feasible action plan to effectively respond to climate change in each short-term/long-term periods” all that to “ensure sustainable development [...], take over opportunities to develop towards a low-carbon economy, and joint international community’s effort to mitigate climate change impacts and protect global climatic system” (MoNRE, 2008a).

As specific objectives the program defines eight which can be summarized as follows: identify and asses climate change impacts on every sector; identify suitable measures; promote technological and scientific activities related with climate change; improve organizational structure, institutional capacity and implement appropriate policies on climate change; strength international relationships to get support and to joint efforts to protect global climatic system; incorporate NTP to social-economic development strategies; and finally to develop an action plan of all ministries and sectors, and to implement pilot projects.

The approaches defined include a broad range of stakeholders group focusing on local communities considering adaptation needs and using a two-way discussion and feedback, a multidiscipline and succession approach, based on references to national strategies, and finally base on existing organizations (domestic resources and international support).

Scope

Temporal scope:

- Phase I (2009-2010): Start-up.
- Phase II (2011-2015): Implementation.
- Phase III (post 2015): Development.

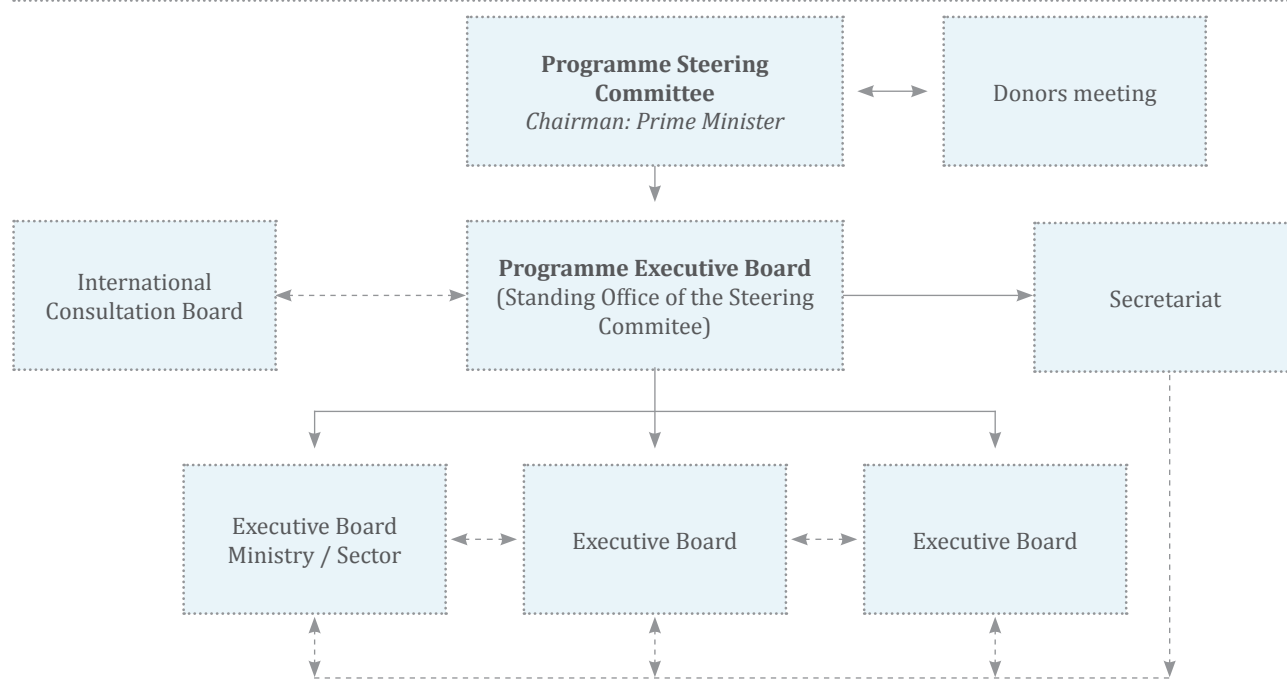
Spatial scope: the whole country.

Main activities

- Assessment of Climate Change Impacts in Viet Nam: assess variability and impacts of climate change on different fields, sectors and regions and develop climate change scenarios, and sea level rise scenarios.
- Identify measures to respond to climate change based on the result of the previous activity.
- Develop a scientific-technological program on climate change to provide scientific basis for the development of policies, institutions and action plans, to collaborate with the international goals, to use energy effectively and develop clean technologies, and to strengthen ministries and sectors capacity to respond to climate change.
- Strengthen the Capacity in the Organization, Institution and Policy on Climate Change focused on legal normative documents, legal basis to implement the activities, mechanisms to encourage coordination of NTP implementation in the whole country and sectors, and improvement of efficiency in the management’s organization structure relating to climate change from central to local levels.
- Awareness Raising and Human Resources Development: the scope of this activity is to strength communication and coordination among ministries, sectors, decision-makers, community and enterprises in the implementation of activities and to raise the awareness and responsibilities among society in terms of climate change.
- Enhancement of International Cooperation for support from the international community and to participate in the global efforts on climate change.
- Mainstreaming NTP in Strategies, Plans, Socio-economic Development Planning and other Sectoral/Local Development Plans.
- Develop Action Plans to respond to climate change by relevant ministries, sectors, and localities that should take initiative in developing their own action plans to respond to climate change based in previous assessment and developed climate change scenarios. All ministries, provinces and cities will prepare in 2010 a 5 years plan for the period 2011-2015, raising the key issue of their capacity to integrate adaptation into their planning. Actions plans must consider all key sectors as well as particular conditions of the regions of the country.

Water resources: Water is being used as a key policy factor, the following activities must be included

Figure 14: Government Institutional Arrangement for Responding to Climate Change (Chaudhry and Ruyschaert, 2007; UNEP-SEI, 2009)



in the action plans: develop and improve a legal framework, strength managements mechanisms of related ministries, develop implementation plans and programs at all levels, identify scientific and technical solutions (for use, pollution, etc.) and raise community awareness.

Agriculture: Efforts are focused on developing a diverse and sustainable agriculture, and to apply scientific achievements effectively. Evolve to new rural areas with modern infrastructures and relevant economic structure of agriculture-industry-services that ensures enough employment, equity and poverty eradication. The MARD together with other ministries should develop a program that contains: an improved law framework, revise policies and mechanisms to insert the use of new technology and new knowledge suitable with climate change conditions, develop scientific and technical activities to improve adaptation to new conditions and plan an effective use of land and water to ensure sustainable agricultural production.

Actions plans also should be developed for most vulnerable regions. For coastal zones the Ministry of Planning and Investment and the Ministry of Defence are in charge of developing the action plan to prevent and mitigate natural disasters developing storm and flood prevention and rescue plans, adjusting infrastructures and economic structure to adapt to sea level rise, calculating expenses and implementing

relocation projects as response to sea level rise, and reinforcing research of coastal ecological systems function and its adapting capacity.

For Northern and Southern Deltas, People's Committees of provinces should coordinate with the Ministry of Planning and Investment (MPI), MoNRE and the MARD the developing of the adaptation strategy, focusing on natural disaster prevention and system of sea dykes.

Organizational structure for the implementation

In 2008, the Prime Minister established the Steering Committee and Executive Board for the NTP, which is a high level organization comprising the Prime Minister and other Ministers of relevant line agencies and the Executive Board comprises ministers and vice-ministers of relevant line agencies (see Figure 14). MoNRE and MPI have key roles in the implementation of the program.

Institutional Settings Concerning Disaster Risk Management

Due to the exposure of Viet Nam to meteorological phenomena, and the long history of natural disasters, such as floods and typhoons, the country has an extensive long-standing institutional response system, which reflects the country's vulnerability to these events.

Disaster Risk Management

In addition, Viet Nam has a longstanding institutional response system for natural disasters, which is coordinated mainly by the Central Committee for Flood and Storm Control (CCFSC), chaired by the MARD. The CCFSC was created in 1955 to coordinate disaster risk management activities; other relevant ministries are also members such as the Department of Floods and Storm Control and Dyke Management, the Disaster Management Centre, the Hydro-meteorological Service, and the Viet Nam Red Cross (VNRC) (which is working from national to commune level on awareness raising, disaster preparedness, response and prevention). The CCFSC is responsible of data and record flood and storm events, as well as send out official warnings and coordinating disaster response and mitigation measures. Local authorities and each sector ministry also have committees for flood and storm control (CFSCs), which are important for sharing information on damage and needs, communicating early warning information, damage assessments, coordinating rescue during floods, and protecting dykes and other infrastructure (Chaudhry and Ruysschaert, 2007). These cross-sectoral committees are presently expected to produce annual disaster preparedness plans.

The Government, NGOs and donors compose the Natural Disaster Mitigation Partnership (NDM-P) to promote dialogue and common ways of working for disaster reduction rather than disaster response. The MARD was assigned by the Government to lead the initiative supported by the Royal Netherlands Embassy (RNE) and the United Nations Development Programme (UNDP); also it is in charge of coordinating the implementation of the Second National Strategy and Action Plan for Disaster Mitigation and Management (discussed below).

National Strategy for Natural Disaster Prevention, Response and Mitigation

Viet Nam's policy framework for disaster management is set in the National Strategy and Action Plan for Disaster Mitigation and Management 2001-2020, in which the MARD is the standing agency, and the Central Committee for Flood and Storm Control, will both preside the implementation for the strategy to 2020 and the Government is the one that has to ensure enough resources, investment and mobilization of society. The national strategy states that it must be implemented in synchronous, period-base and priorities-based manners, responsive to both intermediate and long term purposes and following the "four-on-the-spot" principles for

response (command, man-power, materials and logistics).

The National Strategy's specific objectives are: enhancing disaster forecasting, improve development planning (integrating strategy and plans of disaster risk management) and building codes, trainee and strength human resource (staff) for disaster prevention and increased public awareness, complete relocation of people living in disaster vulnerable areas, improve response to emergency situations (search and rescue capacity), ensure national security and defence in coastal areas (improved sea dykes and embankments), improved safety of reservoirs, completion of shelters for shipping, improved communications system for fishing boats. It also proposes to formulate a law, consolidate organizational structures and ensure there are sufficient budgetary resources for disaster risk management.

The strategy describes in detail the general responsibilities and solutions for developing the specific objectives as well as the natural disaster prevention, response and mitigation responsibilities and solutions for each region (Red River Delta and North Central, Central Coast, Eastern South and Islands, Mekong River Delta, Mountainous areas and Central Highlands, and Sea areas).

The national strategy provides a list of programs grouped according to the objectives and responsibilities and ordered by priority. Among the priorities can be found: complete the system of legal documents, especially Natural Disaster Prevention Response and Mitigation Law; strengthen organizational mechanism giving priority to the steering mechanism for natural disaster prevention, response and mitigation at all levels; among the non-structural measures, there are several programs involved, the program of establishing and reviewing plans (here the priority is given to create a zoning map of flash-flood risk), the program of improving the community awareness (which starts with the inclusion of knowledge related to disasters at the secondary school), program of planting and preserving protective forest (starting with upstream forest) and program of enhancing disaster management and science and technology application capacity; and finally, the structural measures, starts with the program to review, upgrade, and build structures for natural disaster prevention, response and mitigation in line with the designed standards and natural disaster characteristics of each region (and local).

Gaps identified

Rapid population growth and urbanization have caused serious pressure, causing the natural resource and the environment to degrade. The total population in the country has reached more than 85 million people now. In the near future, the population of Viet Nam will be about 100 million people (ADPC 2006). The rapid population growth in the areas of potential productiveness has led to the land shortages for both residential and cultivation purposes. The impacts of human activity and human being have constrained the water flows, impoverish the land silt reservoirs, cause landslides in the mountainous and hills areas, etc. As a result, natural disaster risks have risen.

The economic growth in the 90s was beyond 7% and has been even higher in the next decade. If there is no integration of natural disaster prevention response and mitigation in the development process, the growth may cause more environmental pollution and break the ecological balance, resulting in major disaster risk and unsustainable development.

Natural disasters in the country are the main impediment to development and poverty reduction. Viet Nam has the 80% of its population living at risk of direct impacts of natural disasters. From 2002 to 2006, natural disasters have killed 1700 people and caused losses of 4.2 billion of assets, millions of people are in need of assistance because of natural disaster every year. Also this widens the gap between residents' living standards, inhibits hunger and poverty eradication and impoverish back to those who had already escaped poverty. Natural disaster, affects educational development, destroys educational infrastructure and interrupts school time, especially in mountainous areas and the Mekong River Delta, and causes negative impacts on vulnerable groups (old, woman, children, etc.)

Recent projects

There is a proposal to create the Institute of Environment Monitoring and Disaster Management within the MoNRE to help with climate change coordination, instead of the IMHEN as it is at the moment. However the Prime Minister has not approved this yet.

The GFDRR programme is currently helping the government with risk management because, although DRM is a priority for the government, there is extremely weak capacity for client implementation so Bank execution is proposed for GFDRR grants; there is a strong need to integrate DRM into

many of Viet Nam's new investment projects. The Government has proposed integrating DRM into its socioeconomic planning and, in partnership, and the World Bank Hanoi would like to integrate DRM into its upcoming and existing projects. Currently there are four Indicative Program for GFDRR Funding, that are projects and engagement areas being considered for GFDRR funding: (1) Integration of Disaster Risk Reduction into Pipeline World Bank projects in Viet Nam, implemented by WBOH; (2) Risk Financing Options – Supporting the Development of Viet Nam's Strategy, implemented by WBOH, Ministry of Finance and the MARD; (3) Support Viet Nam's NAP Implementation, implemented by WBOH, Central Committee for flood and Storm Control, MoNRE and Provincial authorities; (4) Strengthen the hydrological and meteorological capability for Viet Nam, implemented by the MoNRE, Department of Hydro-meteorology and Climate Change, National Center of Hydro-meteorology (World Bank, 2009a).

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Most strategies in Viet Nam are focused on emergency responses to short term climate extremes and reconstruction after them, rather than long-term adaptation to future climate change. They are also not integrated into wider policies for sustainable rural development and poverty reduction.

In the first Viet Nam mission report (October 2009) elaborated by the Regional Climate Adaptation Knowledge Platform for Asia and in the First Draft for Policy and Institutional Scoping Assessment for Climate change adaptation in Viet Nam (UNEP-SEI, 2009) some gaps in climate change adaptation have been highlighted.

There is lack of understanding of the nature of adaptation and adaptive capacities. Also, adaptation is not mainstreamed into planning and strategy development at all levels (national and sub-national) that is why the Government has established a requirement for it. Within the Government, there are three ministries that are mainly involved with climate change adaptation, working independently with the other ministries in the government, but also with all the stakeholders involved in the country. There is a need for better coordinated efforts, well-defined allocation of responsibilities and more effective mechanisms of sharing knowledge. Coordination between government agencies in climate change

adaptation, via the Steering Committee for the UNFCCC and KP faces more challenges than the disaster risk management via Central Committee for Flood and Storm Control (CCFSC).

There is an evident on the shortcoming of data on adaptation alternatives and mechanisms for disseminating and sharing information across sectors. Also, translation of scientific studies into the end-users and easy-to-understand language for various target groups is lacking. "The local people would not talk in the same language as the experts, and they don't like complicated scientific issues, so all the results should be simplified and correlated with local/regional customs and problems" (ICEM, 2009). NGOs and Civil Society (CS) acknowledge the support from the Government agencies on information sharing. Thus, most NGOs and CSs work and implement their climate change adaptation and disaster risk reduction projects at local levels.

Climate change programs including long term programs by the government, provincial, district and commune institutions are not given sufficient priority in work plans. In the context of NTP, the MoNRE downscales the assessments of climate change predictions at provincial levels to eliminate uncertainties in planning, but adaptation being understood as a process to cope with and plan for uncertainty, is also needed at national levels. Also, the Ministry of Planning and Investment, which focuses on mainstreaming climate change issues into Socio Economic Development Program (SEDP) and other national and provincial planning activities stands out the capacity deficits to prepare adaptation plans at provincial level. It also recognizes the importance of activities at provincial level due to the high decentralization that Viet Nam has, and so, the importance of addressing the lack of capacity. It is needed to identify the research needs and create a policy brief for mainstreaming of adaptation into developmental planning. In this sense, capacity building for provinces in knowledge, skills, methodologies and measures to support the most affected and vulnerable communities is needed. Many provinces are not aware of climate change issues and, lack of information, methodologies, tools and experiences dealing with climate change and its impacts. The authorities sometime undertakes climate change activities independently from the government when there are concerns about climate change impacts.

A notable gap in climate change adaptation development is that there is no government budget specifically for climate activities at the

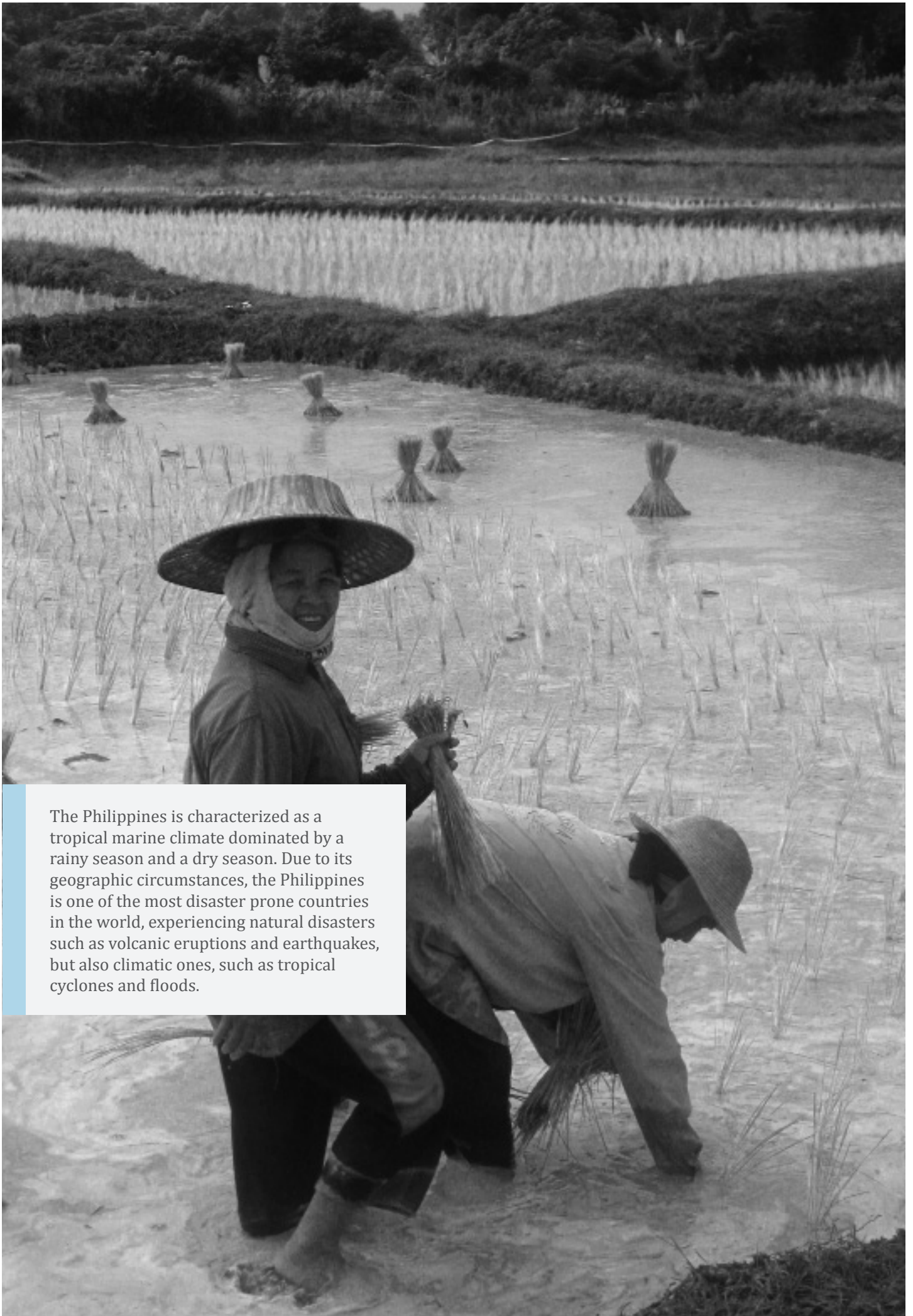
province or lower levels. The budgets that the national government and local authorities have at their disposal for adapting to climate change are inadequate (ICEM, 2009).

Another key gap mentioned in the report, is the need to generate awareness about the nature of climate change adaptation and its opportunities at all levels, specifically at senior policy and political level, and at the provincial level, where most responsibilities are being place but capacities are weak. Also, there is a lack of knowledge which justifies the need for more evidence-based research on specific topics related to climate change as well as technical assistance from international organization. Current knowledge about adaptation or climate change impacts in Viet Nam is based on International studies. This is not enough for sector level planning and mainstreaming strategies and policies. Further, lack of proper understanding of provincial and local level needs are other gaps and concerns. Priority areas: disaster management, water resources (agriculture), aquaculture and forestry. In Viet Nam, the concept of climate change, its potential impacts and the need for adaptation are not yet well known beyond a small community of experts and development workers, some concerned state management agencies, and some localities.

Government priorities are focused on the coastal zone and two delta areas of the country but there is a need to identify the gaps in rain-fed agriculture, rural areas and need of water resources and irrigation in the southern part of the country. Number of shortcoming of vulnerability and adaptation assessment also reflects that the national expertise to undertake this (V&A assessment) is weak. The perception of communities and some governmental institutes on climate change is also a limitation in taking up appropriate activities. Human resources, especially technical staff who can guide and manage the process, are limited.

On developing scenarios, downscaling them at sub-regional and local levels is needed as well as an inclusion of advanced research to increase the number of climate parameters (today's scenarios for Viet Nam include three climatic parameters – temperature, rainfall and sea level rise). To summarize, there is a need to a better understanding of adaptation measures, uncertainty issues and social and economic impact of Climate Change at both national and provincial level.

It also emphasizes the need of knowledge to identify linkages between disaster and climate risks, as NTP does not provide any guidelines or directions.



The Philippines is characterized as a tropical marine climate dominated by a rainy season and a dry season. Due to its geographic circumstances, the Philippines is one of the most disaster prone countries in the world, experiencing natural disasters such as volcanic eruptions and earthquakes, but also climatic ones, such as tropical cyclones and floods.

RESEARCH SYNTHESIS ON THE PHILIPPINES

COUNTRY CHARACTERISTICS

Country characteristics of the Philippines's geographical, social, economic and climatic risk situations are presented here. An overview of the country's characteristics is provided in Table 5.

Geographic Attributes

The Philippines with a total area of 299,404 square kilometres constitute approximately 2 % of the world's total land area. The country comprises a total of 7,107 islands stretched over the 2.2 million sq. km. of water within exclusive economic zone (Republic of the Philippines, 1999, Velasco, 2000). The 65% and 32% of the total area are covered with mountains and agricultural land respectively (U.S. Department of State, 2009, National Statistics Office, 2005). The country is bounded by three seas: the South China Sea on the west and north, the Pacific Ocean on the East, and the Celebes Sea and the coastal waters of Borneo on the south (Republic of the Philippines, 1999).

Socio-Economic Status

The Philippines was ranked the 12th most populous country in the world in 2009 with an estimated population of about 92 million (National Statistics Office, 2006, International Monetary Fund, 2008). It is estimated to reach 126 million by 2020 (Velasco, 2000). Approximately, 64 % of the population lives in the urban areas in 2007.

The Philippines has one of the fastest-growing economies in Asia with a GDP growth rate of 7.1% in 2007 (CIA, 2009). The main contribution to the GDP is generated from the service sector including trade, finance, mining and quarrying, amounting to

Table_5 The Philippines Country Profile Overview

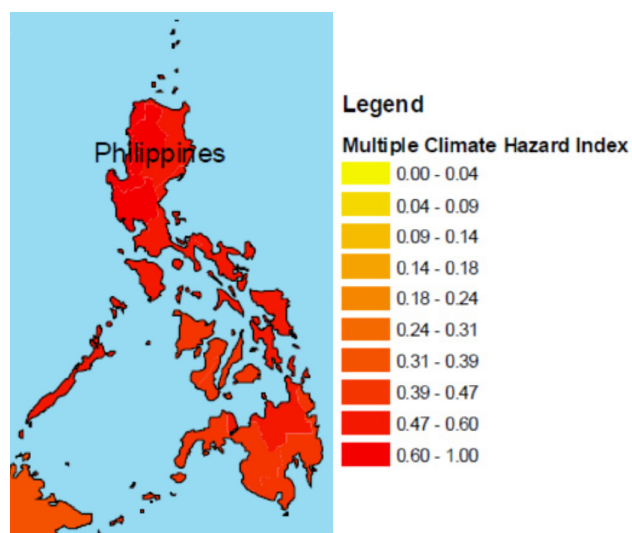
Country Information (UNdata 2009, UNDP 2009c, UNESCAP 2009, CIA 2009, WHO / UNICEF 2006, Republic of the Philippines 2005)	
Surface area (km ²)	300,000
Bordering countries	no land border
Population density, 2007 (persons/km ²)	293.2
Population growth rate, 2005-2010 (%)	1.9
Mountainous land (% of total area)	65
Agricultural land (% of total area)	32.2
GDP, nominal, 2007 (million USD)	144,129
Contribution of agricultural sector to GDP, 2008 (%)	14.7
Contribution of industrial sector to GDP, 2008 (%)	31.6
Contribution of service sector to GDP, 2008 (%)	53.7
Percentage of population, 2007 (%) in	
- rural areas %	35.8
- urban areas %	64.2
Population below poverty line (2001-2006)	22
Infant mortality rate, 2005-2010 (per 1 000 live births)	23.1
Adult literacy rate, 1999-2007 (% of total population, estimate)	93.4
Access to water supply, 2004 (% of total population, estimate)	84.5

Figure 15: Location map of the Philippines (CIA,2009)



53% in 2008, while the agricultural and industrial sector only accounts for 15 % and 32 % of GDP. However, the agricultural sector, together with fishery and forestry, represents 36% of the total employment on an average between 2003 and 2005. Among agricultural crops, rice is the most important crop produced in the country (Benson, 2007, cited in RMSI, 2007). Most industries are concentrated in the urban areas around metropolitan Manila (CIA, 2009). Access to an improved source of water supply decreased from 87% in 1990 to 85% in 2004 with the growing population (WHO/UNICEF, 2006).

Figure 16: Climate hazard map of the Philippines (Extracted from Multiple climate hazard map of Southeast Asia, Yusuf A.A. and Francisco H.A., 2009)



Climate Risks

Current Climatic Conditions

The Philippines is characterized as a tropical marine climate dominated by a rainy season and a dry season (Velasco, 2000). Due to its geographic circumstances, the Philippines is one of the most disaster prone countries in the world, experiencing natural disasters such as volcanic eruptions and earthquakes, but also climatic ones, such as tropical cyclones and floods (val Aalst, 2006, cited in RMSI,

Figure 17: Percentage of people affected due to top 5 natural disasters 1980-2009

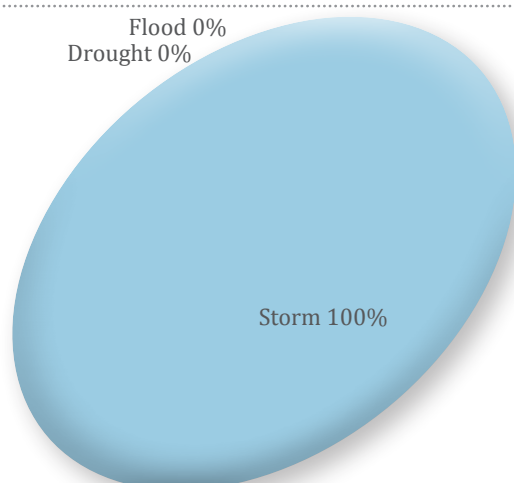
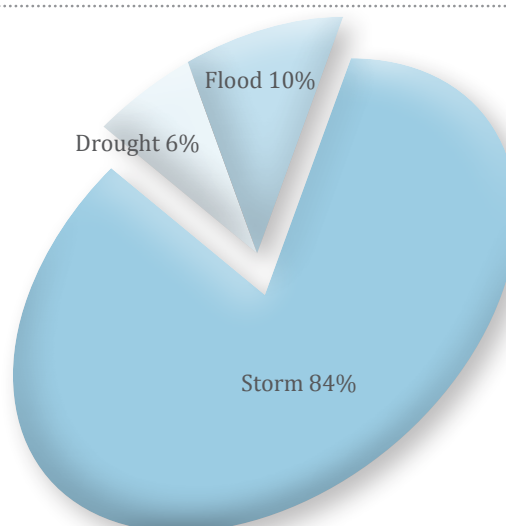


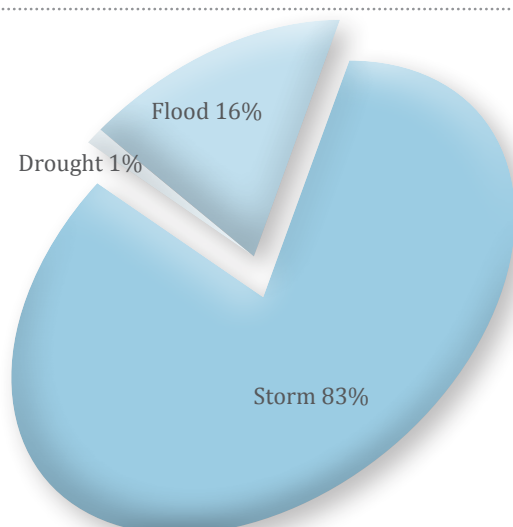
Figure 18: Percentage of people affected due to total natural climatic disasters 1980-2009



2007). 30% of the cyclones passing the Philippines are considered destructive (RMSI, 2007). Table 6 show the top five natural disasters – with respect to the number of people affected. Also, over all the natural hazard events concerning climatic disasters, i.e. storms, draughts and floods, between 1980 - 2009, storms were responsible for 84% of all the people affected (see Figure 18) and 83% of all the economic damages caused (see Figure 19) within this time period.

Fluctuation in the seasonal rainfall distribution is observed in the Philippines. This is one of the distinctive effects of the El Niño Southern Oscillation (ENSO) phenomenon that is associated with ENSO warm (cold) events. For the decades between 1950 and 2005, seven El Nino and La Nina episodes have occurred exhibiting certain climatic changes. For example, the seasonal rainfall response to ENSO turned sign between boreal summer (July - September) and fall (October - December) for both, El Niño and La Niña. Changes in the large-scale monsoon system occurred during the ENSO events that brought drought and flood conditions (Lyon et al., 2006, cited in RMSI, 2007). Meanwhile, significant decrease in the number of

Figure 19: Percentage of damage (US\$) due to total natural disasters 1980-2009



Table_6 Overview on natural disasters in the Philippines from 1980 to 2009

Top 5 Natural Disasters in the Philippines, 1980-2009

Type of natural disaster	Date/year	No of people affected
Storm	Nov 1990	6,159,569
Storm	Jun 2008	4,785,460
Storm	Sep 2009	4,321,149
Storm	Oct 1998	3,902,424
Storm	Sep 2006	3,842,406

Total Natural* Disasters in the Philippines for the period 1980-2009

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Storm	192	90,765,856	5,045,830
Drought	7	6,549,542	64,453
Flood	84	10,546,024	981,557

*not considered are earthquake, epidemic, insect infestation, wet or dry mass movement, volcano, and wildfire

Source: EM-DAT (2009) The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain - Brussels, - Belgium.

rain days is observed in some areas since 1961 throughout Southeast Asia (Manton et al., 2001, cited in GRID-Arendal, 2003).

Sea levels have risen partly due to local subsidence particularly in the Manila area and partly due to global sea level rise (Hulme and Sheard, 1999, cited in ADB, 2009c).

Climate Projections

Climate change is expected to exacerbate existing climatic hazards by creating more flood, drought, and storm events (val Aalst, 2006, cited in RMSI, 2007).

Climate change projection studies show that temperatures are expected to rise by 2.2 °C by the last quarter of the 21st century (World Bank, 2005). In addition, not only are rainfall patterns and substantial sea level rise projected, but also changes in climate variability and extreme weather events are anticipated to entail higher intensity in rainfall, hot spells and monsoon rainfall variability (Amadore, 2005). Moreover, peak wind and precipitation intensity of tropical cyclones are likely to increase in some areas of the Philippines (ibid).

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

This section focuses on adaptation issues in the Philippines in the three identified sectors -water resources, agriculture and food security, and the socio-economic aspects. This chapter includes reviews of the existing studies and programs on the three identified sectors and analyzes the methods used.

Water Sector

Range of Studies Reviewed and Methods Applied

The possible impacts of accelerated sea level rise (ASLR), vulnerability and adaptive responses to threats in the context of the Manila Bay coastal were assessed. The methodology applied for this study was 'Common Methodology' of the Coastal Zone Management of the Intergovernmental Panel on Climate Change (IPCC 1990 cited in Perez et al. 1999). This methodology is composed of seven steps: (1) delineating the study area and specification of ASLR scenarios; (2) inventorying the study area characteristics; (3) identifying relevant development factors; (4) assessing physical changes and natural system responses; (5) formulating response strategies and assessments of their costs and effects; (6) assessing the vulnerability profile and interpretation of results; and (7) identifying needs and a plan of action (Perez et al. 1999).

Vulnerability of water resource in the Angat and Lanao reservoirs and identified possible coping measures were assessed by Jose A.M. and Cruz N.A. (1999). Three general circulation models (GCMs), namely, the Canadian Climate Center Model (CCC), the United Kingdom Meteorological Office model and the Geophysical Fluid Dynamics Laboratory (GFDL) model, were selected to identify future values of rainfall and precipitation under a double CO₂ scenario. Beside the GCMs, climate change scenarios were projected through the use of incremental changes in temperature and precipitation that could capture a wide range of climatic variability. Furthermore, a hydrological model, WatBal, was employed to investigate the rainfall-runoff relationship. The two main modeling components equipped in WatBal were the water balance and the calculation of potential evapotranspiration.

Lasco (2006) studied the impacts of climate variability on climate conditions such as floods, drought and streamflow, their implication of water demand and supply, the degree of vulnerability and adaptation measures to cope with the impacts of climate change on water resources. The geographical areas focused on Pantabangan-Carranglan Watershed (PCW). The impacts were described using available records of observed climatology and hydrology. To characterize future climate impacts, downscaling of regional results of GCMs were undertaken. The SEA-BASIN model was used to predict the future changes in streamflow resulting from climate variability and land use and land cover. Various research techniques such as focus group discussions, secondary data gathering, key informant interview, and direct field observations were employed for collecting the data for the assessment of impacts.

The World Bank's study on natural disaster risk management reflects the geographical areas vulnerable to water related hazards (World Bank, 2005, cited in RMSI, 2007). The study identified the vulnerable regions in the Philippines, based on frequency of floods, persons and property damages.

Impacts on the Water Sector

The impact analysis of the Manila Bay demonstrated that most areas along the coast Bay—specifically, Cavite City, Noveleta, Kawit, Imus and Bacoor in the province of Cavite, some parts of Las Pinas and Parañaque, Malabon, Navotas in Metro Manila, and parts of Bulacan such as Hagonoy and Malolos—would succumb to a 1m sea level rise (Perez et al. 1999). It also pointed out that the areas that were projected to be inundated by 0.3 m sea level rise had already been faced by flooding during high tides (ibid). Even at the areas which may survive from the accelerated sea level rise, frequency and severity of storm surges are anticipated to increase (ibid). These physical changes may cause various ecological as well as socio-economic negative consequences. The natural ecosystem in the coastal areas has already faced degraded state of corals, fish habitats and mangroves due to certain human activities. If accelerated sea level rise occurs, these weakened ecosystems may not respond to the warmer temperature and reduced light. Warmer water causes bleaching of the corals. The salinity of water affects the growth of mangroves. The changes in sediments and salinity may decline wetlands and freshwater swamps. In addition to ecological effects, socio-economic impacts of climate change are anticipated. Saltwater intrusion into coastal soils may decline agricultural productivity and water

quality, in return contributing to human health damages.

A study of changes in annual precipitation, temperature and runoff for Angat water reservoir demonstrated two opposite impacts: that the GFDL model projects greater frequency of flooding in future, while the CCCM model anticipates decreased runoff because of frequent drought episodes, implying potential drop of water availability (Jose and Cruz 1999). Furthermore, the projected water demand and supply for the Angat reservoir in the year 2050 indicates that the supply would not be sufficient to meet future demand.

Meanwhile, in the case of Lake Lanao, the same study also showed similar projections. Both, decrease and increase in runoff were anticipated depending on the selected models. Apart from the climate change scenario projected from GCMs, the incremental climate change scenarios indicate that runoff is more sensitive to variations in precipitation as compared with variations in temperature in both reservoirs.

The study of the PCW demonstrated that in 2080, rainfall is projected to increase by as much as 12.7 % and temperature to increase by more than 5% of the average observed values between 1960 and 1990 (Lasco, 2006). This change in climate could translate to about 17% increase in wet season streamflow and a decrease of around 35% in dry season streamflow of the PCW. The increase in streamflow could lead to higher likelihood of floods in the service areas of Upper Pampanga River Integrated Irrigation System than it is at present. Likewise, the projected decrease in streamflow of the PCW during the dry season will likely increase the incidence of water shortage which could be aggravated by the increased water demand due to the increase in temperature. The projected changes in climate and the associated changes in streamflow patterns of the PCW will likely have more serious impacts on the lowland rice farmers. There is a tendency whereby the number of months when water shortage is of high concern could increase. This indicates the imminent risks of water shortage to the lowland farmers such as a sudden drop of rice harvest (Lasco, 2006). In addition, the increased events of monsoon rain cause excessive siltation in the PCW reservoir. This causes the decreased capacity of the reservoir to store enough water for hydroelectric power generation (Lasco, 2006). The gross power generated in the reservoir dropped to almost zero in the late 90's from a maximum of more than 300,000 Mwh in the early 80's.

Vulnerability and Adaptation in the Water Sector

Vulnerability

The World Bank's Natural Disaster Risk Management study identified that the regions Luzon, Manila, Panay, Negros and Mindanao would be highly vulnerable to flashfloods and suffer from damages to persons and property (World Bank, 2005, cited in RMSI, 2007). Most of the mentioned regions are affected by flashfloods more than once in a year. In addition, most vulnerable areas identified in the study of PCW are those municipalities that lie at the tail of the service area. Due to the topographical and topological limitations, they suffer most from droughts, water shortage and floods, especially during dry season (Lasco, 2006).

Adaptation

The first National Communication (1999) and Jose and Cruz (1999) identifies several adaptation options in the water resources based on supply and demand. The first National Communication applied a set of criteria focusing on cost-effectiveness and feasibility. The supply adaptation measures included construction of new infrastructures; modification of existing physical infrastructure(s); and alternative management of the existing water supply systems. The demand Adaptation measures recommended were conservation and improved efficiency and technological change. Jose and Cruz (1999) further provided detailed suggestions on both supply and demand adaptation measures. The supply side adaptation strategies included comprehensive watershed management and reallocation system of water supply. Governmental watershed programme is recommended to focus on rehabilitation of erosion and siltation of rivers, lakes and reservoirs through preventing excessive logging and shifting cultivation. Another suggested option for the supply-side management was water reallocation and compensation schemes that would balance the water use demand for different purposes such as agricultural irrigation, hydropower energy and domestic use. In addition to adaptation in water supply, adaptation measures to control water demand were investigated. Being a case of greatest consumer of water, the agricultural sector was reflected upon. These demand side adaptation measures included enhancement of irrigation efficiency through changing the cropping schedule to reduce water demand, lining canals to reduce water losses and building drainage reuse system to reuse their effluents for other secondary purposes, as well as introduction of low water use

crops and improved farming practices to reduce wind speed and evapotranspiration. Apart from the agricultural sector, the water sector also needs to adapt the new technical and institutional system such as improvement of monitoring and forecasting capability for floods and droughts and introduction of water pricing policies looking at water as commodity.

A study of the PCW identifies common as well as potential adaptation strategies employed in the agricultural field (Lasco, 2006). Common adaptation practices include resorting to shallow tube wells to irrigate their farms, use of water from nearby streams using pumps to bring water to their cultivated fields and switching to alternative crops. Meanwhile, one of potential adaptation strategies suggested was seeking alternative water sources. The strategy was promising because of the opportunity of new water sources for farming even with the shortage of water from the irrigation system. However, the weakness in this strategy is that the cost involved significant reduction in the net revenue from its produce. In addition, the strategy of switching to alternative crops, such as vegetables is very effective since the net income the farmer gets is higher than the one from rice production. However, there is a geographical limitation that this is done only in selected areas due to the type of soil that is suitable only for rice.

Perez et al. (1999) suggested the adaptation strategy for coastal areas, especially for future sea level rise in the context of integrated coastal zone management (ICZM). It was highlighted that ICZM should entail 'a process of governance consisting of legal and institutional framework necessary to ensure development and management of the coastal zones, integrated with environment and socioeconomic goals in a community-participatory process' (Post and Landin, 1996 cited in Perez et al., 1999).

Moreover, adaptation strategies entail not only technical practices but also information sharing schemes. It is observed that a community that has been well-informed on the latest techniques in the farming community and is provided with hybrid rice seeds, yield more than the ordinary rice varieties, and is most of the time the best weapon to cope with the impacts of water shortage and floods (Lasco, 2006).

Gaps Identified in Programs and Studies

Governance Gaps

The Initial National Communication indicates that, due to the financial constraint and socio-cultural behaviours and traditions, it would be hard for the country to adopt several available water resource adaptation measures, to enable it to respond to climate change impacts on water supply and demand. Due to the fact that different political units encompass the Manila Bay coastal zones with different development priority, it is difficult to make coordinated efforts for ICZM. In addition, effective implementation of existing laws, rules and regulations have been undermined because of institutional weakness or lack of political will at different level of government, especially at the local government units to which the mandate of municipal water management was devolved (Perez et al., 1999).

The holistic policy intervention to protect water resources are lacking which includes land use planning in coastal zones, mangrove management facilitated by a massive reforestation of degraded mangrove system. The approach is community-based, incorporating wetlands, swamps and marshes in the National Integrated and Protected Areas, multi-hazard mitigation and protection plan for natural coastal hazards, geological, hydro-meteorological and structural engineering evaluation as a part of the environmental impact assessment prior to coastal development. This limits subsidies or tax incentives given to land development that would be affected by sea level rise and promotion of public awareness on climate change impacts (Perez et al., 1999).

Furthermore, the roles of stakeholders are not well considered or divided for the ICZM processes. The involvement of different stakeholders into the development and implementation of ICZM is key to assist by enhancing political will to take action among the policy-makers. Also, allocation of day-to-day tasks of ICZM to community groups, including monitoring of water quality of streams and carrying out "clean-up" activities on coastal lands can lead to effective management of the coastal zones (Perez et al., 1999).

Lasco (2006) pointed out that vulnerability will arise from the absence of programs to reduce the vulnerability of the lowland farmers to floods and water shortages. It was observed that the watershed is suffering from severe degradation of the forests, chronic grass fires and extensive cultivation of the

upland areas (ibid). Responding to the situation, efforts were made to sustain early gains from reforestation initiatives, but they failed as funds from donor agencies ran out.

There are limitations for farmers to adopt these measures due to the absence of the adequate financial and technical support, including little governmental intervention in raising the price of rice in the market to entail additional production cost raised for adaptation practices. Other limitation is the lack of training to enhance adaptation skills of the farmers (Lasco, 2006).

Capacity Gaps

There is low adaptive capacity to implement risk assessments and/or the inappropriateness of the methods used in the formal or official assessment of risks and hazards to natural events (Lasco, 2006). This creates a common gap of understanding by the farmers and by government agencies of what constitute a problem or risk to the farmers.

Agriculture and Food Security Sector

Range of Studies Reviewed and Methods Applied

In the Philippines', first National Communication on Climate Change, vulnerability of rice and corn to the impacts of climate change were examined employing four global circulation models (GCM) together with a range of crop models, namely, CERES- the Crop-Environment Resource Synthesis - Rice and Corn Models of the Decision Support System for Agro technology Transfer (DSSAT) version 3; the modified version of the CERES-Rice International Benchmark Sites Network for Agro technology Transfer (IBSNAT Crop Model); the ORYZA 1 rice model; and the Simulation Model for Rice- Weather relations (SIMRIW) model (Republic of the Philippines, 1999). Furthermore, in the same report, the possible adaptation strategies for the agricultural sector were identified and assessed based on the decision matrix described in the IPCC methodologies³ and also through a series of focused and consultative workshops held with major stakeholders (Republic of the Philippines, 1999).

RMSI (2007) assessed the impact of ENSO on rice and corn production based on the analysis of agro meteorological data from Philippines Department of Agriculture.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) elaborated national vulnerability maps for rice and corn, using a Moisture Availability Index (MAI)-calculated from the ratio of the monthly rainfall to the monthly evapotranspiration – that was then transformed into a Drought Vulnerability Index for each province (PAGASA, 2005, cited in RMSI, 2007). Also, PAGASA applied a Generalized Monsoon Index (GMI) and a Yield Moisture Index (YMI). Regularly published in its bulletin, the region-specific data can be used for converting meteorological data into information about potential agricultural losses. For example, the GMI can be used to assess rain-fed crops by considering the amount of monthly rain for the season, and the YMI helps to assess the agro-climatic crop conditions for a particular crop (PAGASA, 2008). The calculated values will indicate the resulting climatic impacts on the agricultural sector situation, such as a potential flood damage, near normal crop conditions, moderate drought impact, major yield losses due to drought impact, or severe drought impact with potential food shortages (PAGASA, 2008). The bulletin seems to serve as a venue for risk communication in which timely information on climatic impacts is provided to decision-makers and planners so as to enable the development of food assistance and mitigation measures strategies.

Acosta-Michlik and Espaldon (2008) assessed the vulnerability of farmers in Tanauan City, Batangas Province, and evaluated several adaptation options to reduce future vulnerability to the impacts of both climatic and market risks. The vulnerability framework applied for the study was an agent-based model (ABM) that model human adaptive behavior to global environment change. To run the ABM, the agents' profiles and their socio-economic and biophysical environment were defined by conducting social survey and interviews at the three villages. Global Positioning System (GPS) and GIS were used to collect and develop maps of farm ownership and land use.

Impacts on the Agriculture and the Food Sector

Drought is second to the Cyclones, contributing about 18 % of total agricultural damage in the Philippines. During the 1982-83 El Nino events, for example, around 50% of the total area under irrigation was reduced (RMSI, 2007). It is reported that palay crops are most vulnerable to drought during the flowering stage, increasing the growing season period from 70-80 days to the 110–115 day. Meanwhile, acreage under irrigated as well as rain-fed production can fall in the event of a drought.

³ For the details of the Adaptation Decision Matrix (ADM), please visit the UNFCCC's website: http://unfccc.int/files/methods_and_science/impacts_vulnerability_and_adaptation/methods_and_tools_for_assessment/application/pdf/adm.pdf

The Cagayan Valley was identified as one of the provinces that are most affected to chronic flashfloods, typhoons and droughts (RMSI (2007). Between 1991 and 2005, the region Cagayan Valley has lost in total approximately 1 million tons of palay due to flashflood and typhoons and 0.4 million tons due to drought (ibid).

Lansigan et al. studied agricultural impacts and differentiated the impacts of long-term weather variability and short-term weather episodes (2000). The effects of long-term climate variability include the delay of sowing date, the narrower dry season planting period, and unnecessary water stress during the wet season cropping period and the resulting lower yield (ibid). The several impacts of short-term weather episodes are: high temperature induced sterility in rice that results from disturbance of pollen shedding and decreased variety of pollen grains; increasing irrigation water requirement that is attributed to decrease in rainfall during the El Nino year and water stress at rice panicle initiation. This leads to increase in the proportion of unfilled grains and decrease in 1000-seed weight as well as reduced water availability at vegetative stage.

Vulnerabilities and Adaptation in the Agriculture and Food Sector

The Philippines' Initial National Communication identified three aspects with high vulnerability to climate change-the loss of arable lands due to sea level rise; decreased soil fertility due to increased soil erosion; and decreased crop productivity (1999). It further addressed the second consequences of decreased crop yield: loss of food supply and loss of jobs, particularly for marginalized farmers. The adaptation strategies recommended in the First National Communication consists of four key areas: economic, technological, institutional and research strategies. These strategies were chosen mainly because of low implementation cost (First National Communication, 1999). The Department of Agriculture have already accepted some of these recommended measures with low investment costs, compared to the planned irrigation system development. Improved coordination of basic services offered by various governmental agencies are safe and judicious and optimum/efficient use of fertilizers or the so-called Balanced Fertilization Strategy, implementation of strategies to address the ENSO episodes, and the introduction of new least-cost technologies such as hydroponics and evaporation control (ibid).

In the study of Lansigan et al. (2000), vulnerability and adaptation measure are investigated in the light of crops and crop production system, but not comprising enhancement of farmers' capacity to adapt their responses to changing climatic conditions. The main focus of this study is the causality between vulnerability and risks of crop production and climate variability. The conclusion was that the degree of vulnerability of crops to climate changes depends mainly on the development stage of the crops at the time of weather fluctuation. Scientific understanding of crop-climate relationships would contribute to formulating location-specific production technologies. Adaptation measures introduced, therefore, include planting new rice varieties in unstable production areas that are early maturing, lodging-resistant and water-logged resistant ones.

Adaptation measures recommended by Lansigan et al. (2000) are developed by the International Rice Research Institute (IRRI). IRRI has created three new rice species grown from genetically modified seeds that have built-in traits of flood, drought and salt-tolerance (2009). In Philippines, around 400,000 ha of coastal rice-growing land, 370,000 ha of rice-growing land and 1,180,000 ha of cultivated rice-growing upland are affected by salinity from sea water, flooding and drought respectively (ibid). Thus, the three new rice varieties have been invented with an aim to "help Filipino farmers grow more rice in difficult conditions" through the following steps: 1) increase of rice breeders and foundation seeds by IRRI and the Philippines Rice Research Institute (PhilRice), 2) official approval 3) making basic seeds available to seed growers and selected farmers, 4) catering to other farmers by those selected; and 5) other farmers gaining the overall increase in productivity of rice (ibid).

The vulnerability study of the farmers in Tanauan City identified frequent intense droughts and increased market competition as important sources of their vulnerability (Acosta-Michlik and Espaldon 2008). Particularly, this is evident for farmers who do not own irrigation infrastructure, since their income are reduced by lower crop yield as well as higher production and marketing costs induced from public market. In the study, it was found that production support for increasing cropping intensity of rice production as well as yield would considerably reduce vulnerability only if complemented with market support to increase the price of rice and/or decrease the transport costs to the market (ibid).

Gaps Identified in Programs and Studies

Scientific Gaps

There are limited data and analysis on the definition of meteorological drought and potentially, this could be a barrier in devising drought risk assessment to prepare drought risk management plans as in the rice sector. Basic maps such as drought hazard maps are either incomplete or unavailable. In addition, while there seems to be reasonable amount of study pertaining to El Niño and la Niña, there have been no efforts to fuse El Niño and la Niña into one 'drought index'-based on meteorological and rain gauge stations recorded historical time series data (RMSI, 2007).

Capacity Gaps

According to RMSI (2007), only limited data and basic maps on meteorological drought hazards are available. There is need for hazard maps, as done at regional level to enable municipal governments to prepare drought risk management plans.

The results and recommendations of the studies made by Lansigan (2000) and IRRI (2009) does not support local vulnerable people to enhance their capacity to adapt existing adaptation practices to changing climate conditions nor increase resilience of people to climate change.

Acosta-Michlik and Espaldon (2008) stated that the adaptive capacity of most vulnerable farmers to apply available technical adaptation measures is prevented mainly due to lack of money and information.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

RMSI assessed economic damages in agricultural fields such as rice and corn farmlands that were caused by water hazards (2007). These covered reduced rice crop and palay production, increased power demand for agricultural water pumping, impact on rice-based industries and employments.

The PCW study views vulnerability in line with IPCC Fourth Assessment Report which defines vulnerability to climate change as "the propensity of human and ecological systems to suffer harm and ability to respond to stresses imposed as a result of climate change impacts" (Chapter 17, Zero Order Draft in Lasco, 2006). Analytical framework depicted the determinants of vulnerability at two

spatial scales, namely, households and communities. The occurrence of climate variability and extremes assessed with consideration of the climatic type in PCW included El Niño, La Niña, early onset or delay of rainy season, prolonged rains and typhoons. The data collection methods employed in the study were secondary data gathering, household survey, use of participatory rural appraisal techniques, and direct field observation and GPS readings of identified vulnerable areas. Information gathered were analyzed through several approaches for the different purposes. The qualitative approach was used for assessing the degree of present of vulnerability of the differentiated socio-economic groups. The vulnerability index was developed with multi-level indicators, namely, food, water, livelihood, and health, in order to determine the factors influencing the households' vulnerability to climate variability and extremes and compare the researchers' judgment and the local communities' perspectives. The quantitative techniques such as correlation and regression models were used to determine the combined effects of the different hypothesized factors on households' vulnerability. Finally, mapping of vulnerable areas was created to assess the degree of vulnerability by land use type with the aid of GIS.

Resurreccion et al. focused on social implications of climatic variability and extreme events and highlighted the difference between local adaptation strategies practiced by well-off and marginalised farmers (2008). Resurreccion et al. further pointed out a key process that would enhance adaptation capability.

Acosta-Michlik and Espaldon (2008) reviewed vulnerability study based on a behavioural model of agent's adaptation to climate change and addressed social values and network as key determinant factors of individuals' mal-adaptation responses.

Impacts on Socio-Economic Sector

Cyclones, floods, and droughts induced 82.4% of the total Philippine rice losses between 1970 and 1990. In 1990 alone, domestic losses resulted from climatic events amounted to US\$ 39.2 million. Between 1990 and 2006, the Philippines faced an average annual damage of 0.5% of GDP due to disasters, of which cyclones accounted for 62% of total damage and 70% of agricultural damage (Benson, 2007, cited in RMSI, 2007). Particularly, during the periods of severe El Niño as well as la Niña, economic losses were reported to be very significant (RMSI, 2007). For example, the ENSO occurring during the 1997-

1998 El Niño/La Niña episode put the severe economic impact of a total of P7.6 billion in rice and corn production losses. The ENSO has impacts on all segments of society, among which the most affected are resource constrained farmers whose livelihoods heavily relies on the changing seasons. This situation is most apparent among rain fed farmers who are exclusively dependent on rainfall to irrigate their crops (ibid). As a consequence, those most affected are reinforced to suffer from poverty (World Bank, 2005).

A study of PCW reveals that most vulnerable areas invariably experience decline in rice production levels from 20% to 100% (of 90-100 cavans/ha) and escalation in production cost by at least 25% during periods of drought (Lasco, 2006). During floods, most of the vulnerable areas suffer between 40-100% (of 60 - 90 cavans/ha) loss in production. It has also been found that the low yield of food grain, combined with environmental stresses like prolonged dry spells and excessive rains, leads to loss of crop values. For example, Isabela had faced three consecutive crop failures because of erratic rainfall and flooding in 2005.

Some researchers observed a fall in student enrolment in the province of Albay because of the extreme events such as storm surges with floods and volcanic lahar (Resurreccion et al., 2008). This led to reconfiguring livelihoods including increase of child labor and urban migration.

Vulnerabilities and Adaptation in the Socio-Economic Sector

Vulnerability of Areas

The vulnerable places in the PCW identified by the local communities include low-lying flood-prone settlement areas, agricultural areas prone to floods and droughts, dying streams/rivers, and farmlands at the tail-end of irrigation canal (Lasco, 2006). The interesting finding is that these places are highly congruent with the result of GIS-generated levels of vulnerability. Hence, the study of the PCW suggested combining the two methods for identifying the vulnerable areas as a comprehensive assessment of vulnerable areas.

Vulnerability of People

Among the differentiated socio-economic groups, namely, small farmers, average farmers and fishermen, employees and small entrepreneurs, and rich farmers, the small farmers were identified as

the most vulnerable by local community members (Lasco, 2006). It is to be noted that even though the climate-related losses may not be destructive at the community level, the damage climate-related losses generate to the household level could have lasting impacts and lead to a chain-reaction of negative effects (ibid). The nature of impacts of climate variability and extremes seems to be almost the same among the above-mentioned groups. However, the small farmers were identified to have the high degree of negative impacts and vulnerability due to lack of access to, or control of, reproductive resources such as small land and little capital, as well as due to ineffectiveness of adaptation strategies.

The study of the PCW further examined vulnerability of people to future climate variability and extremes. The projected climate change impacts with relation to food availability and crop production, livelihood, health and water supply, potential adaptation strategies and the degree of vulnerability of the abovementioned socio-economic groups were described (Lasco, 2006: 59). The degree of negative impacts and vulnerability of small farmers will exacerbate due to lack of capacity to cope with the negative impacts. For example, not only will their crop production decline, but they are likely to be exposed to starvation, eventually resulting in malnutrition and other kinds of health diseases.

Factors influencing vulnerability were highlighted in the study of the PCW, with a focus on socio-economic circumstances as well as in the socio-political and institutional contexts. In terms of socio-economic factors, farm income, monthly food expenditures and farm distance to market were found significantly associated with vulnerability (Lasco, 2006). The more dependent people are on their farm income, the more vulnerable they become to climate-related events. Also, people who spend less on food due to their limited financial capacity are more vulnerable. Finally, households in far-flung areas tend to be more vulnerable because of being cut off from market during the rainy season and flooding. In addition to socio economic factors, the socio-political and institutional aspects also affect vulnerability. The quality of services provided by organizations that the farmers join matters for reducing vulnerability. Also the larger the farm size, the more vulnerable the owners become. Furthermore, demographic research shows that women were found to be more vulnerable than men while migrants were more vulnerable than the original inhabitants.

Adaptation

Bicol University identified local adaptive strategies to changing weather conditions including increased rice cultivation in upland areas with 14 varieties, planting of fruit trees, digging canals for fish farming and planting root crops (Resurreccion et al., 2008). In some resettlement areas of Albay, a number of well-off farmers started to cultivate high value vegetables whose crop maturation could occur within a short period. This practice is expected to yield increase as well as water storage from rainfall.

Marginalized farmers cannot take the risk of experimenting with new farming technologies due to little access to financial capital for new inputs (Resurreccion et al., 2008). Responding to this situation and in order to avoid the above-mentioned social impacts of extreme events, the engineering department of Bicol University has invented a mobile coconut shredder for upland farmers. The office of the Department of Agriculture in Albay have also been forming farmer's groups for introducing agribusiness, which enable farmers to gain farm inputs for crop diversification and food for work for rice production subsidy (ibid).

The processes in which some research programs of climate change and adaptation on agriculture and water resources were conducted involved on-site investigations and stakeholder consultation (ibid). These processes themselves have enhanced the adaptation capacity by making a case for a) improved decision-making and coping strategies of farmers through access to scientific climate and crop forecasting information; b) recognizing that multiple stresses arising from climate change spur varied coping strategies; c) local stakeholder adaptation strategies could inform planned adaptation options; and that d) vulnerability varies among different social groups depending on their assets and arising from combined climate and non-climate factors (Tibig and Lansigan, 2008, De los Santos, Lansigan and Hansen, 2007, and Pulhin et al., 2008, cited in Resurreccion et al., 2008)

Acosta-Michlik and Espaldon (2008) pointed out that social values and network could indicate the factors that determine individuals' maladaptive responses such as ignoring economic opportunities or climate change risks. However, social networks are often limited to relatives and neighbors as reflected in the case study of four types of farmers (ibid). Cooperatives and local officers, who have access to technical knowledge on adaptation, do not usually interact with the vulnerable nor take much

role on exchanging information in the network. Hence, it is suggested to improve social interaction with the vulnerable people in order to reduce their vulnerability.

Gaps Identified in Programs and Studies

Research Gaps

Research on non-climatic and socio-economic related factors such as migration and urbanisation needs to be conducted for the projected water demand from the industrial, domestic and irrigation sectors. A vulnerability assessment study on the Angat and Lake Lanao reservoirs in 1999 pointed out that the projected water demand for domestic use would increase until 2050 due to the expected rapid migration of people to Metro Manila and suburbs and accelerated industrialization (NIA, 1997 cited in Jose and Cruz, 1999). Considering the increasing demand for water as a consequence of both extreme events and changing social and economic environments, the holistic approach should be employed for developing adaptation strategies.

Water reallocation was highlighted as an adaptation option (Jose and Cruz, 1999). For reallocation procedures, water rights are a key issue to determine and consider. Hence, institutional aspects, including the endowment and entitlement, as well as socio-economic conditions that could determine access to water need to be reviewed. Based on this research, an effective and equitable distribution of water should be implemented to ensure that the certain sectors and groups of people do not become vulnerable even after reallocation or redistribution of water.

Furthermore, comprehensive management of degraded watershed was identified as an adaptation option with emphasis on regulation of excessive logging and shifting cultivation in the watershed. These economic activities as income resource cause widespread decline and resulting erosion and siltation of rivers, lakes and reservoirs (Santos 1997 cited in Jose and Cruz 1999). This clearly shows that adaptation schemes adopted in watershed areas need to reflect on human induced impacts on water sector.

Vulnerability index developed as data analysis method shows the gaps between the value of vulnerability weighted by the researchers and local communities (Lasco, 2006). The values of the index are relative since it depends on the perception of whoever is giving the weights. Hence, it is suggested

to involve the different stakeholders, especially those who are directly affected by climate-related events, to ensure the accuracy of the vulnerability index.

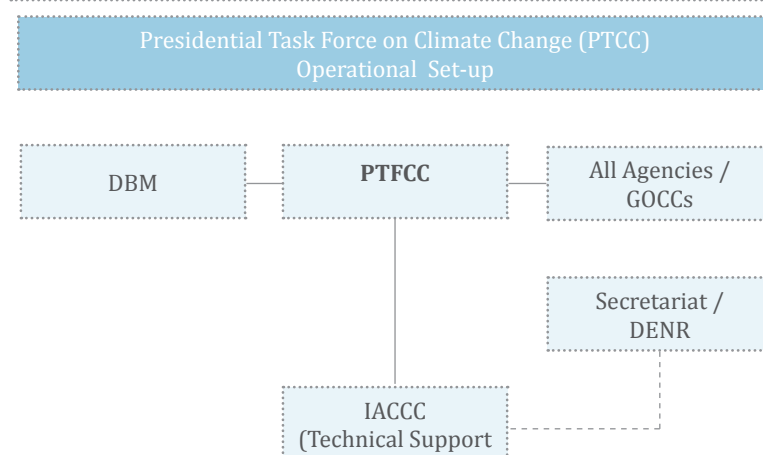
The variables identified in the regression model used in the study of PCW, namely, ethnic affiliation, household size, monthly food consumption, and farm distance to market were found insufficient to analyse household's vulnerability. An average of approximately 55% of the vulnerability variance based on the weights provided by both researchers and the local communities were unaccounted for on an aggregate level (Lasco, 2006).

Many studies on climate change impacts and adaptation in the forest, agriculture and water resources sectors have reported that there exists a fragmented approach as well as a disconnection between local planning and actual adaptation strategies and also inspected the lack of interdisciplinary partnership in research projects that could assist in more holistic analysis and findings on adaptation processes (Penalba et al., 2007, Allen, 2006, Capili, Ibay and Villarin, 2005, Castillo et al., 2008, and Sales, 2008, cited in Resurreccion et al., 2008).

Governance Gaps

Lack of enabling national policies and institutional support to enhance adaptive capacity to reduce climate change impacts appears to have prevented the local communities from making efforts to reduce biological as well as socio-economic vulnerability. For example, the forest policy does not allow timber harvesting in watershed areas in which the communities are already involved in the projects of plantation establishment (Lasco, 2006). Lack of direct access to natural resources and limited sources of livelihood opportunities, community members are forced to get involved in illegal logging and charcoal-making, which has resulted in degradation of the watershed contributing to biological vulnerability. There is no institutional support to build the capacity of the local communities to anticipate the occurrence of variables and extreme climate events. The lack of assessing policy-planning processes based on behavioural analysis on policy-makers might affect the extent of vulnerability of local communities to climate change because vulnerability is an outcome not only of decision processes of the communities but also of the responses of policy makers to certain opportunities or risks faced by climate change (Acosta-Michlik and Espaldon 2008).

Figure 20: Operational set-up of Presidential Task Force on Climate Change (Environmental Management Bureau, 2007)



Capacity Gaps

The study on people's vulnerability points that a sense of dependency for external assistance, rather than the culture of self-reliance has been built through the long-term socio-political process started from 1971 to the present, whereby the chain of development projects have been implemented (Lasco, 2006). Such resettlement projects were little intended towards building capacities of the local communities to increase resilience from climate change impacts.

The capacity of the poor community to increase resilience from climate change impacts remains low due to the prevailing inequitable social structure especially in PCW (Lasco, 2006). This is reflected by the community's own typology of small, average and rich farmers. Given that enhancing the adaptive capacity is associated with availability of, access to and control over productive resources, the prevailing inequality that embodies the Philippine social structure is a crucial issue to tackle as a root cause.

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Climate Change

Current Institutional settings for Climate Change Related Activities

The Philippines was one of the earliest countries to address the challenges of climate change. In 1999, the country submitted to the UNFCCC an Initial National Communication on Climate Change. Since the preparation time for the ratification of UNFCCC,

several governmental agencies have been engaged in forming a committee with certain mandates.

One year prior to the ratification of UNFCCC in 1992, the Inter-Agency Committee on Climate Change (IACCC) was created to serve as the ‘national mechanism’ for climate change with a main task of coordinating all climate change related activities and the country’s representations in international negotiations (Resurreccion et al., 2008 and DENR, 2009). The committee is co-chaired by the Secretaries of the Department of Environment and Natural Resources (DENR) and the Department of Science and Technology and represented by about fifteen (15) government agencies and non-government organizations.

After the ratification of the Kyoto Protocol, the Presidential Task Force on Climate Change (PTFCC) was established in 2007 to conduct rapid assessments on climate change impacts, especially on the most vulnerable sectors such as water, agriculture as well as on the terrestrial and marine ecosystems (Rincón and Virtucio, Jr, 2008). The original operational set-up is shown in Figure 20. The PTFCC’s four main functions are: secretariat, technical, budget and other supports (Environmental Management Bureau, 2007). The PTFCC’s secretariat was initially led by DENR. The composition of the PTFCC was later changed with the Department of Energy (DOE) as its chief (Resurreccion et al, 2008). The PTFCC receives technical and budgetary support from IACCC and Department of Budget and Management (DBM),

respectively. Other required supports are provided by all the government agencies and Government-Owned and Controlled Corporations (GOCCs). The Advisory Council on Climate Change Mitigation, Adaptation and Communication (ACCCMAC) was also formed under the DENR (ibid).

At the provincial level, local governments conduct their own climate change adaptation initiatives. For example, the Provincial Government of Albay has started its own program to ‘mainstream’ climate change adaptation into its economic and social development programs.

Gaps Identified

The three bodies, namely, IACCC, PTFCC and ACCCMAC, presently overlap functions without clear lines of coordination between them. As a result, not only the Philippine Climate Change Response Action Plan, but also the second national communications are yet to be completed (Resurreccion et al., 2008).

Recent Programs and Projects

In 2007, the Environment Management Bureau of the DENR implemented a project called Climate Change Adaptation Phase 1 for a period of nine months with financial support from World Bank and Global Environment Fund (Resurreccion et al., 2008). The project intended to develop the institutional set-up that would be best suited for the country to develop sector-responsive adaptation activities to reduce vulnerability to climate change risks as well as reliable climate risk information.

Figure 21: Disaster Coordinating Councils (DCCs)’ organizational network (Asian Disaster Preparedness Center, 2003)



Institutional Settings Concerning Disaster Risk Reduction

Current Institutional settings for Disaster Risk Management

The current basis of the Philippines’ disaster management arrangement is centred at the National Disaster Coordinating Council (NDCC) as the highest policy-making body on disaster-related issues (Asian Disaster Preparedness Centre, 2003). The members of the NDCC are comprised of nineteen (19) Cabinet Secretaries including the Secretary of National Defence as the chairman. The updated Calamities and Disaster Preparedness Plan included six more Cabinet members as members of the NDCC (ibid). The member agencies are responsible for conducting respective tasks and responsibilities, which include preparedness, mitigation, response and rehabilitation. NDCC does not have a regular budget, but it operates through member-agencies and their local networks, namely, the Regional,

Provincial, Municipal and Barangay (village) Disaster Coordinating Councils (DCCs) (Asian Disaster Preparedness Center, 2003, Rincón and Virtucio, Jr, 2008). The NDCCs' organizational network is illustrated in Figure 21.

The Regional Disaster Coordinating Councils (RDCCs) facilitates activities of national government agencies at the regional level. RDCCs do not have their own budget and can operate only through mutual coordination of the member agencies such as the Philippine National Police and the Metro Manila Development Agency. The RDCCs' activities include establishment of a Regional Disaster Operations Center, Implementation of guidelines within the regions set by the NDCC, and provision of advice to local-level disaster coordinating councils on disaster management. The local-level disaster coordinating councils are expected to carry out all the necessary activities at the respective levels, namely, provincial, city/municipal and barangay system levels.

Gaps Identified

World Bank's study (2005) highlights that institutional setup in disaster management systems in the Philippines tend to focus on a reactive and post-disaster relief approach and short-term preparedness. To avoid disaster-prone conditions, it is imperative to take a proactive approach such as integration of the threat of natural hazards into the development of long-term sustainable development and adequate land-use planning and construction. The shortcomings of proactive approach are associated with a lack of a national framework for comprehensive disaster risk management as policy support. The study defined key areas that have to be addressed for an integrated risk management within the necessary steps of risk identification, risk reduction, and risk sharing and financing (World Bank, 2005). Further, the study suggested that such institutional changes would need to be accompanied by coordinating and implementing agencies, working in a participatory, instead of top-down approach. The participation of all stakeholders in a bottom-up approach will help to improve the resilience of the most vulnerable communities. Further, the study emphasized that since the Philippines still tends to rely on centralized top-down systems, local government units need to be encouraged to undertake respective bottom-up initiatives.

Recent Projects

UNDP, FAO, WHO, UN-Habitat, UNICEF, ILO, and UNFPA are implementing the three-year joint

program (2007-2009) to strengthen the country's institutional capacity to adapt to climate change, in collaboration with UNEP, the Interagency Committee on Climate Change, donors and other partners working in the most disaster prone eastern seaboard. The program aims to achieve three outcomes in the areas of policy/planning/programming; capacity development of concerned national government institutions and local governments and local higher educational institutions; and capacity development of communities to develop demonstrable climate change adaptation measures. Specifically, three outcomes are climate risk reduction mainstreamed into key national and selected local development plans and processes; enhanced national and local capacity to develop, manage and administer projects addressing climate change risks; and coping mechanisms improved through pilot adaptation projects.

FAO has launched a two-year capacity building project at the community-level with a focus on the agricultural sector in January 2009. The project objective is to develop the capacity of the selected communities in the Bicol region to better prepare against natural disasters such as typhoons, floods and drought for improved livelihood and food security. In particular, it assists the small farmers, fisher folks and livestock raisers in enhancing the capacity to plan their production and marketing in accordance with the climatic, market and financial risks.

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Research Gaps

There have not been much research focus on the large scale structural causes of vulnerability such as poverty, inequity, institutional and economic barriers to development that undermine the enhancement of the ability of the farmers to cope with floods and water shortages. As indicated in the study of the Pantabangan-Carranglan Watershed (PCW), an ideal program for reducing the vulnerability of farmers, the most affected from climate change, should address structural improvement, such as the ability to gain access to cheaper alternative water sources, to engage in alternative cropping systems for their livelihoods, and to set in place systematic mechanisms for providing the farmers with technical and logistical assistance particularly designed for

adoption of appropriate adaptation strategies. In order to increase the ability of the farmers to access and adopt alternative adaptation practices, it is necessary to conduct scientific research on socio-economic, political and institutional structure in which the most vulnerable are placed.

In addition, cost-benefit analysis of potential adaptation strategies needs to be implemented for strengthening the adaptive capacity of stakeholders. As described in the study of PCW, the challenge is to make all the stakeholders agree on the real risks related to climate change and steps necessary to reduce them. In order to enhance the capacity of facilitation and decision-making between and among the stakeholders, it is recommended that scientific research be focused on priority-based interests and the cost involved that needs to be borne by the stakeholders, once the strategy is implemented.

Scientific research conducted by Lansigan (2000) and IRRI (2009) highlights importance of understanding of changing environments between and within human and natural systems. The assessment on vulnerability of crops and crop production system is inevitable for building adaptation strategies of the agriculture sector. However, the scientific insight into vulnerability of people and local communities needs more attention since it is the farmers and farming communities that implement adaptation practices to reduce vulnerability of crops. The poor communities vulnerable to the changing socio-economic, political and institutional systems may maintain to plant crops vulnerable to climate variability due to the lack of access to new rice species.

Increasing rice production in areas that are highly vulnerable to climate variability through planting genetically modified rice varieties is introduced as an adaptation measure in the IRRI research (2009). This scientific approach could result in enhancement of efficient use of natural resources. However, it does not necessarily ensure food security for the poor in local communities that are vulnerable to climate change, since decisions on whether the high yield of rice produced is distributed to the people in food insecurity or not is beyond the technological field. Rather, it is the scientific research with a focus on socio-political and institutional processes that affect decision-making.

Governance Gaps

The climate change adaptation strategies recommended by the two studies of Lansigan (2000) and IRRI (2009) are built on top-down decision

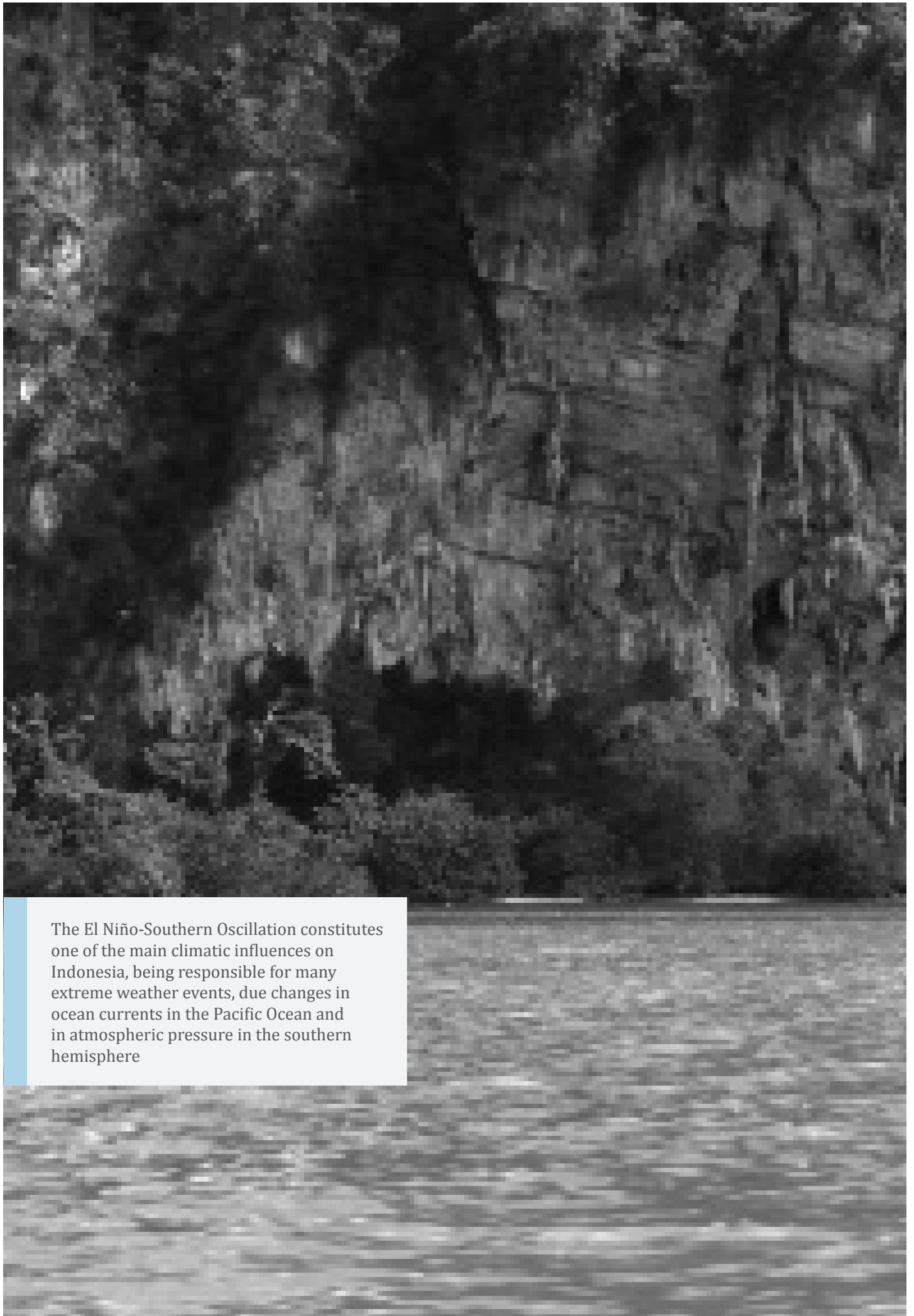
making and information dissemination processes. These strategies have been developed without reflecting on traditional knowledge system or existing community-based adaptation practices or having multi-stakeholder consultation on opportunities and threats of introducing genetically modified rice seeds that farmers would come across. Hence, inclusive governance, in which different groups of stakeholders, including socially, economically and politically vulnerable people, participate in planning and decision-making processes, is of high importance.

Capacity Gaps

There is lack of bottom-up assessment and planning to address vulnerability and enhanced adaptive livelihood at the local and national level.

Also, it is necessary to consider participatory action research engaging the different stakeholders to be pursued to minimize vulnerability of the poor and enhanced adaptive capacity at the local level.

- **Water sector**
There is a need to integrate climate and human induced risks in watershed planning and management in consultation with the local communities. Further, it is necessary to highlight the demand and supply of water in building both socio-economic and institutional remedies.
- **Agriculture and Food Security Sector**
It is required to conduct an assessment of socio-economic and political vulnerability of the farmers and enhance the adaptive capacity of the farmers to cope with floods and water shortages based on the vulnerability assessment.
- **Disaster Risk Reduction**
The World Bank (2005) found that most of the costs arising from natural disasters are endured by individual households and the Philippine Government. In order to effectively relieve the economic burden, alternate options for covering costs from disasters are considered that include a catastrophe insurance pool or contingent credit facilities. Also, for local government units, currently no incentive for taking proactive risk reduction steps exists, which must be changed with the introduction of strong fiscal incentives. This would also reduce the currently existing funding gap.



The El Niño-Southern Oscillation constitutes one of the main climatic influences on Indonesia, being responsible for many extreme weather events, due changes in ocean currents in the Pacific Ocean and in atmospheric pressure in the southern hemisphere

RESEARCH SYNTHESIS ON INDONESIA

COUNTRY CHARACTERISTICS

Information on Indonesia's geographical, social, economic and climatic risk situations are covered in this section. An overview of the country's characteristics is given in Table 7.

Geographic Attributes

Indonesia is the world's largest archipelago country, including a coast line length of 81,000 km and consisting of 17,508 islands (Republic of Indonesia, 1999). The main islands are Sumatra,

Java, Kalimantan, Borneo (two-thirds of the island are Indonesian land), Sulawesi and Irian Jaya. The archipelago is located on two shelves (Sunda Shelf as continuation of the Asian mainland and Sahul Shelf of Australia and New Guinea), dividing the islands into three groups that are for example having different sea depths (233 meters up to 5,000 meters). Due to the location on these shelves, the whole archipelago of Indonesia is prone to tidal waves and earthquakes. Indonesia is mainly mountainous, with the highest mountain being 5,030 meters (Mount Jayawijaya) and including about 400 volcanoes of which 100 are active (Republic of Indonesia, 1999).

Table_7 Indonesia country profile overview

Country level information (CIA, 2010, Republic of Indonesia, 1999, UNdata, 2009, WHO and UNICEF, 2006b)	
Surface area (million km ²)	1.9
Bordering countries	Timor-Leste, Malaysia, Papua New Guinea
Population, 2009 (million)	240
Population density, 2007 (per km ²)	121.6
Population growth rate, 2005-2010 (% per year)	1.2
Mountainous land (% of total area)	Predominantly mountainous
Agricultural land, 1994 (% of total area)	6.8 (plantation) 4.4 (rice fields, wetlands)

GDP, 2008 (estimated, billion US\$)	511.8
Contribution of agricultural sector to GDP, 2008 (projected, %)	14.4
Contribution of industrial sector to GDP, 2008 (projected, %)	48.1
Contribution of service sector to GDP, 2008 (projected, %)	37.5
Percentage of population, 2007 (%) in	
- rural areas	49.6
- urban areas	50.4
Population below poverty line, 2006 (% of total population)	17.8
Infant mortality rate, 2009 (per 1 000 live births)	29.9
Adult literacy rate, 2004 (%)	90.4
Access to improved drinking water sources, 2006 (% of total population) in	
- rural areas	71%
- urban areas	89%

Figure 22: Location map of Indonesia (UNdata, 2009)



Socio-Economic Status

Indonesia is the largest economy in South-East Asia. Although the country's economy experienced a recession in 1990's as a result of the economy crisis that spread over most Asian countries, the economy is now relatively stable (Republic of Indonesia, 2010). Between 1997 and 2007, Indonesia achieved the two-fold increase in GDP (nominal) from US\$ 215.7 billion to US\$ 432.8 billion (The World Bank, 2008). The agricultural, industrial and service sector amounted for 14%, 48% and 38% of GDP respectively in 2008 (CIA, 2010). The country has wealth in natural resources outside Java islands such as crude oil and natural gas, which constitute the main industries in Indonesia.

The estimated national population of 2009 is approximately 240 millions, the 4th largest

population in the world (CIA, 2010). The half of them lives in the urban areas, out of which approximately 90% are estimated to have access to improved drinking water sources. Approximately 70% of the rural population does so. Although the adult literacy rate accounted for about 90% of the population, nearly 20% still live under poverty line.

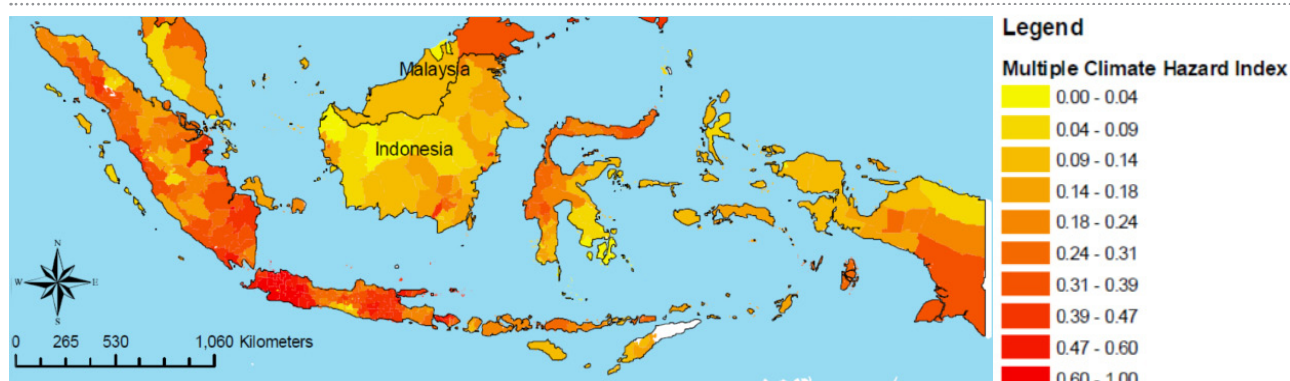
Climate Risks

To assess Indonesian-specific climate profile, current climatic conditions as well as projected climate scenarios are discussed.

Current Climatic Conditions

Indonesia is located in the tropical belt and has a tropical maritime climate (Republic of Indonesia, 1999).

Figure 23: Climate hazard map of Indonesia (Extracted from Multiple climate hazard map of Southeast Asia, Yusuf A.A. and H.A. Francisco, 2009)



The El Niño-Southern Oscillation (ENSO) constitutes one of the main climatic influences on Indonesia, being responsible for many extreme weather events, due changes in ocean currents in the Pacific Ocean and in atmospheric pressure in the southern hemisphere (UNDP Indonesia, 2007). In the case of El Niño, the currents are unusually warm, whereas they are unusually cold in the case of La Niña. At the same time, El Niño events tend to bring more droughts and La Niña is often associated with more floods. Other climate-related hazards include tropical cyclones in the eastern south Indian Ocean from January to April as well as in the eastern Pacific Ocean from May to December. These tropical cyclones and also the transitions between Southwest and Northeast monsoons can cause strong winds and heavy rainfall (UNDP Indonesia, 2007).

In particular, changes in temperature, rainfall and seasonality of precipitation have been observed in different areas of Indonesia. Annual mean temperature increased during the year between 1901 and 1998 by about 0.3°C (Hulme and Sheard, 1999 cited in Case et al., 2007). Overall annual precipitation decreased during the same period by 2 to 3% across Indonesia. However, precipitation patterns vary depending on the region. Annual rainfall has declined in the southern regions including Java, Lampung, South Sumatra, South Sulawesi, and Nusa Tenggara, whereas precipitation has increased in the northern regions of Indonesia including most of Kalimantan, North Sulawesi (Boer and Faqih, 2004 cited in Case et al., 2007). Also, the seasonality of precipitation has changed differently in each region: the wet season rainfall has increased in the southern region while the dry season rainfall

has decreased in the northern region (ibid). Furthermore, in most of Sumatra and similarly also in most of Java, the onset of the wet season has been observed to be about 10 - 20 day later in recent years (1991 - 2003) compared to three decades ago (1961 - 1990), whereas the dry season starts approximately 10 - 60 days earlier (Naylor et al., 2007, cited in UNDP Indonesia, 2007).

Recent years have shown the tendency that the frequency and intensity of extreme climatic events is increasing (Ministry of Public Works, 2007, cited in UNDP Indonesia, 2007): while droughts occurred on average every four years between 1844 and 1960, the frequency has increased to every three years in the period 1961 - 2006. Also, the frequency of floods has increased. However, It seems to be unclear, whether currently experienced climatic changes are a result of increased greenhouse gas emissions or whether they are related with the ENSO, or a consequence of both (UNDP Indonesia, 2007).

Table 8 shows an overview of natural disaster related statistics from International Disaster Database (EM-DAT, 2009). The disaster statistics indicate that

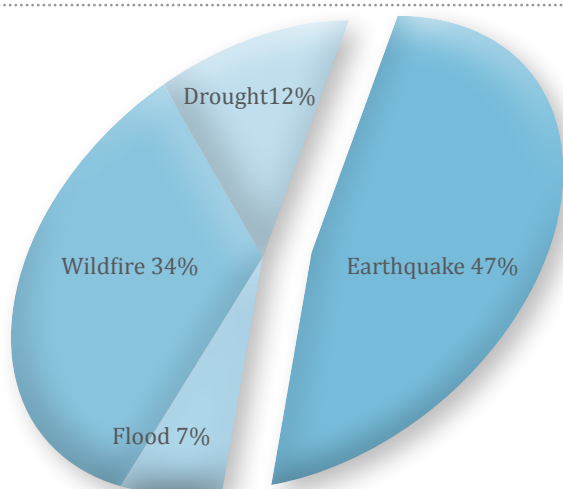
Table_8 Overview on natural disasters in Indonesia from 1980 to 2009

Top 5 Natural Disasters in Indonesia for the period 1980-2009			
Type of natural disaster	Date/year	No of people affected	
Earthquake (seismic activity)	May 2006	3,177,923	
Wildfire	Oct 1994	3,000,000	
Drought	Sept 1997	1,065,000	
Earthquake (seismic activity)	Sep 2009	450,000	
Flood	Dec 2006	420,000	
Total Natural Disasters* in Indonesia for the period 1980-2009			
Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Drought	6	1,083,000	89,000
Earthquake (seismic activity)	73	6,910,847	9,195,726
Epidemic	29	658,923	N/A
Flood	114	7,221,380	2,374,522
Mass movement (wet)	38	392,945	120,745
Storm	5	14,638	N/A
Volcano	34	612,393	344,190

* not considered: mass movement (dry)

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain - Brussels, - Belgium.

Figure 24: Percentage of people affected due to top 5 natural disasters 1980-2009

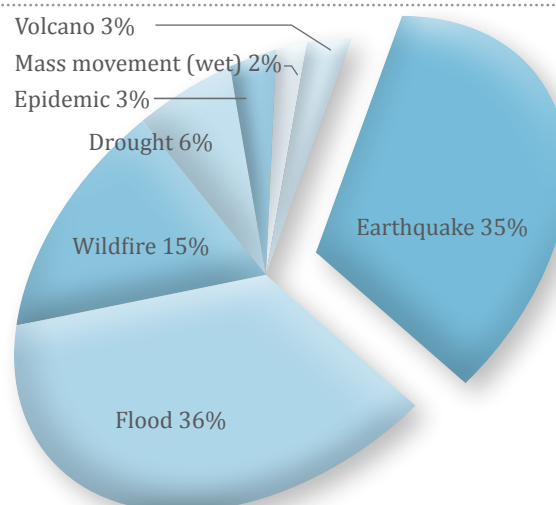


earthquakes constitute the major natural risk, affecting 47% of all the people affected by the top five natural disasters from 1980 to 2009 (see Figure 24). When it comes to the total number of events within this period, floods appear in 114 events, and are responsible for 36% of all affected people (see Figure 25) and create 11% of the total economic damage (See Figure 26). Drought, on the other hand, affects 12% of the top 5 natural disasters affecting people, and 6% of the people affected by the total natural disaster events. Also, wildfires constitute an important climatically induced natural disaster, responsible for affecting 34% of the people (Figure 24) or 15% of the people (Figure 25), and wildfires also create 43% of the total economic loss (Figure 26). All together, climate related disasters – like drought, wildfire, flood, wet mass movement and storm – account for 53% of the people affected in the top five natural disasters as well as 59% of the people affected and 55% of the economic damages in all the natural disasters between 1980 and 2009.

Climatic Projections

Temperature and precipitation are expected to increase in the future in Indonesia. The rate of warming is likely to rise relatively uniformly across Indonesia from about 0.1 to 0.3°C per decade for the next 100 years (Hulme and Sheard, 1999 cited in Case et al., 2007). Another study shows that it will be slightly greater from 0.2 to 0.3°C per decade (Boer and Faqih, 2004 cited in Case et al., 2007). Meanwhile, change in precipitation is not as uniform: annual rainfall is projected to increase across most of the Indonesian islands, with a possible exception of the southern parts of Indonesia, including Java, whereby it is expected to decline by up to 15%

Figure 25: Percentage of people affected due to total natural disasters 1980-2009



(Hulme and Sheard, 1999 cited in Case et al., 2007). However, variance in rainfall significantly differs depending on different climate models, regions, and time of the year. For example, the parts of Sumatra and Borneo are expected to become wetter by 10 to 30 % by the 2080's during the December-February season while Jakarta is projected to become drier by 5 to 15 % during the June-August season, depending on the emissions scenario (Hulme and Sheard, 1999 cited in Case et al., 2007).

Moreover, the changes in the timing and seasonality of precipitation is also predicted to be greater: annual monsoon is likely to be delayed by 30 days, leading to 10% increase in rainfall later in the crop year (April to June) and significant decrease in rainfall later in the dry season (July-September (Naylor et al., 2007 cited in EEF, 2007). Furthermore, more extreme weather events such as more frequent and fiercer storms in coastal zones, droughts, floods and sea level rise are likely (UNDP Indonesia, 2007).

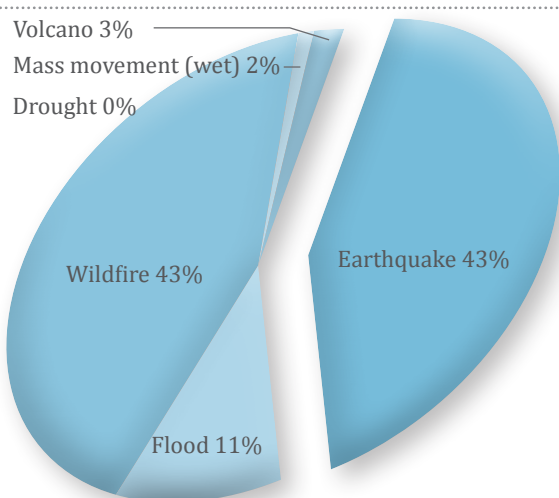
CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

Water Sector

Range of Studies Reviewed and Methods Applied

Presented here are a range of studies and applied methods that were reviewed for analyzing the Indonesian water sectors' situation in view of climate change.

Figure 26: Percentage of damage (US\$) due to total natural disasters 1980-2009



Boer (2009) of the Centre for Climate Risk and Opportunity Management in South East Asia and Pacific, Bogor Agriculture University, indicated a method for assessing climate change adaptation options in the water sector. For this purpose, a case study in Krueng Aceh evaluated the flood design under two climate change and land use scenarios, and a second case study evaluated the climate change adaptation options in view of certain frequency and intensity of climate hazards at Indramayu. While it is common practice to use historical climate and land use data for designing flood control systems, Boer proposes to include climate change and spatial planning scenarios (Boer, 2009).

Prior to the study, Boer (2006) assessed the impacts of land use and climate changes on stream flow at the upper Citarum River by using VIC-BASIN model, in which the hydrology of regional-scale river system was modelled as a geospatially-explicit water mass balance for each grid cell (0.01=1 km²). To investigate the impact of land use change within VIC-BASIN, the historical land use of 1989, 1993, 1999, and 2001 of the Citarum watershed and historical land use of 1985 and 1994 of the Sumberjaya watershed were referred. A model called CLIMGEN v1.0 was employed to generate daily climatic data from the monthly means. In addition, Boer (2006) assessed willingness of downstream community of the Citarum watershed to pay for protecting and promoting forest cover at the upper watershed. The study was carried out through intensive survey to both the upstream and downstream communities at the Citarum Watershed.

In, 2007, some of Indonesian experts and Indonesia-based institutions from all relevant sectors issued climate change related country reports. A group of researchers presented to the Government of Indonesia an overview of climate variability and climate change impacts in Indonesia (Ministry of Environment, 2007). UNDP Indonesia (2007) researched the major threats for poor people posed on their livelihood including water usage and indicated some of the priority areas for climate change adaptation. Case et al. (2007) summarised the observed and projected climate change as well as its impacts on water availability and sea level rise, and addressed vulnerability and adaptation issues for humans and nature. Furthermore, based on existing information and knowledge, the Republic of Indonesia (2007) demonstrated its National Action Plan addressing the Indonesian context of climate change including water resources crisis.

Impacts on the Water Sector

The climatic variability, especially by the decrease and increase in rainfall at different time and spatial scale, induces imbalance of water quantity and quality in the river flow and reservoirs. The rivers all over the country such as the Citram River in Java face reduced flows (UNDP Indonesia, 2007). The Lombok and Sumbawa islands experience the reduced amount of water sources from 580 in 1985 to 180 in 2006, and are becoming more often affected through droughts during wet seasons (UNDP Indonesia, 2007). Also during dry seasons (June-September), the occurrence of ENSOs causes significant decrease of water levels in the reservoirs (Ministry of Environment, 2007). For example, the islands of Bali, Java, Madura, West and East Nusa Tenggara are reported to suffer from water deficit.

The water shortage in reservoirs has generated the second impact on electricity generation. Data from eight dams in Java showed that in El-Nino years of 1994, 1997, 2002, 2003, 2004 and 2006, most of the power plants run in the eight dams produced less electricity than usual (Ministry of Environment, 2007). In addition to electricity generation, the water shortage in the reservoirs during extreme dry year is expected to reduce the availability of drinking water especially in urban and metro areas (ibid). For example, the water volume of the Citarum Dam, which serves drinking water to Jakarta, may reduce to a level of less than 75m during the extreme dry years.

In addition, the sea-level rise is increasing in coastal areas of Asia, including Indonesia, at a rate

of 1 to 3mm per year and is predicted to accelerate to a rate of approximately 5mm per year over the next century (Cruz et al., 2007 cited in Case et al., 2007). WWF highlights that this drastic change will cause magnificent losses of 80,000 km of coastlines, thousands of islands and the resulting marine resources such as coral reefs, fisheries and mangroves in Indonesia (2007). The most affected areas are the north coast of Java, the east coast of Sumatra, and the south coast of Sulawesi (Subandono, 2002 cited in Ministry of Environment, 2007). The sea-level rise further generates the second and third consequences in the coastline such as flooding and sea-water intrusion. One estimate indicates that approximately 405,000 ha of coastal land including small islands are expected to be flooded with a sea level rise of about 1 m (Case et al., 2007). In particular, Jakarta province, especially its northern parts, is almost yearly attacked by flood. Along with the factors such as the position of the moon to the earth and subsidence of Jakarta land due to high building and exploitation of groundwater, sea level rise is one of the major causes of flooding in the area. Further impacts of sea-level rise in the Jakarta province are explained in the section of socio-economic aspects. As a second consequence of sea-level rise, the loss of groundwater and sea water intrusion are caused, threatening water resources for irrigation and drinking (UNDP Indonesia, 2007). The saline water intrusion has occurred in many coastal cities, including Jakarta, Surabaya and Semarang, since 1960s (Ministry of Environment, 2007), inducing a variety of water-related impacts such as reduced quality and quantity of fresh water supply particularly during the dry season and threatened mangrove habitat and coral reefs as well as fish populations (Republic of Indonesia, 2007).

Vulnerability and Adaptation in the Water Sector

Water shortage

The amount of available drinking and irrigation water is projected to reduce in the watershed surrounding the Citarum Dam (Boer, 2006). The degree to which this area is exposed to the risk of water shortage varies depending not only on the decrease in rainfall, but also on a long term land use policy of the region. For example, the Bandung District, located along the basin of the Citarum river (see Figure 27), has developed a long-term land use

Figure 27: Map of Basin of Citarum River (Takeuchi, 1995)



strategy that aims at expanding the total area of paddy field from about 40 thousand to 100 thousand ha in 2010 (Bapeda, 2002 cited in Boer, 2006). If this plan is completed, agricultural demand for irrigation water would exceed the water supply from the Citarum watershed. This may lead to not only risks of drought but also increased conflict over water in the area (Boer, 2006).

Responding to the scarcity of water due to climate change and the increase on water demand, new initiative of inter basin transfer of water is suggested as one of the potential option to adapt to the scarcity of water in the future (Ministry of Environment, 2007). In Indonesia, many basins have surplus water resources but others face significant water shortage. Building of storages and inter-transferring of water from surplus to deficit basins could be one way to achieve optimal utilisation of water. Another adaptation strategy specifically suggested for the areas where water resources are already under pressure from growing water demands is improved water management with increased water efficiency and re-prioritizing current water use (Manton et al., 2001 cited in Case et al., 2007).

Particularly for the watershed of the Citarum Dam where the water deficit is expected, the study result suggests that increase in forest cover to at least 25 % from the total land area should be required at the upper Citarum watershed so as to reduce risks of drought under current and future climatic conditions (Boer, 2006). In order to achieve this, 14,000 ha of degraded land and forest needs to be

rehabilitated. According to the survey, this reward system for environmental services provided from the downstream to the upstream communities is found possible as the former communities are willing to support forest cover activities of the latter community by providing more payment to drinking water. It is further indicated that the willingness to pay of the downstream communities depends on the level of understanding on forest function and its role in reducing impacts of extreme climate events as well as their perception on the upstream communities' role of rehabilitating forest. Thus, highly suggested for both upstream and downstream communities to take adaptation practices is a programme for raising awareness as well as institutional system for collecting, transferring or distributing the payment to community (Boer, 2006).

Institutional Responses

In 2004, eleven ministries of Indonesia's Government signed the National Declaration on Effective Water Management in Addressing Disaster (Republic of Indonesia, 2007). Following this, Indonesia announced in 2005, the National Partnership Movement to Save Water (GN-KPA), covering six strategic components that are i) spatial planning, ii) forest, land and water conservation and rehabilitation, iii) control of damage through water, iv) control and management of water quality, v) management of water demand, vi) fair, efficient and sustainable use of water resources (Republic of Indonesia, 2007).

Further in 2007, the Ministry of Environment, the National Focal Point to the UNFCCC in Indonesia, developed a long-term plan for adaptation, in which measures towards the projected climate change are taken in consideration and identified adaptation programmes in both the short- and long-terms for nine sectors, including water and agriculture. Presented here are some examples of proposed adaptation programme in the water sector, which are categorised under five relevant sub-sectors, namely, water resources, domestic water, irrigation water, industrial water and coastal water sectors.

- **Water resources**
To respond to the major water-related impacts such as flood events, water conservation, coordination of water demand and supply, raising of public awareness, rehabilitation of reservoirs, indigenous options etc. are proposed. Specifically, short term program, like cloud seeding (artificial rainfall) to fill reservoirs is suggested. The long term specific

programmes, on the other hand, include additional reservoirs, embung/situ and rehabilitation of function of upper watershed by vegetative and hydrology restoration.

- **Domestic water**
Considering decreased water availability and quality for domestically used water, four long-term adaptation measures are indicated: municipal and in-home reuse of water, leak repair, dual-supply system (portable and non-portable) and rainwater collection for non-portable uses.
- **Irrigation water**
The long-term adaptation measures responding to the decreased water availability for second rice crops and dry season crops include irrigation timing and efficiency; drainage re-use and use of wastewater effluent; cultivation of high value and low water use crops; irrigation system with drip, micro-spray and low energy; and salt-tolerant crops that can be grown with use of drain water.
- **Industrial water**
Recommended examples of the long term adaptation measures for the industrial purposes include water re-use and recycling, closed cycle and/or air cooling, more efficient hydropower turbines and cooling ponds and wet and dry towers.
- **Coastal zone management**
There are several long term adaptation options for intensified extreme events reduction as well as for coastal livelihoods. The former entails relocation from high risk zones, natural disaster management planning, and physical protection such as revetments and dune restoration. The latter includes mangrove planting from varieties and various types of vegetation that have a wide spectrum of tolerance to change of salinity and high variation of tidal, identification of special type of fishes that are capable to adapt to changing environment to be introduced into river mouth and laguna areas.

Gaps Identified in Programmes and Studies

Regardless of climate change effects, many parts of Indonesia encounter water deficit because of socio-economic development and ecological degradation. For example, Java, Bali and East Nusa Tenggara already suffer from and are increasingly exposed

to water shortage due to growing population and economic activities (Republic of Indonesia, 2007). The water collection facilities such as reservoirs and ponds provide water to only about 10% of the total existing irrigated network area, and supply clean water to 37% of the urban population but only to 8% of the rural population. Also, superficial water resources are degraded through the reduction of the quantity and quality of the river flow. This is mainly caused by forest clearing, land management practices that create downstream sedimentation, and pollution caused from improper disposal of industrial, domestic and agricultural waste as well as mining (Republic of Indonesia, 2007).

As a measure to fulfil the water demand increase from both human- and climate-induced water shortage, the use of groundwater is suggested as one adaptation option (Republic of Indonesia, 2007). Groundwater resources, however, are particularly shallow and are vulnerable in terms of quantity and quality, especially in the dry season. Problems related to the excessive extraction of ground water - mainly due to industries - are land subsidence that on the other hand increases the risk for flood and the intrusion of salt water (Republic of Indonesia, 2007). With regards to the sea level rise in Indonesia, there is a concern that the sensitivity to the sea level rise is likely to get higher in the areas whereby coastal erosion cannot be minimised or stopped (Ministry of Environment, 2007). Indeed, more than hundreds of severely eroded coasts have been recently observed in seventeen provinces (Subandono et al., 2001, cited in Ministry of Environment, 2007). This coastal erosion is, again, associated with changing socio-economic as well as ecological environments: the interruption of the continuous along shore sand transport by physical structures such as massive jetties and harbour breakwaters (Reclamation of Bali Airport, Pulau Baai harbour Breakwater), circulating currents generated by seawalls, the decrease of sediment from rivers caused by construction of many dams or diversion channels in the upstream regions (Krueng Aceh river mouth), coral or sand mining (Tanjung Pasir Tangerang, west Java) and deforestation of mangrove forests (East Lampung, Northern Coast of Java).

Responding to these different types of causes on water shortage, the Ministry of Environment (2007) suggests reducing scientific uncertainties on the expected impacts of climate change in Indonesia through collect historical climate data and validating all climatic models and techniques. In particular, data collection of hydrological and meteorological

phenomena, including changes in river run off and the water quality, is essential since the current and projected impacts of climate change and climatic variability are directly or indirectly associated with the water sector. Also, the use of both satellite and ground based observation for data collection is important (ibid).

Agricultural and Food Security Sector

Range of Studies Reviewed and Methods Applied

The PT. Pelangi Energi Abadi Citra Enviro (PEACE) (2007), Republic of Indonesia (2007), UNDP Indonesia (2007) and Amien and Runtunuwu (2008 cited in EEPSEA, 2008 and Pribadi, 2008) studied the impact of adaptation to climate change concerning the Indonesian agriculture.

Also, a project by the Asian Disaster Preparedness Centre (ADPC) in collaboration and cooperation with the Institute of Agriculture in Bogor, the District Agriculture Office of Indramayu, the Directorate of Plant Protection and the Bureau of Meteorology and Geophysics was reviewed (Boer et al., 2006).

Keil et al. (2008) assessed the factors that determine the resilience of farmers towards ENSO-related drought with the help of a case study in Central Sulawesi in Indonesia. The study was done at the household level and used indicators for assessing consumption expenditures and an index that measured the households' drought resilience, including natural, economic and financial, human, and social capital (Keil et al., 2008).

Impacts on the Agricultural and Food Security Sector

The agricultural sector in Indonesia will have, to certain degree, either a positive or negative impact of climate change, depending on the climatic conditions and geographical location (PEACE, 2007). For example, solar radiation may be an advantage while the rise in temperature is most likely to be disadvantageous to the agricultural practices. Particularly, crop acreage and productivity will be affected by rising temperature, altered patterns of rainfall and drought periods, changes in water availability and hydrological systems as well as increasing extreme climatic events are expected to affect (Amien and Runtunuwu, 2008, cited in EEPSEA, 2008).

Apart from various climatic conditions, climate change impacts on the agricultural sector depend

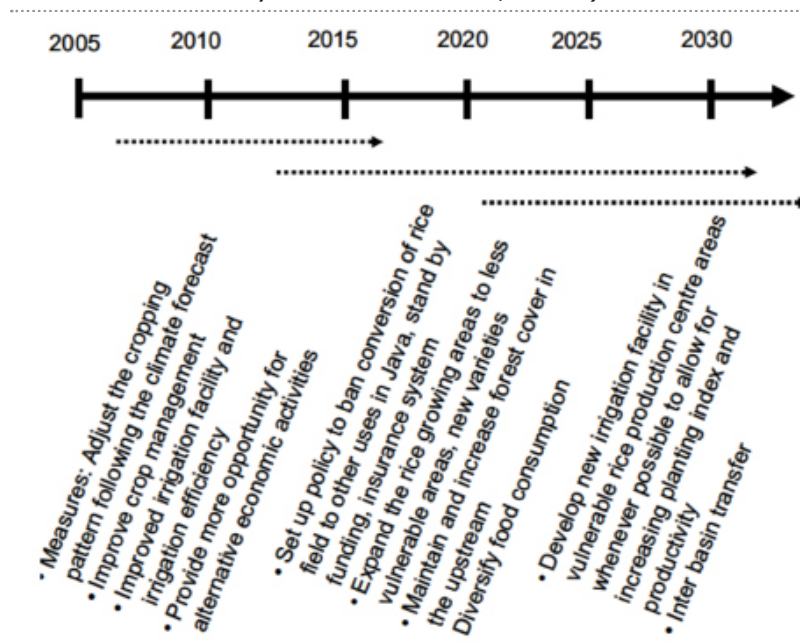
on geographical situations. The UK Meteorological Office identifies that climate change causes a decrease of crop harvest in West Java and East Java (Amin, 2004 cited in PEACE, 2007). Specifically, a 30-day delay of monsoon will reduce January-April rice production in West/Central Java by about 6.5% and in East Java/Bali by 11% (Ministry of Environment, 2007). Also, the UNDP study shows that the areas highly vulnerable to climate change are some upland regions whose soil cover is projected to reduce due to the soil erosion caused by the change in rainfall pattern (2007). The yield of upland crops such as soybean and maize could decrease by 20 to 40 percent, and this agricultural pressure has significant implications for national food security. While the harvest failure was 100,000 ton per district during 1981 - 1990, it reached 300,000 ton in the period of 1991 - 2000 (Boer and Las, 2003, cited in Republic of Indonesia, 2007). Climatic threats therefore endanger Indonesia's agriculture development program that aims to increase food security and to increase farmer welfare (Republic of Indonesia, 2007).

In Central Sulawesh, farmers suffer from the ENSO-related drought (Keil et al., 2008). 82% of the enquired households have already been affected by exceptionally long dry periods, especially in the years of 2002 and 1997/98. The most severely affected crops in the region were irrigated rice and cocoa, declining of yield to 64% and 62% respectively, compared to no ENSO affected years.

Vulnerability and Adaptation in the Agriculture and Food Security Sector

At the time of dry season, some downstream farmers adapt to the water shortage through pumping groundwater, which is increasingly polluted by intrusion of seawater. In some districts, the farmers respond to water dispute and tension among farmers through choosing one of their traditional respected leaders as a mediator. Through reliance on the traditional scheme, they ensure their turn for water (UNDP Indonesia, 2007). These practices are ex-post strategies that are applied only for the short term solution on climate change impacts. The study of Keil et al. (2008) found out that only 24% of the sample households employ ex-ante strategies for the

Figure 28: Example of long term plan for adaptation for the agricultural sector (Boer, 2007 cited in Ministry of Environment, 2007)



case of drought conditions, including to have food stocks (62% of these households) and to realize cash savings (31%).

Meanwhile, some researchers and organisations have developed the framework of long term adaptation strategies and introduced the community-level adaptation practices to farmers in Indonesia. Boer et al., suggested the planned adaptation strategies for over the next 30 years, starting from cropping pattern and irrigation facility adjustment followed by policy set-up for conversion of rice field to other uses in Java and development of new irrigation facility in vulnerable areas for rice production (Ministry of Environment, 2007). This example of long term adaptation plan is illustrated here with a time line till 2030 (Figure 28).

The ADPC assists in the institutionalization of climate information application for many sectors including the agriculture sector (Boer et al., 2006). The ADPC identifies the barriers against reducing farmer's vulnerability to extreme weather events: difficulty in understanding climate forecast information that contains probability; lack of effective climate information dissemination system; limited capacity to implement climate forecast in practical use; and missing awareness on the economic significance of climatic forecast information (Boer et al., 2006). In order to tackle these barriers, a focus is placed on increasing rice farmer's knowledge on climate information application through the Climate

Field School (CFS) concept. The CFS included training modules given in the form of game or simulation with materials relying on the farmers' experiences; the translation of climate information from scientific language into field language and then into farmer's language through the so-called 'Field Facilitators'. The CFS effectively increases the farmers' understanding on the applications of climate information. Through this programme, the farmers are encouraged to form a group and develop their own agribusinesses using climate information as inputs for planning and decision making. Furthermore, climate information needs are utilised for the local government programme to improve the farm management system, the agricultural institutional system and partnership systems for agribusiness activities (Boer et al., 2006).

Institutional Responses

In 2007, the Ministry of Environment developed a long-term plan for adaptation with a focus on measures toward the projected climate change and identified short and long-term adaptation programmes for the agricultural sector. Demonstrated here are some examples of proposed adaptation programme:

Short term adaptation programmes:

- Conservation and efficient use of water including control of groundwater exploitation.
- Introduction of the crop varieties that mature early and are tolerant to drought, flood, pest and disease, high temperature and salinity.
- Development of farmers' capacity in understanding drought and flood behaviour.
- Adoption of cropping calendar to overcome impacts of climate variability.
- Improvement of crop environment including control of pest/disease and crop fire.

Long term adaptation programmes:

- Establishment of early warning system for drought and flood hazard.
- Development of integrated management of irrigation and drainage water as well as integrated crops pest and disease control.

Gaps Identified in Programmes and Studies

The study of Keil et al. (2008) assessed that most of the farmer households in Central Sulawesi do not have access to ENSO forecasts, although the

information is generally available in Indonesia. There is also evidence that ENSO effects agricultural production in the mountainous region of Central Sulawesi and are more difficult to predict than in many other parts of Indonesia. In fact, some farmers rely on an 'official' source of information, for example, from the radio and the agricultural extension service as their knowledge base, but others use indigenous knowledge. Hence, whether either one of the two types of information is more reliable or not needs to be addressed from the local context.

Moreover, the majority of farmers from this region depend on non-technical irrigation systems with an irregular supply of water and that the cropping and irrigation schedule at the village level is not well coordinated (ibid). According to the descriptive data analysis, the land with less effective irrigation facilities more often experiences the drought-induced reduction of rice yield. Based on the assessment of household, it is identified that the access to credit or a high level of technical efficiency in their agricultural production is associated with a higher level of drought resilience.

UNDP Indonesia (2007) pointed out farmers in certain upland regions seem to be especially vulnerable to climate change impacts due to the erosion of soil cover caused by erratic rainfall or drought. Many of them, however, do not seem to know how to response the crop failure, not being able to decide on when to plant their crops. In addition to limited adaptive capacity of the farmers, there seems lack of well-coordinated system of water distribution from upstream to downstream areas, which renders farmers in downstream more exposed to climate change effects especially during a long dry season (UNDP Indonesia, 2007). The pressure of income earning during the period has triggered panic and disputes among farmers, and in a worst case, forced some households to send a family member to work abroad where she or he suffers from inhuman treatment (Personal communication conducted by UNDP cited in UNDP Indonesia, 2007).

In addition to lack of reliable information and technical, financial and institutional assistance, industrialisation and urbanisation led to the clearing of areas of vital critical ecosystems (Republic of Indonesia, 2007). In Puncak, Bogor, West Java, for example, the development in the green zone for water catchment cannot be controlled, so it may result in accelerating water shortage.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

The Economy and Environment Program for Southeast Asia (EEPSEA) (2010) investigated indicators presenting vulnerability and adaptive capacity of household based on the assessment of the flood event that hit Jakarta in 2007. The factors assumed and analysed for this study included the proportion of the labour in the total member of a household, the waged labour and non-farming income in a household, the permanence of households' house, the time of receiving early warning information before flood, and the period during which household is able to recover, with prior training.

UNDP Indonesia (2007) studied the major climate change impacts particularly on vulnerable population such as the poor and children. In the study, impacts on various sectors such as water and agriculture were also analysed, which are found in the respective section of this report (See 2.2.1 and 2.2.2).

Susandi, Firdaus and Herlianti (cited in Pribadi, 2008) applied the MAGICC/SCENGEN model for predicting sea level rise and estimating its corresponding socio-economic impacts, while Keil et al. (2008) examined the secondary economic impacts posed by the climate-induced economic loss of agricultural sector.

Impacts on Socio-Economic Sector

Susandi, Firdaus and Herlianti (cited in Pribadi, 2008) predicted that sea level rise of 1.1 m is expected by the year 2100 which will cause an economic loss of approximately US\$25.5 billion in view of a loss of 90,260 sq km of land area⁴, including coastal areas and small islands, such as the South Kalimantan coast, South Sumatra, East Java, Central Sulawesi, Nusa Tenggara, the Moluccas, and South Papua.

Besides sea level rise, flooding as a result of heavy rainfalls constitutes an important impact on Indonesia's population. For example, due to the flood event that hit Jakarta in 2007, 57 people were killed, 1,500 houses destroyed and a total damage of almost US\$700 million was caused (UNDP Indonesia, 2007). Among the population affected by climate change impacts, poor people are highly vulnerable and tend to increase their poverty level. This has been shown by a study of comparisons in the proportion of poor households in Indramayu in

West Java between a normal year (2001) and a year with El Niño (2003). The study results shows that the former was approximately 55% but the latter amounted to almost 70% (Boer et al., 2006; UNDP Indonesia, 2007). This vulnerability of the poor to climate variability also led to rising malnutrition, especially the children. In the El Niño years 2002 and 2005, for example, the acute malnutrition were observed among about 25% of children younger than five, compared to 8 – 12% in normal years (UNDP Indonesia, 2007).

In addition, the income loss of the agricultural sector caused by climate change also poses an indirect economic impact on non-agricultural sector in the locality. Local agricultural income declines due to drought and is most likely to result in the decline of the demand for goods and services sold at the local market, thus negatively affecting non-agricultural income that the neighbouring households gained through self-employment (Keil et al., 2008).

Vulnerability and Adaptation in the Socio-Economic Sector

The EEPSEA study identified three crucial factors that influence the household vulnerability to climate related events from the perspective on time period required for recovery at the household level: a) the total number of household members, b) time to be spent for coping with the events; and c) the total loss of household (2010). If the total number of household member is increased with one person, the flood recovering time of the household will increase 0.197 days (5 hours). The households with the large number of family members would find it more difficult to evacuate from flood than the ones with the smaller one. In addition, if the time period to cope with flood increased by one hour, the recovery time for the household will increase by 0.051 days (1 hour 13 minutes). The longer time to cope with the event needed, the longer time to recover from flood would be taken. Moreover, if the total loss of household's income increased with 1 US\$, the recovery time of household increased by 0.001 days (2 minutes). Responding to the study findings, the EEPSEA demonstrated several adaption options for household. Listed are some examples of structural, behavioural, technological and financial adaptation strategies suggested for household (2010).

Structural adaptation

- Building flood wall using sandbags
- Recovering the house and facilities with hard and protective construction

⁴ The estimated land value taken into account was of US\$0.28 million per sq km.

Behavioural adaptation

- Participate in emergency response working program at commune level
- Prepare family kits such as food, first aid, medicine in one bag
- Relocate to safety place

Technological adaptation

- Use a water pump to remove flooded water

Financial adaptation

- Allocate special budget for disaster preparedness

Apart from these factors influencing vulnerability of household, poverty is also one factor that seems to render the household vulnerable to climate change. According to the UNDP's assessment of the major threats to poor people, certain characteristics of their livelihoods that could affect their vulnerability are implied. These include 'acutely climate sensitive' livelihoods such as agriculture and fisheries and overwhelmed sanitation systems in slum areas (UNDP Indonesia, 2007).

Gaps Identified in Programmes and Studies

Not many economic assistance or income-smoothing ex-ante strategies for farmers to maintain their usual level of expenditure are provided after drought events and yield depression (Keil et al., 2008). 62% of the households turned out not able to maintain their usual level of expenditures for food, health, clothing and housing as a consequence of drought conditions. Alarming, 85% of the expenditure reduction was effectuated in the food. This induces majority of farmers to engage in illegal activities that could eventually make them exposed to socially, economically and ecologically vulnerable environment. For example, one fifth of the sampled households needed an informal loan to smooth their consumption. With the high interest rates levied, the farmers are exposed to the risk of becoming indebted, drugging them in a vicious circle of poverty. In the past, there was a case of real interest rates in excess of 100% charged for informal consumption credit (Zeller et al., 1997 cited in Keil et al., 2008). In addition, less than one quarter of the sampled households adopt ex-ante mitigation measures (Keil et al., 2008). The most commonly applied is the ex-post strategy to smooth consumption by tapping income sources from an illegal activity including the extraction and sale of rattan from neighbouring national park. This implies not only degradation of biodiversity in the surrounding rainforest but also

high number of farmers being dependent on an illegal activity as a climate change coping practice.

In addition, despite the existing studies that identified the climate change effects on socially and economically vulnerable population and on the other local economic activities, not many adaptation strategies are found to tackle these situations.

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Two different domains could be identified as being cross-sectoral institutional arrangements, i.e. climate change institutions, on the one hand, and institutional settings concerning disaster risk reduction, on the other hand.

Climate Change

Indonesia ratified the UNFCCC in 1994 and the Kyoto protocol ten years later in 2004 (Republic of Indonesia, 2007). The formulation of the National Strategy as well as the National Action Plan is a further effort in the country's climate change issues.

National Committee for Climate Change

In 2003, a National Committee for Climate Change was established through a decree of the Environmental Ministry. Representatives from climate change-related departments and institutions constitute the members of this National Committee (Republic of Indonesia, 2007).

National Adaptation Strategy

Indonesia considers the triple track development strategy of 'pro-poor, pro-job and pro-growth' as an integral part for addressing climate change, since poverty alleviation is essential for responding to climate change that is making the poor most vulnerable (Republic of Indonesia, 2007). Besides the mitigation agenda, the adaptation agenda is considered a 'key aspect of the national development agenda' with the goal to achieve a development of the country that is resilient to current and future climate variability. The integration of climate change adaptation into national development plans constitutes a long term objective of the national climate change adaptation agenda. The approaches chosen included the following points:

- Integration of climate change adaptation into medium and long term national development plans;

- Review and adjustment of existing programs and initiatives in order to make them climate-proof;
- Institutionalization of information on climate change in view of climate risk management;
- Fostering the autonomous integration of climate risk into local development plans;
- Strengthening of information and knowledge on future climate risk;
- Provide for domestic funding and resources for realizing adaptation activities, eventually internationally supported;
- Reliance on 'no regret options' that reduce climate change vulnerability as well as benefit national development;
- Establishment of a national dialogue in order to accelerate the implementation of climate change adaptation strategies in the country.
- Inventory locations of drinking water withdrawal that will be impacted by sea level rise and identify actions for addressing the impact;
- Developing the water collection through reservoirs and ponds in regions such as Java, Sumatra, Sulawesi, Maluku and Bali for storing water during rainy season for use in dry season;
- Increasing the carrying capacity of the river watersheds through rehabilitation measures such as terracing, absorption wells and vegetation; and
- Institutionalizing the use of weather and climate forecast information in order to effectively operate and manage reservoirs and dams and reduce the risk of flood and drought.

The National Adaptation Strategy has been formulated together with the corresponding National Action Plan (Republic of Indonesia, 2007).

National Action Plan Addressing Climate Change (RAN-PI)

The RAN-PI, also called RANMAPI or NAP, was published by the Republic of Indonesia in 2007 (Republic of Indonesia, 2007) and defines the strategic principles as well as the action plans for mitigating and adapting to climate change (UNDP Indonesia, 2007). The RAN-PI aims at guiding the country's institutions in 'carrying out a coordinated and integrated effort to tackle climate change' (Suryanti, 2009). At the same time, the goal is to support the achievement of local and national development goals (UNDP Indonesia, 2007). The RAN-PI is to be dynamic, through continuously being evaluated and periodically being improved (Republic of Indonesia, 2007). The approach applied follows the triple strategy of 'pro-poor, pro-job, and pro-growth'. The time frame defined for immediate actions falls in the period 2007 - 2009, short-term actions during 2009 - 2012, medium-term actions from 2012 - 2025, and, long-term actions in the period 2025 - 2050 (Republic of Indonesia, 2007). The sectors that the RAN-PI focuses on are: water resources; agriculture; marine, coastal and fisheries; infrastructure; health; forestry and biodiversity; and cross cutting sectors. Listed here are examples of actions proposed for the water and agricultural sectors:

Water resource sector

The following proposed actions are some examples that aim at efficient, effective and sustainable water utilization.

Agricultural sector

The following actions are some examples that are recommended to establish a competitive, sustainable industrial agriculture system that is able to provide food security and farmer welfare.

- Develop a spatial and temporal early detection system for draught and monitor drought with the help of maps on drought prone areas;
- Institutionalize the use of weather and climate forecast information as well as an agriculture information system and networking at various levels and regions;
- Increase water saving in farming activity through improvement of irrigation systems and network; and
- Conduct research on impacts of the season shifting and on productive seeds and livestock and develop a food diversification policy;

Gaps Identified

The RAN-PI states that Indonesia's long-term gap are lack of a basic plans or 'long-term sustainable development management regulations' and a 'guarantee to rehabilitate the ecologic social condition' (Republic of Indonesia, 2007). Furthermore, climate change agendas on mitigation and adaptation need to become integrated in such basic regulations for guaranteeing a 'connection to the government sectors and other services'. Overall, a harmonization of the key development sectors is needed, including the public finance, industry and other production, social service sectors and those that need to undergo strengthening in order to anticipate impacts and vulnerability to climate change (Republic of Indonesia, 2007).

Furthermore, the RAN-PI puts forward strategic consideration needs in order to guarantee funding

to undertake climate change adaptation (and mitigation) actions' (Republic of Indonesia, 2007). This is due to the fact that Indonesia as a developing country has limited financial ability due to a 'small amount of national product and the huge amount of public spending which is allocated for fulfilling the debt responsibilities'. Funding from domestic as well as foreign sources should be sought. Also, for making effective use of the national budget allocated to addressing environmental problems, a new framework that harmonizes and integrates different departments and institutions, particularly related with climate change, and that covers development as well as financial management needs are to be introduced (Republic of Indonesia, 2007).

Also, international cooperation is needed in order to overcome current capacity limitations at central and local governments, legislative bodies, and in community and private sectors. For doing this, efforts such as climate change training and education programmes for these stakeholders are needed (Republic of Indonesia, 2007).

Ongoing and Planned Activities on Adaptation

Activities on adaptation to climate change are planned or ongoing (Suryanti, 2009), are as follows:

- National climate change adaptation programs and policies are being developed, such as transferring knowledge to local stakeholders, developing capacity building materials; assisting local governments on adaptation actions and strategies, conducting public consultations regarding the integration of climate change issues into local action plans;
- A Ministerial Decree concerning green building is being developed, including the dissemination of the regulation, the development of a green building policy and corresponding technical certification criteria;
- Use livestock manure biogas, providing a new source of energy that enhances the water quality of the rivers and that increases the communities' income;
- Conduct vulnerability and adaptation assessments, such as in Lombok-Nusa Tenggara Barat, Tarakan District-East Borneo, and South Sumatera;
- Develop a vulnerability to climate change index (VI), including a stocktaking on the previous, ongoing and planned vulnerability and adaptation (V&A) assessments in Indonesia, technical assistance and supports on the

ongoing and planned V&A, and developing a VI-concept in a multi-criteria approach;

- Establish data base and information systems on V&A issues in Indonesia.

Institutional Settings Concerning Disaster Risk Reduction

Already, Indonesia is prone to a wide range of natural disasters such as earthquakes, tsunamis, volcanic eruptions, fires, floods and extreme weather events (Boer et al., 2006). Meanwhile, people in Indonesia historically are used to applying risk reduction and disaster preparation. There is a tendency, however, to re-establish the risk reduction thinking (Boer et al., 2006).

Situation of Disaster Risk Management

In line with an increasing awareness on disaster management, the Indonesian Government has taken some important steps such as the introduction of the National Disaster Management (Risk Reduction) (UNDP Indonesia, 2007). This new legislation aims at encouraging the investment of communities to increase their own safety through the reduction of risk of disaster damage. Another initiative of the Government included the intergovernmental public-private dialogue on a National Action Plan on Reduction of Disaster Risk (RAN-PRB). The RAN-PRB was established by the Government in 1999 with an aim to reduce the risk factors causing disasters such as through climate change. Furthermore, some local governments such as in Yogyakarta, Central Java and Maluku are ahead with already being preparing their Local Action Plans for Disaster Risk (UNDP Indonesia, 2007).

Gaps Identified

Based on the assessment of institutional adaptive capacity, the EEPSEA concludes that government agency and local community organisation have inadequate capacity to cope with climate-induced disaster risks (2010). In particular, local government is lacking good local governance, risk assessment, monitoring and warning system, knowledge and information sharing scheme and climate change adaptation technologies. In order to structure good local governance, it is suggested for government to require the private enterprises for assistance for example in occupational health and safety, pollution control and payment for infrastructure and services and disaster preparedness (Satterthwaite, 2007 cited in EEPSEA, 2010). For local community, the following aspects necessary for institutional capacity on flood response are reported as lacking: economic

Table_9 Adaptation strategies to reduce disaster risk (EEPSEA, 2010)

Top 5 Natural Disasters in Indonesia for the period 1980-2009			
	Government Unit	Community	Household
Structural Adaptation	Construct dam along the coastline in North Jakarta Develop the integrated coastal planning Plan and develop lakes as water reservoir	Provide disaster evacuation space Build sea wall through self help groups	Build flood wall using sandbags
Behavioural Adaptation	Increase the maintenance for water infrastructure to support food resistance Increase water saving campaign Beach protection program by involving community to preserve ecosystem and environment Early warning system development program	Create disaster preparedness team and send disaster assistance goods to affected people Build the mitigation disaster centre immediately Provide early warning system	Participate in emergency response working program at commune level Prepare family kits such as food, first aid, medicine in one bag Relocate to safety place
Technological Adaptation	Early warning system development program	Provide early warning system	Use a water pump to remove flooded water
Financial Adaptation	Allocate the local budget for reforestation along east canal in Jakarta Department of Fishery and Ocean to allocate the financial resources for adaptation action Increase taxes from groundwater usage of the household and industry sector	Collect fund from each household for environmental cleaning Raise fund to help affected people	Allocate special budget for disaster preparedness

resources, network, knowledge and skill, technology, and infrastructure.

Recent Projects Concerning Disaster Risk Reduction

Recently, the UNDP has introduced the new programme, Safer Communities for Disaster Risk Reduction in Development in Indonesia, with funding support from the United Kingdom's Department for International Development (DFID) (UNDP Indonesia, 2007). The programme will be implemented by the National Development Planning Agency (BAPPENAS) and pursues the objectives to foster the strengthening and expansion of the regulatory and policy disaster risk reduction (DRR) actions undertaken by national and local governments as well as individuals. It also aims at building partnerships that would support decentralized decision-making and develop programmes on education and public awareness. At the same time, a range of innovative DRR demonstration projects will be implemented country-wide, such as for teaching how to build flood-resistant houses, introducing credit programmes for those that want to climate-proof their houses, and for helping communities to prepare for disasters and evacuation and to carry out risk assessments and corresponding risk reduction programmes, etc. The goal of the projects is to demonstrate the economic

preference of investing now on DRR than being obliged to react in a post-disaster manner (UNDP Indonesia, 2007).

In January 2010, the EEPSEA issued the final report on Adaptive Behaviour Assessment Based on Climate Change Event, based on the Jakarta flood in 2007. In the report, EEPSEA highlighted that the adaptation process to reduce risk disaster needs to be conducted at all scales, namely, the government, community and household. The report addressed six key issues for consideration, as follows:

- Access to Information;
- Early warning system;
- Coordination among Government Agencies, community, and household in Resource Management;
- Fulfilment of five basic needs;: food, clean water, sanitation, health services and temporary dwelling places;
- Safety guarantees of citizen assets; and
- Implementation of the recovery phase.

Also, the EEPSEA categorises adaptation strategies implemented by each level into four aspects, namely, structural, behaviour, technological and financial

adaptation (2010). The adaptation strategies suggested for government units focuses on water related practices, whereas the ones addressed for the community and household levels seem to emphasise on capacity building in long term disaster response and in short term coping practices, respectively. Shown in Table 9 are some examples of the strategies at all levels.

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Water Sector

- Regardless of climate change effects, many parts of Indonesia experience the reduction of the quantity and quality of water resources due to growing population, economic activities, forest clearing, land use practices and improper disposal of waste. For example, reservoirs and ponds provide water to only about 10% of the total existing irrigated area, and supply clean water to 37% of the urban population but only to 8% of the rural population (Republic of Indonesia, 2007). This water shortage is expected to increase due to climate change, especially the decrease in rainfall. There are several adaptation options that have been suggested to fulfil the water demand increased from these human- and climate-induced water shortage, but these options are of high concern since they may cause the second and third consequences. For example, the use of groundwater is suggested as one adaptation option (Republic of Indonesia, 2007). Groundwater resources, however, are particularly shallow and are vulnerable in terms of quantity and quality, especially in the dry season, and the excessive extraction of groundwater, mainly because of the industrial use, may lead to land subsidence that would result in increasing the risk for flood and the intrusion of salt water (Republic of Indonesia, 2007).
- In addition, despite the existing studies that demonstrates both human- and climate-related causes of water shortage and sea level rise, the suggested adaptation strategies revolve around the options that addresses scientific knowledge on the expected impacts of climate change, but not to emphasise on changing socio-economic as well as ecological environments. The

Ministry of Environment (2007) recommends reducing scientific uncertainties surrounding the climate change effects through the collection of long-term historical data on hydrological and meteorological phenomena and validating all climatic models and techniques. Meanwhile, the sea level rise in Indonesia is expected to be greater with continuous coastal erosion, which is actually associated with socio-economic development such as the interruption of the along-shore sand transport through physical structures, circulating currents generated by seawalls, the decrease of sediment from rivers caused by construction of many dams in the upstream regions, coral or sand mining and deforestation of mangrove forests (Ministry of Environment, 2007). However, these human activities that have partially affected the sea level rise are not embodied in the governmental policies yet.

Agriculture and Food Security Sector

- Although information on ENSO forecasts is generally available in Indonesia, the access to information is not well established yet so that farmers cannot take precautions measures before the draught events (Keil et al., 2008). Also, climate models that are accurate for mountainous regions such as Central Sulawesi need to be developed, addressing the local context.
- Moreover, most of the farmers from this region rely on non-technical irrigation systems with an irregular supply of water and the cropping and irrigation schedule at the village level is not well coordinated (ibid). The land with non-technical irrigation facilities often faces the drought-induced reduction of rice yield. Given that the access to credit or a high level of technical efficiency in their agricultural production results in a higher level of drought resilience, the technical and financial assistances for the farmers should be taken into consideration.
- In addition, there are limited adaptive capacity of the farmers in certain upland regions whose soil cover is eroded due to erratic rainfall or drought, as well as lack of well-coordinated system of water distribution from upstream to downstream areas, for which renders farmers in downstream more exposed to climate change effects especially during a long dry season (UNDP Indonesia, 2007).

Socio-economic Sector

- There are not many economic assistance or income-smoothing ex-ante strategies for farmers to maintain their usual level of expenditure after drought events and yield depression (Keil et al., 2008). This forces the majority of farmers to engage in illegal activities to fulfil the income deficit. However, this could eventually make them further exposed to socially, economically and ecologically vulnerable environment. For example, one fifth of the sampled households needed an informal loan with the high interest rates levied. This ex-post practice poses a risk of the farmers becoming indebted, trapping them in a vicious circle of poverty. In addition, the farmers commonly smooth their consumption by tapping income sources from an illegal activity including the extraction and sale of rattan from neighbouring national park. This implies not only degradation of biodiversity in the surrounding rainforest but also high number of farmers being dependent on an illegal activity as a climate change coping practice (Keil et al., 2008).
- Moreover, despite the existing studies that identified the climate change effects on socially and economically vulnerable population and on the other local economic activities, not many adaptation strategies to tackle these situations are found.

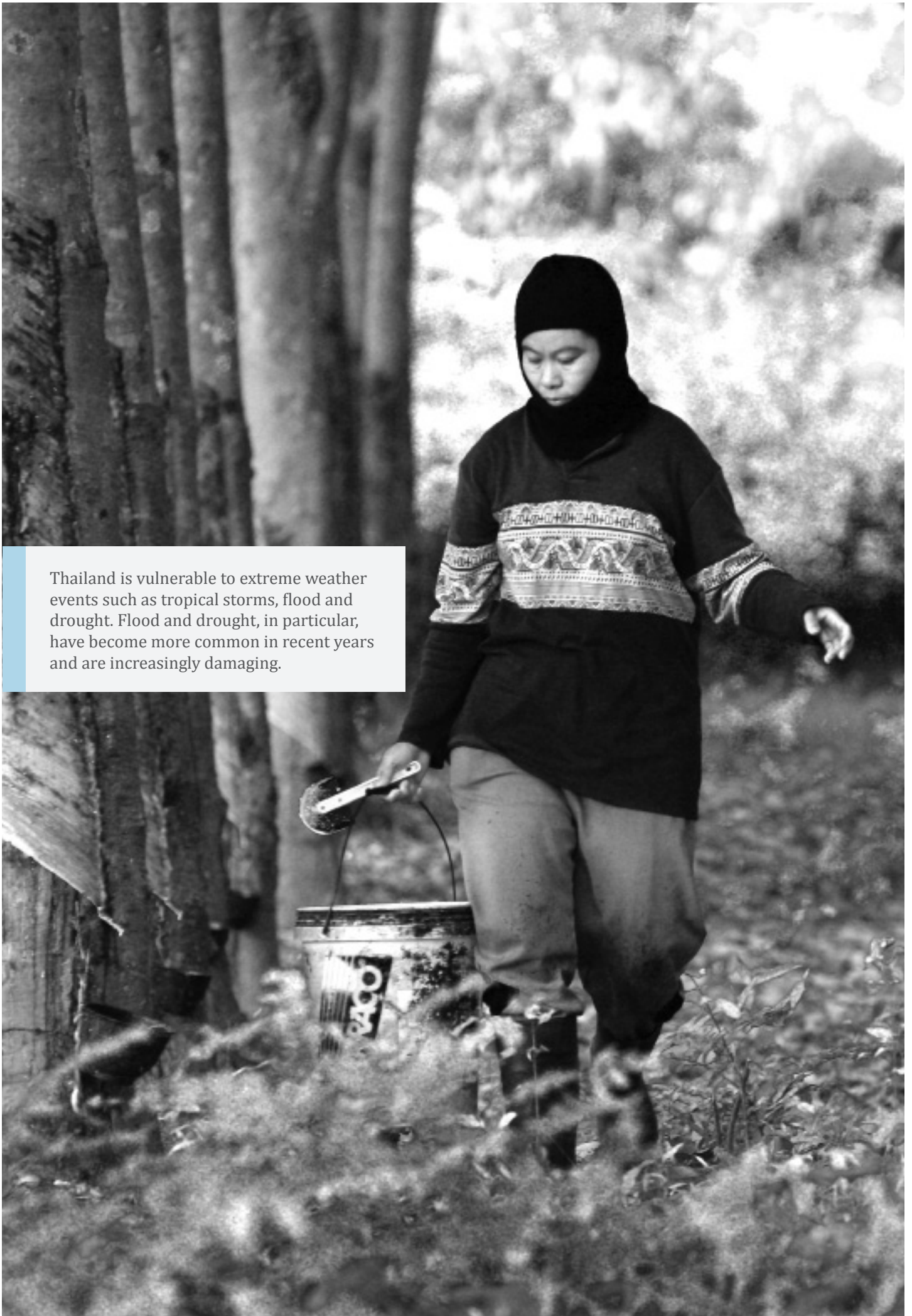
Institutional settings concerning Climate Change

- According to the National Action Plan Addressing Climate Change (RAN-PI), Indonesia's gaps on long-term adaptation is that there is a lack of a basic plan or 'long-term sustainable development management regulation' and a 'guarantee to rehabilitate the ecologic social condition' (Republic of Indonesia, 2007). Furthermore, climate change agendas on mitigation and adaptation are not well integrated in a manner that connects with the government sectors and services. Overall, a harmonization of the key development sectors is needed, including the public finance, industry and other production, as well as social service sectors (ibid).

- In addition, the RAN-PI indicates lack of strategic considerations that guarantee funding to undertake climate change adaptation action (Republic of Indonesia, 2007). This is remarked to be associated with Indonesia's limited financial ability, which is caused from 'small amount of national product and the huge amount of public spending'. Funding from domestic as well as foreign sources should be considered as one option. Also, in order to allocate the national budget effectively to environmental problems, a new framework that integrates different departments and institutions, particularly related with climate change, and that covers development as well as financial management needs to be introduced (Republic of Indonesia, 2007).
- Furthermore, international cooperation is requested for overcoming current capacity limitations at central and local governments, legislative bodies, and in community and private sectors. Efforts such as climate change training and education programmes for these stakeholders are needed (Republic of Indonesia, 2007).

Disaster Risk Management

- The recent study of the Economy and Environment Program for Southeast Asia (EEPSEA) identifies that government agency and local community organisation have inappropriate capacity to reduce climate-induced disaster risks (2010). In particular, local government does not have the capacity to conduct good local governance, risk assessment, monitoring and warning system, knowledge and information sharing scheme and climate change adaptation technologies. It is suggested to demand the private enterprises' assistances in forming local governance, for example through engaging in occupational health and safety protection, pollution control and payment for infrastructure and disaster preparedness (Satterthwaite, 2007 cited in EEPSEA, 2010). On the other hand, local community does not equip with institutional capacity in disaster risk response due to lack of economic resources, network, knowledge and skill, technology, and infrastructure.



Thailand is vulnerable to extreme weather events such as tropical storms, flood and drought. Flood and drought, in particular, have become more common in recent years and are increasingly damaging.

RESEARCH SYNTHESIS ON THAILAND

COUNTRY CHARACTERISTICS

The country characteristics cover information on Thailand's geographical, social, economic and climatic risks. An overview of the country's characteristics is provided in Table 10.

Geographic Situation

Thailand is located in the Mekong Region, bordering on Myanmar in the Northwest (1,800 kilometres), Laos in the Northeast (1,754 kilometres), Cambodia in the East (803 kilometres), and Malaysia in the South (506 kilometres). From its total land area of about 513120 km², approximately 20% are mountainous, located mainly in the north along the borders with

Myanmar and Laos and extending down the Isthmus of Kra to the southern border with Malaysia. The central plain, which extends to the Gulf of Thailand, is a lowland area drained by the Chao Phraya and its tributary rivers. The narrow and tropical Isthmus of Kra runs from mainland Thailand to the border with Malaysia and has a low-lying range of hills at the narrowest part, about 600 meters in elevation (FRD, 2007).

Socio-Economic Status

According to the 2006 census, the population of Thailand is 64.4 million inhabitants (reaching the nineteenth position among the most populous countries in the world), resulting with 125 people per km² (FRD, 2007). The population growth rate was about 20.7% and some estimates made in

Table_10 Thailand country profile overview

Country level information (UN data, 2009; FRD, 2007)	
Surface area (km ²)	513,120
Bordering countries	Malaysia, Myanmar, Lao PDR, and Cambodia
Population density, 2007 (persons/km ²)	124.5
Population growth rate, 2005-2010 (% per annum)	0.7
Mountainous land (% of total area)	20
Flat land (% of total area)	80
Agricultural land (% of total area in 2005)	27.5
GDP, 2007 (million current USD)	245351

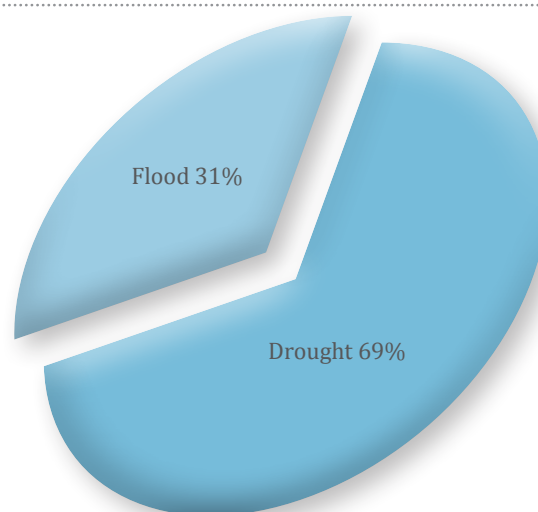
Contribution of agricultural sector to GDP, 2008 (%)	11.4
Contribution of industrial sector to GDP, 2008 (%)	44.5
Contribution of service sector to GDP, 2008 (%)	44.1
Percentage of population, 2007 (%) in - rural areas - urban areas	67.1 32.9
Poor population, 2004 (% of households)	10
Infant mortality rate, 2005-2010 (per 1 000 live births)	11.0
Adult literacy rate, 2007 (% of total population, estimate)	92.6
Access to water supply, 2007 (% of total population, estimate)	85

Figure 29: Location map of Thailand
(UNdata, 2009)



2006 indicate a birth-rate of 13.8 births per 1,000 population. Thailand's age structure for 2006 was 22% of inhabitants are less than 15 years of age, 70% are between 15–64 years of age, and 8% are

Figure 31: Percentage of people affected
due to top 5 natural disasters
1980-2009



65 and older. Around 67% of the Thai population lived in rural areas. Official government estimates indicate that people of Thai ethnicity make up 75% of the population, another 14% are ethnic Chinese, and 4% are Malay, leaving 7% as uncategorized. The country's poverty shows a 10% of households living below the poverty line in 2004. The adult literacy

Table_11 Overview on natural disasters in Thailand from
1980 to 2009

Top 5 Natural Disasters in Thailand for the period 1980-2009

Type of natural disaster	Date/year	No of people affected
Drought	Apr 2008	10,000,000
Drought	Jan 1999	6,000,000
Flood	Jun 1996	5,000,000
Drought	Feb 2002	5,000,000
Flood	Aug 1995	4,280,984

Total Natural Disasters in Thailand for the period 1980-2009

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Drought	6	23,500,000	424,300,000
Flood	55	27,027,428	3,705,902
Tsunami	1	67,007	1,000,000
Storm	29	3,235,503	892,039

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain – Brussels, – Belgium. Created on: Dec-23-2009. - Data version: v12.07

Figure 30: Number of days
per annum
with maximum
temperatures
above 33°C.
CO₂ = 360ppm
(baseline) (SEA
START RC, 2006
cited in MRC,
2009)

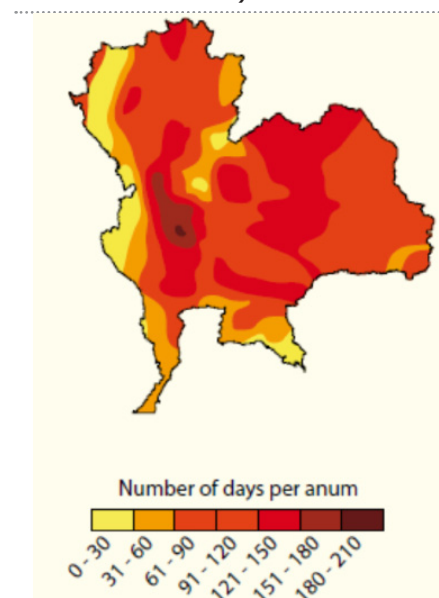
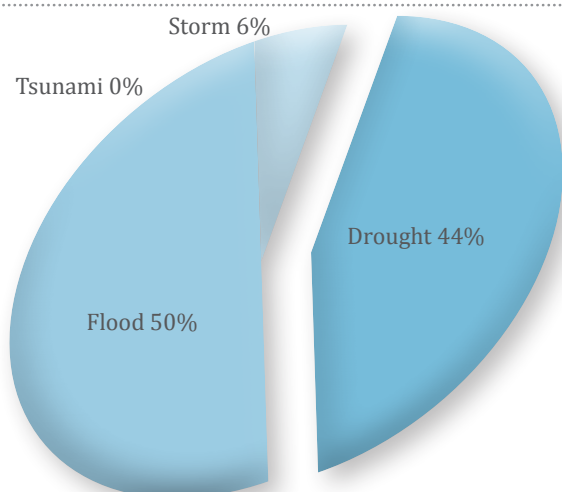


Figure 32: Percentage of people affected due to total natural disasters 1980-2009



rate was almost 93% in 2007. In the UN Human Development Index, Thailand ranks 87th out of in total 182 countries in 2009. Regarding the economic activity, out of the total US\$ 245,351 million Gross Domestic Product (GDP) in 2007, 11.4% were provided through the agricultural sector, 44.5% through the industrial sector, and 44.1% through the service sector.

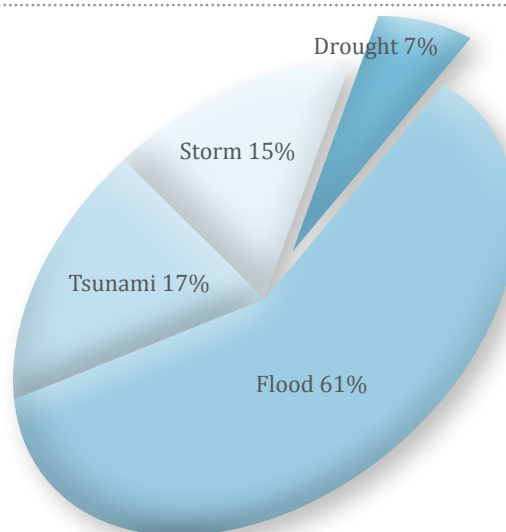
Climate Risks

Current Climatic Conditions

Thailand is characterized as warm sub-humid tropics. Its climate can be classified into three distinct seasons: hot, wet and cool seasons. The mean annual temperature is between 22-32°C, with the peak normally occurring in April. The highest recorded temperature during the period 1961-1990 was 44.5°C; in the past experienced an average daytime temperature of up to 40°C, especially during the month of April. Temperature in Thailand has increased, ranging from 0.10 to 0.18°C per decade over 5 decades of observation (ADB, 2009c). Average annual precipitation is 1,692 mm, although rainfall exceeding 2,000 mm is common in the Southern Peninsula. Rainfall has decreased in the past 3-5 decades compared to the first half of the last century.

Thailand is vulnerable to extreme weather events such as tropical storms, flood and drought. Flood and drought, in particular, have become more common in recent years and are increasingly damaging. During the period 1951 to 1991, almost all of the 145 tropical cyclones fell into the category of "tropical depressions," the least severe storm classification. Since 1991, at least two tropical storms have affected

Figure 33: Percentage of damage (US\$) due to total natural disasters 1980-2009



Thailand annually, resulting in considerable damage to human life and property. Areas affected by flooding appear to be on the increase (OEPP, 2000).

Table 11 gives an overview on further natural disaster statistics. The five top natural disasters in Thailand from 1980 to 2009 were all flood and drought events. Although droughts were among the most severe in the top 5, with a 69% (see Figure 31), when it comes to all the events of climatic disasters occurring between 1980 and 2009 – i.e. six drought, fifty five flood, twenty nine storms and one tsunami, the flood events affected the highest number of people (50% of all people affected, see Figure 32), followed by droughts with a 44% and a 6% of storms. Also floods were causing the highest economic damage (61%, see Figure 33).

Climate Projections

Thailand's temperature, based on the climate data generated by a global circulation model, is projected to increase 2-4°C by the end of this century (TEI, 2000). The regional climate change scenario of Snidvongs (2006) study projects that temperature change in the future will vary from baseline condition within the range of 1-2°C; change in temperature in the future will occur in the winter and summertime, while the temperature during rainy season would remain almost unchanged. Hot periods with a temperature higher than 33 °C will increase by 3-4 weeks and cooler days with a temperature lower than 15 °C will be reduced by 2-3 weeks a year (see Figure 30); in other words, the summer tends to get longer and winter time will be shorter (Snidvongs, 2006).

In Thailand, there would be a shift in precipitation from north to south as predicted by impact studies conducted under the United States Country Studies (TEI, 1999) and Boonyawat and Chiwanon (2007). There seems to be almost no change on annual precipitation in Thailand throughout the future under wet year scenario. The condition is different in the driest year of the decade; annual precipitation in Thailand will have higher rainfall by almost 10% (Snidvongs, 2006).

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

Water Sector

Range of Studies Reviewed and Methods Applied

A range of studies and applied methods were reviewed for analyzing the Thailand water sectors' situation in view of climate change and are shortly presented in the following.

Greenpeace reports are based on three General Circulation Models (GCMs) that were chosen in the Thailand's Country Study on Climate Change, elaborated by the Thailand Environment Institute, and used to construct precipitation and temperature scenarios over Thailand (Boonprakrob and Hattirat, 2006). The three GCMs used in the study were UK89, UKMO (United Kingdom Meteorological Office) and GISS (Goddard Institute for Space Studies). This report also highlights the importance of using more than three climate change scenarios to study the changes in rainfall patterns, so the results can be used to improve efficiency in government's water managements plans to ensure future water availability.

The Initial National Communication for UNFCCC, evaluates the impacts on the different sectors studied using GCMs and in the absence of more detailed climate models, and translating into location-specific data by direct interpolation method. Nevertheless, the results of analyses should be viewed more as indicative rather than as giving the precise magnitude of the potential impacts. The GCMs models used provide two scenarios, a standard one, and another one doubling the CO₂ emissions; both scenarios were used. Scenarios

from only one model (ECHAM4⁵) were used in the analysis of impacts on water resources. To derive local climate scenarios, the monthly mean values of climate variables generated by the GCMs were interpolated over the period 1990-2099. The four variables used for the analysis in each model were maximum and minimum temperature, precipitation and solar radiation (OEPP, 2000).

Snidvongs (2006) from the South East Asia Global Change System for Analysis Research and Training (SEA START) Regional Centre presented models in its study on extreme hydrological events and changes in water resources in Southeast Asia, including Thailand. A regional climate scenario was simulated with the Conformal Cubic Atmospheric Model (CCAM) to study climate change. This has been taking place at the level of the Lower Mekong River Basin, since downscaling had been proven to produce inaccurate results for local levels (Snidvongs, 2006). The CCAM has been specifically developed by the CSIRO Division of Atmospheric Research in Australia. For studying the climate change impact on the hydrological regime in the Lower Mekong River Basin, Snidvongs (2006) relied on the Variable Infiltration Capacity hydrological model. This model solves water and energy balances at the land surface-atmosphere interface, including parameters such as spatial variability of precipitation, land surface cover, infiltration, soil and vegetation characteristics. In this study there are three scenarios for future changes in climate depending on the atmospheric CO₂ concentration condition (360ppm, 540ppm and 720ppm).

The Bangkok Assessment Report on Climate Change 2009, attempts to explain why and how climate change is affecting Bangkok, while giving some idea of the trends that may be expected and what action will have to be taken in order to make the predicted outcomes less severe. The city is now starting to participate in the efforts to prevent and reduce climate change effects (BMA et al., 2009).

Impacts on the Water Sector

The models chosen in the country study cited by the Greenpeace report show an increase in average temperature from 21.5- 27.5°C to 25-32°C. The temperature increases by 2.5°C in the northeast region and by 3-3.5°C in the central, north, and west regions. The amount of rainfall in the northeast

⁵ The ECHAM GCM has its original roots in global forecast models developed at ECMWF (European Centre for Medium Range Weather Forecasts). Numerous modifications have been applied to this model at the Max Planck Institute for Meteorology and the German Climate Computing Centre (DKRZ) to make it suitable for climate forecasts, and it is now a model of the fourth generation.

is constant while it increases by 40% in the south. The amount of rainfall in other parts of the country increases by 20% (Boonprakrob and Hattirat, 2006). Based on the climate data generated by the ECHAMA4 GCM used for predictions in the Initial National Communication temperature could increase and reduce annual rainfall in the Chao Phraya basin in the Central Plain of Thailand. As a result of the doubling of CO₂ emissions, temperatures could increase by 2 to 4°C, while annual rainfall could decrease from 960-1,290 mm, to 800-900 mm, from the control case. Average annual runoff could also decrease from the standard case by 34-44 percent. The reduction of annual runoff could be more than 50 percent in certain areas of the lower basin. The potential reduction in runoff will amplify water scarcity in the Central Plain, especially during the dry season. Note that the results are based on only one GCM and limited observed locations in the basin (OEPP, 2000). Snidvongs (2006) study also makes projections for future scenarios that have been described in the climate risk situation analysis of Thailand.

The change in the amount of precipitation and evapotranspiration will affect the hydrological and biogeochemical cycles, affecting the balance of fresh water ecosystems, changing river flows, ground water recharge, water quality (temperature, pollutants, etc.), watershed, etc. Consequently, ecosystems will change as well as land uses, inducing at the same time changes in regional water balance (Boonprakrob and Hattirat, 2006).

Besides, there will be some other impacts related with changes in precipitation patterns; variations in the frequency and intensity of rainfall, in a monsoon region like Thailand, increases the risks of drought and flood in the dry and wet seasons respectively and storm surges, which are the most notable impacts of the climate change scenarios on water resources. Conflicts over the distribution of surface water have become a critical issue due to the expansion of demand and a shortage of supply. Rainfall patterns affect the level and intensity of surface runoff, while higher temperature increases the rate of evapotranspiration and hence reduces the water storage capability of the rivers and reservoirs. Thailand, as an agricultural country, depends on natural water resources, and the supplies from fresh water are expected to change, which could affect agricultural development substantially. Lower water levels in the dams require serious water resource management. Crop yields and cropping pattern could be severely affected (MRC, 2009). Water for irrigated areas may need to be rationed to allow for other

uses; water conflicts between different uses may increase, especially in the dry season. Thailand has the highest ratio of annual freshwater withdrawal to total internal water resources (41.5%); this indicates the vulnerability of the country to changes in water resources. Most of the water withdrawals are used for agricultural production (ADB, 2009c).

According to the results of the simulation of the Snidvongs study, most of the tributaries of Mekong River in Thailand tend to have more water in the future because of higher precipitation. For the wet year scenario, almost every watershed will have higher discharge. However, in the dry year scenario, many sub-basins will have slightly less water under climate condition at less CO₂ concentration, but the discharge will increase under the climate condition at higher CO₂ concentration (Snidvongs, 2006).

Variations in temperature and rainfalls will also modify fresh water ecosystems, which will also affect to water availability and quality. The impacts will be higher in the shallow water of the lakes where certain vegetation will benefit from higher concentration of CO₂ and higher temperatures and nutrients will result in abundant growth. At the same time, changes in habitats, reduction of productivity, extinction of some species (such as small invertebrate and fishes) will occur due to lower water levels. Decreasing lake volumes will lead to higher concentrations of nutrients that can result in eutrophication, which will produce a greater loss of species diversity, deterioration of oxygen conditions and water quality, causing serious problems in those regions where most drinking water comes from surface sources (Boonprakrob and Hattirat, 2006).

Thailand will also be affected by sea level rise and seawater intrusion into the estuaries. This is already being a problem in some rivers like Chao Phraya River where water is used for domestic supply, especially in the dry season. The Songkhla Lake, could also be very affected because of shores inundation and lagoon expansion (MRC, 2009).

The BMA et al. report gathers information about the impacts of water resources on the city of Bangkok. The effects of global warming have caused the river flows in Thailand to be variable, with too high or too low flow rates during the rainy and dry seasons, respectively. The Chao Phraya and Mae Klong rivers, Bangkok's main source of water for services, will experiment these changes that will also be further exacerbated by increasing demand. Heavy pumping of ground water has resulted in land

subsidence in most areas of Bangkok and in ground water contamination with saline intrusion, nitrates, coliform bacteria and volatile organic compounds (BMA et al., 2009).

Vulnerability and Adaptation in the Water Sector

In Thailand, there are different levels of concerns about climate change issues according to the vulnerability on water resources, as the AIACC report establishes, Thailand appears in the medium and low level of concern. In the first one, the outcomes of concern is more frequent flood events that increases loss of life, damage to infrastructure, loss of crops and disruption of economic activities. The climate driver is the increase in heavy precipitation events and other drivers include growth in populations and infrastructure in flood-prone locations, poorly managed land-use change, clearing of vegetation and filling of wetlands that can provide flood protection and ineffective disaster prevention, preparedness, warning and response systems. Low level of concern, includes the losses to water uses from localized, temporary and manageable fluctuations in water availability, the main climate driver highlighted is the seasonal drought but also more severe effects kept in check by effective management, planning and policies for water demand and supply (Leary et al., 2007).

Thailand has been implementing adaptation and mitigation measures since long time ago due to the fact that pressure on natural resources and energy demand is not a new problem for the country. The efforts that have been done, not always linked with climate change concern and greenhouse gas emission reduction, are focused on better management and conservation of natural resources and rising energy security. These past efforts can be summarized as (MRC, 2009): (i) the Royal Projects on the development of water resources for cultivation, for preserving water sources and streams and for water drainage from low-lying areas to extend land areas for cultivation; (ii) integrated water resource planning for surface and ground water by the Ministry of Natural Resources and Environment; (iii) the projects by the Ministry of Natural Resources and Environment to promote participation by local administration agencies and local communities to manage water resources at the river region level; (iv) the projects by the Ministry of Natural Resources and Environment to build capacity to improve water resource efficiency in the agricultural sector and water resource conservation; and (v) the projects by the Ministry of Natural Resources and Environment

(MoNRE) to promote participatory planning in the sustainable management of wetlands.

Measures and policies implemented in Thailand not only address immediate problems but also support adaptation process to climate change; other measures that are helpful to reach adaptation are focused on improving water resources management and policies to enhance environmental quality (reforestation, protection and conservation of forest, and land and water conservation). Policies and plans designed to improve water management emphasis on: (i) water act, to reach a more unified management system; (ii) water resources pricing, which is important to harmonize prices between pipe and ground water to ensure right use of the resource, and water rights that is a current topic; (iii) integrated watershed management system; (iv) community –based resource management; and (v) water conservation and crop diversification in agriculture (OEPP, 2000).

The BMA et al. report compiles some adaptation measures in Bangkok related with water resources. It classifies the measures in three groups: (i) in community infrastructure and operations the measures are water use restrictions, such as the imposition of fines during periods of water shortage, optimize reservoir releases (based on historical data and drought anticipation), expand storage capacity, and implement a more realistic water pricing or greater regulation of withdrawals of surface and ground water; (ii) in business and commercial the measures are water efficiency and conservation programs, water pricing (marginal cost pricing to replace average cost pricing, use of water metering), irrigation practices, and revise shipping and tourism regulations; the last group measures are in (iii) residential health and general population and are referred to water efficiency and conservation programs, such as reducing volume of toilet flush, installing residential water conservation technologies and irrigation practices (BMA et al., 2009).

Gaps Identified in Programmes and Studies

As is shown in the Greenpeace report (Boonprakrob and Hattirat, 2006), a study on climate change in the Mekong river basin was performed using one Regional Climate Scenario resulting in the conclusion that there is an urgent need to study changes in the rainfall pattern in all the watershed areas by using more than three climate change scenarios. The results from these studies will be useful to

incorporate in the government's water management plans to maximize their efficiency, and to ensure future water availability. Besides, there are few studies in Thailand using mathematical models to assess physical property of water resource (water flow conditions, element dispersion, sediment transfer and accumulation), for instance, to plan for water resource management; studies on biological diversity and the impacts of climate change on water resources and fresh water ecosystems using mathematical models need to be included (Boonprakrob and Hattirat, 2006).

Agriculture and Food Security Sector

Agricultural activity in Thailand represents 11.4% of the total GDP. The activity declined its relative importance in the country's economy (both incomes and export earnings) due to the industrialization since the 1960s, but agriculture is still the dominant economic activity in rural Thailand and it provides the benefits of employment and self-sufficiency, rural social support, and cultural custody, and has the characteristic of being highly diversified, which expose the country in many different ways to climate change.

According to the International Rice Research Institute (IRRI), Thailand has a land area of 51 million ha, of which one-third is cultivated for annual crops and about 7% is under permanent crops. Rice is the most important crop of the country and Thailand is a major exporter in the world rice market (exporting about 6.5 million tons of milled rice per year); its reputation for high-quality, long-grain white rice, which usually commands a substantial price advantage over lower grades. Even though declining in relative importance, it still occupies about 55% of the total arable land. Rice farmers in the northeast, the main rice-growing region and the home of the famous Jasmine rice, are generally subsistence farmers, selling only their excess production. The main surplus production is from the central region and the north, where the average farm size is three times larger than in the northeast, and the production environment is favourable (IRRI, 2002).

Other agricultural commodities produced in significant amounts include fish and fishery products, tapioca, rubber, grain, and sugar. Exports of industrially processed foods such as canned tuna, pineapples, and frozen shrimp are on the rise. Thailand feeds four times its own population.

Range of Studies Reviewed and Methods Applied

The Mekong River Commission report and the initial National Communication under the UNFCCC (the first one based in the second) used scenarios derived from four GCM models in the analysis of impact on agriculture in Thailand. The four models were (1) CSIRO global coupled ocean-atmosphere-sea-ice model (CSIRO coupled GCMs or CGCM), (2) HadCM2 model (Hadley Centre GCM), (3) ECHAM4/OPYC3 model and (4) CCCMA's First Generation Couple General Circulation model (Canadian Centre for Climate Modelling and Analysis) (CGCM1) (OEPP, 2000).

Snidvongs (2006) presents a number of methods and models in the study on extreme hydrological events and changes in water resources in Southeast Asia. To study climate change impacts on rain-fed agriculture, the Decision Support System for Agro Technology Transfers (DSSAT version 4.0) was used for crop modelling to simulate future potential yield of rice vulnerability. Data considered in the modelling includes parameters such as the range of temperature, precipitation and solar radiation. The potential impact of increased floods due to climate change, however, was not included (Snidvongs, 2006).

Impacts on the Agricultural and Food Sector

There are a wide variety of impacts concerning agriculture and food security, in different scales. For example, as the Greenpeace report (Boonprakrob and Hattirat, 2006) shows, there are specific characteristics and parts of the crops that will be more affected by climate change due to its sensitiveness. For example, pollen of some species of rice exposed to higher temperatures than 34°C losses its fertility, hence the crops lose their productivity by failing to fill the grain, although the plant is still growing; however, others can tolerate up to 38°C. Also, crops have their optimum range of temperatures for growing, which is usually 22-27°C; over this temperature crop production declines. This is especially important for tropical crops because they grow in the higher end of the range, so an increase of temperature may decrease yield. On the other hand, temperate crops (which grow closer to the bottom end of the range) yield may increase (Boonprakrob and Hattirat, 2006).

The Mekong River Commission report describes that rain fed rice crops in Thailand are highly vulnerable to climate change; some results, based

on climate data from four GCMs, suggest similar declining trends in rice and maize yields over time with different magnitudes depending on climate conditions, soil types and crop practice. Maize yields, for example, could drop from 5 percent in Nakhon Sawan province to 44 percent in Nakhon Ratchasima province. For rice, yields could drop by 57 percent in Roi-et province, but increase by 25 percent in Surin (MRC, 2009). In the study area, in Ubonratchathani province, the simulation shows trend of increase in yield of rice productivity under future climate condition. The increase in productivity yield could be as high as 10-15% in some areas (Snidvongs, 2006). The four climate models also demonstrated that climate change could increase temperature in areas, during the flowering period of crops, by 1 to 7°C. This will reduce flowering and harvesting periods as well as crop yields in general (MRC, 2009). Rainfall variability also reduces rice, corn and sugar productions. If monsoon events are too strong, inundations can cause plant diseases and insect infestation.

Livestock production in Thailand is based on grazing and farming systems; both dependent on climate conditions such as precipitation and temperature, important for natural pasture and leftover's from agriculture. Droughts and floods can cause food scarcity and new disease outbreak, affecting the production, and therefore, the farmers who has lack understanding in the prospects of climate change (Boonprakrob and Hattirat, 2006).

Because of sea level rise, aquaculture, which is one of the most important sources of foreign exchange earnings of Thailand will be very affected. Large portions of the areas under aquaculture production are mangrove and mudflats, which areas are vulnerable to inundation.

Vulnerability and Adaptation in the Agricultural and Food Sector

In general, the vulnerability of agriculture to climate change varies according to crops and location characteristics, in addition to the climate conditions; also depends on the ability of farmers to diversify their crops as well (OEPP, 2000). Also, there are different levels of concern about climate change issues according to the vulnerability on agriculture and food security, as the AIACC report establishes. Thailand appears in the medium and low level of concern. The medium outcomes of concern are the increase of rural poverty rates, the decrease and more variable net farm incomes for many rural households, failures of small farms and accelerated

rural-to-urban migration. The main climate drivers in this level are: (i) region-wide increase in frequency of climate extremes that cause losses of crops, livestock and income, and (ii) changes in the average climate or significant shifts in rainy season that stress traditionally grown crops and available substitutes. Also, other drivers are listed are declining output prices, rising input prices, lack of income diversification of rural households, lack of access to credit by small farmers, poor rural infrastructure and lack of social safety nets. The outcomes of concern that appear in the low level are also the decrease and more variable net farm incomes for some rural households but also the decreased and more variable quality of crop and livestock output and the temporary migrations as strategy to obtain off-farm incomes. More severe effects can be kept in check by: robust and diversified rural development, equitable access to resources (e.g. improved seed varieties) adequate household savings, maintenance of social safety nets, political stability, well maintained rural infrastructure and services and access to credit and insurance (Leary et al., 2007).

As has been said in the impacts, farmers of rain-fed rice in Thailand are exposed to variations in rice harvests and other impacts from seasonal flooding, shifts in the dates of beginning and end of the rainy season, and variations in rainfall amounts. Those farm household with small land and small subsistence production produce low volumes of rice and incomes from rice, which sustain the household on a year-to-year basis. Therefore, they have limited capacity to cope with losses during the crop season. Also they have short chance to implement other activities to diversify their income sources. The high risk for farm households in Thailand to climate shocks is the higher food costs relative to farm income, lack of income diversification, little savings in the form of financial assets, livestock or food stores, and high debt relative to income (Leary et al., 2007).

The MRC report for Thailand mentions some adaptation strategies that have been going on as The Royal Projects on agriculture to conduct studies, research and experimentation of plant and animal species suitable for the nature of the local areas. The Royal Projects plan to plant vetiver grass for topsoil preservation, the projects by the Ministry of Agriculture to promote agricultural product and market improvements, the projects by the Ministry of Agriculture to build capacity for local agricultural communities, the projects by the Ministry of Agriculture to research drought-resistant plant and animal species, and the projects by the Ministry of

Agriculture to construct dams and irrigation systems. Also, farmers have traditionally implemented a number of practices to adapt to climate variability, for example intercropping, mixed cropping, agro-forestry and animal husbandry. Moreover, over the years Thailand has adopted both surface water and groundwater irrigation and diversification in agriculture to deal with drought and structural or non-structural measures to deal with flood and drought (MRC, 2009).

Gaps Identified in Programmes and Studies

There is a lack of studies about the most suitable species and varieties to face the changes in temperature and rainfall. The fact that different species have a unique capacity to endure heat means that it is essential to study individual species to find those that can best accommodate themselves to a changing climate (Boonprakrob and Hattirat, 2006), and therefore, to be sure that rural households can adapt to the changes that are already happening.

A conservation plan is needed in order to conserve genes of wild species, as they possess characteristics that can overcome stress and enemies. On-going studies in Thailand on the impact of climate change on the Mekong river basin utilize one regional climate model incorporated with CERES crop model to predict the yields of a single variety of economically important crops such as rice, corn, sugar cane and cassava. Other climate change scenarios are necessary for such studies in order to apply appropriate adaptation strategies to minimize the impact of climate change.

For livestock production, it is necessary to enhance understanding and to predict the future production of meat and dairy products under climate change conditions are needed.

Recent Projects in the Agriculture and Food Security Sector

The ADB has among its projects, the Climate Risk Management Assessment for Agriculture in Thailand and Viet Nam, which is a Small Grant for Adaptation Project. Its objectives are to identify and prioritize the sectors most 'at risk' and develop gender equitable agricultural adaptation and mitigation strategies as an integral part of agricultural development. This will include innovations in agricultural institutions, crop and resource management, the role of women, social capital and social networks. It is expected to reach better adaptation to climate change with this project; government will be able to identify

and prioritize areas most at risk and implement appropriate strategies to reduce risk and help farmers adapt. Another expected output is to get improved understanding of the climate variability and its impact on cropping patterns, structures of income and employment, and adaptation strategies (ADB, 2010)

Oxfam is carrying out some projects in vulnerable areas on climate hazards. The report "Oxfam Disaster Risk Reduction and Climate Change Adaptation Resources: Case Study, Jasmine Rice in the Weeping Plain: Adapting Rice Farming to Climate Change in Northeast Thailand" describes the action that it has been doing together with a local organization (Earth Net Foundation) since 2004, promoting organic agricultural production and fair-trade marketing with farmers in Yasothorn Province. The project also received support from START (Global Change Systems for Analysis, Research and Training), which provided technical input on climate-change issues and supervised/commented on the adaptation process, as well as training project extension officers to interpret weather forecasts.

The project activities are: (i) provision of climate-change information to farmers; participatory decision making; (ii) provision of loans to project participants; (iii) implementation of on-farm water-management systems; (iv) farmers as catalysts for change in sharing knowledge and experience with other farmers; and (v) project monitoring and evaluation. And the key outcomes: (i) food security, (ii) reduced decline in rice production; (iii) diversity of crops; and (iv) on-farm water management systems.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

Snidvongs (2006) also makes a review of the vulnerabilities and adaptation strategies that can be found in Thailand related with agriculture but also with socio-economic aspects. The method applied to reach their results is based on field interview and group meeting with local stakeholders selected study sites, which are major rice farming areas; 560 households in Ubonratchathani Province (June-July, 2004) and 625 households in Kula Field (April- May, 2005) in Thailand. The collected data are mostly qualitative information and reflect the opinions and perspectives of the respondents.

In Dutta's case study in Bangkok the overall approach and methodology followed to carry out the project uses the surface and river components of the IISDHM⁶ model for flood inundation simulation. The Anthropogenically Engineered Transformations of Land Use and Land Cover (AGENT-LUC) Model, which is a national scale, integrated, dynamic time-series simulation model, was used for assessing the land use and land cover changes as result of the human activities (Dutta, 2007).

The Bangkok Assessment Report on Climate Change 2009, also gives a review on what will be the impacts of sea level rise in Bangkok (BMA et al., 2009).

Parry et al. although is an old study gives some interesting data related with the impacts of sea level rise that can be used as a reference, and it is based on the GISS 2 x CO₂ climate projection. The potential impacts described are focused on the effects on rice production in Ayuthaya Province and effects of sea-level rise in Suratthani Province (Parry et al, 1992).

Impacts on Socio-Economic Sector

Thailand suffered more than 70 billion baht (around US\$1.75 billion) in economic losses due to floods, storms, and droughts between 1989 and 2002; related catastrophes will increase and intensify under effects of climate change what will result in reduction of productivity and hence less economic development and increasing social problems. The economic losses came mainly from the agriculture sector, as is been said before, crop productions are mostly from rain fed agriculture, which implies changes due to variations in climate; crop yield losses amounted to more than 50 billion baht (around US\$1.25 billion) between 1991 and 2000 (ADB, 2009c).

Thailand has approximately 2940km of coastline, containing important economic activities such as shrimp and rice farming. The Parry et al. study considers the potential impact of a 0.5 m and 1 m rise of sea levels in the Suratthani Province in southern Thailand that has a characteristic dune line of 1m elevation above sea level, which is a natural boundary to the area potentially affected by a 1m sea-level rise. The result is that 7400 ha (37 %) of the study area would be affected by inundation under a 1 m sea-level rise. About 4200 ha of productive agricultural land and large numbers of shrimp ponds would be lost (Parry et al., 1992). There also are other coastal areas that are occupied by different

activities, including agriculture, communities, ports and resorts, among others. These areas would, in one way or another, be affected by a rise in the sea level. Saltwater intrusion has also affected many agricultural areas in the coastal regions of Thailand.

The Bangkok Assessment Report on Climate Change 2009 mentions that the possibility of inundation from rising sea levels also has to be taken into account. Although now this is a relatively slow process, with the waters in the Gulf of Thailand are rising at a rate of about 25 mm per year; if Bangkok were finally inundated, this would mean the destruction of the country's economic engine and its status as a major hub for tourism (BMA et al., 2009).

The case study carried out for Bangkok provides a macro picture of projected flooding and its socio-economic impacts, using various scenarios of mean sea level rises in the twenty-first century. The simulated outcomes of the flood model used in the study shows that almost 55 per cent of Bangkok would be affected by floods if the mean sea level were to rise by 50 cm; if the mean sea level rises to twice that level (by 100 cm), 72 per cent of the city would be affected. Such flooding would have adverse impacts on both the social and economic sectors of the capital. The outcomes of a recent socio-economic impacts analysis show that the number of flood-affected buildings, and the size of the population and number of roads adversely affected would rapidly increase in line with projected sea-level rises from 2025 to 2100 (Dutta, 2007).

Vulnerability and Adaptation in the Socio-Economic Sector

Thailand, as an agriculture base country has vast population of rain-fed farmers, whose livelihood mainly relies on the rice production and could seriously be affected from impact of climate change. The analysis of the review data that Snidvongs (2006) study does is focused on rice productivity variations regarding different climate scenarios and its impact on farmers' livelihood condition. This analysis shows that vulnerability is site-specific condition and depends on the degree of climate impact and socio-economic condition as well as physical condition of each site. The profile of risk to climate change impact would differ from community to community (Snidvongs, 2006).

For Thailand, the same study shows that approximately one-third of population is low risk to climate impact, while the moderate risk group is the largest group, with 40-50% of the surveyed

⁶ The IISDHM (International Institute for Sustainable Development Hydrological Model), is a physically based distributed hydrological model

population. Climate change has favorable impact on rice cultivation, but it cannot cover the influence of extreme climate event and cause large portion of population to be vulnerable. In this case, many of those households in moderate risk group moved to high-risk group (Snidvongs, 2006). According to sea level rise, Thailand has a high concentration of economic activities as well as big cities near the coastal area, which makes the country more vulnerable to this impact.

Managing climate risk and the use of measures to reduce their vulnerability is not new for farmers, specifically rice farmers, of the Southeast Asia region, as for Thailand. These measures are different depending on the specific conditions that the communities are facing, such as climate hazards faced, physical and environmental constraints, available technologies, social and economic condition, vitality of community institutions, market conditions, and the priorities and objectives of the farm households. The results suggest a pattern that is shaped by the socio-economic condition of their community. Some of the measures are focused and appear because of climate risks, but others are implemented because of other concerns, but also reduce climate risks by increasing the resilience of farmers' livelihoods external factors. They include measures that are implemented at the individual farm-level, the community-level, and the national level (Snidvongs, 2006).

Farmers in Thailand lean their measures on: (i) national level; and (ii) household level, which is focused on income diversification, from alternative sources that are not as sensitive to climate variations. The main practice is seasonal migration to work in the cities, in order to secure fixed income for the household due to the fact that salary income from city employment is less sensitive to climate. Seasonal and permanent migration to diversify and support household incomes is made possible by close links between the rural villages and urban areas where there is demand for labour (Snidvongs, 2006).

The measures that the BMA report contains related with sea level rise in Bangkok, especially in Bang Khuntien District, refer to land use planning, construction or improvement of levees and dykes, water reservoirs and waste discharge designs, coastal protection phased retreat, harbour/port operation and engineering for business and commercial, and ecosystem protection (BMA et al. 2009)

Gaps Identified in Programmes and Studies

In Thailand, as a developing country, is very focused on development concerns such as poverty alleviation, economic growth and environmental degradation, given little less attention to the issue of climate change. But, climate change is strongly linked with economic activities central in modern societies: energy production and consumption, transportation, and so on. Therefore, it should not be dissociated from the fundamental concerns of human society, such as national economic planning, public administration and human development (Permpibul and Routray, 2009).

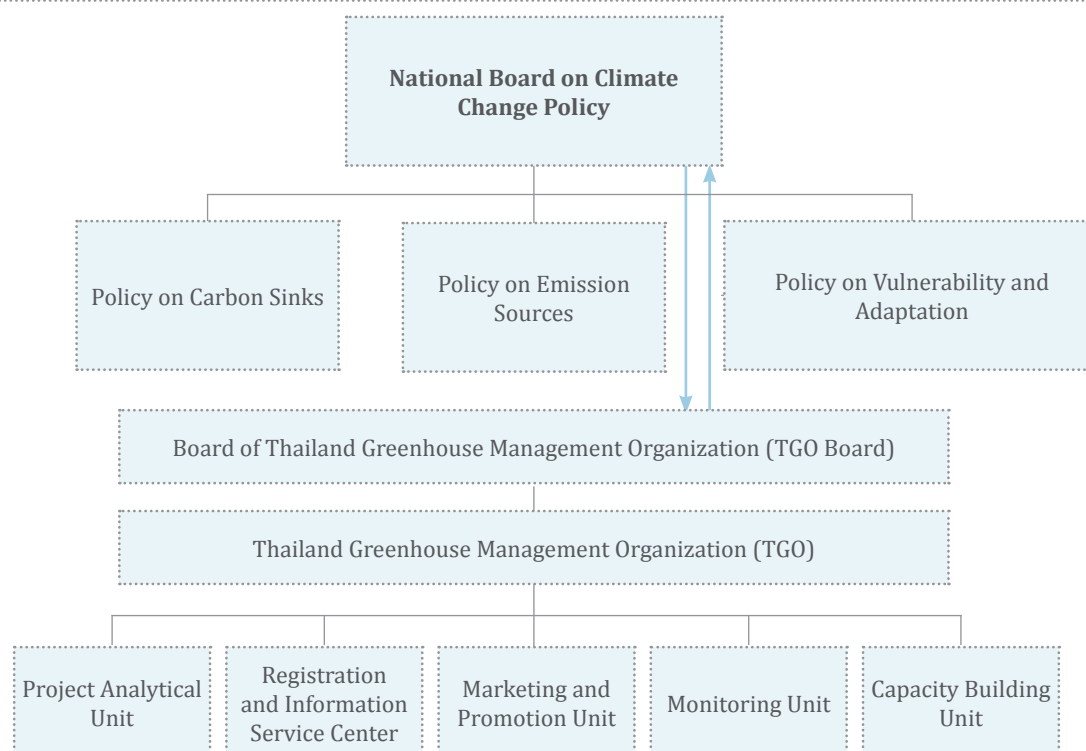
Also, as has been seen in the studies reviewed, the role of community level measures has declined or been neglected for household level and national level (Snidvongs, 2006). Current responses to extreme climatic events are viewed more as disaster preparedness and mitigation opportunities rather than as warning signals of much needed long-term adaptation. Existing climate change models do not provide conclusive assessments of the associated impacts at local levels. Therefore, there is a need for a bottom-up approach to address the level of vulnerability to the existing and future impacts to improve adaptation at local level in the long-term. Adaptation is strengthening capacities of communities in the longer term, and is context specific; hence require an active and meaningful participation of stakeholders (Permpibul and Routray, 2009).

Furthermore, there is still a lack of baseline information to understand the interplay between natural and human systems (economic and social issues) and a gap in information on changes in climate and human systems in different ecosystems and agro-climatic systems. The human dimension, especially livelihood aspects and inter-sectoral relationships have not been incorporated successfully on the national scale assessment. Without this for designing and planning adaptation policies, strategies and programs, decisions on adaptation will stay uncertain and will not conduct to effective results (MRC, 2009).

Recent Projects regarding Socio-Economic Aspects

Thailand, because of the Kyoto Protocol, included the climate change issue in its 11th National Economic and Social Development Plan, to be implemented between 2012 and 2016. On top of the Government's efforts, some initiatives in combating climate change

Figure 34: Institutional organization concerning climate change (Source: MRC, 2009)



comes from His Majesty King Bhumibol Adulyadej; his concept of Sufficiency Economy have provided the needed safeguards against the effect of climate change on the livelihoods and the socio-economic development of the Thai people, especially in times of severe droughts and floods (GPRD, 2009).

The Regional and Rural Development Planning of the Asian Institute of Technology (AIT) in Bangkok, Thailand (2009), developed the study Community-based adaptation to climate change: the case of Thailand. This study has employed a number of participatory rural appraisal research techniques and has attempted to develop a local adaptation enhancement model based on the Adaptation Policy Framework (APF) developed by the United Nations Development Program (UNDP), within Thailand local context, focusing on the flooding due to climate change. The aim of the study is to provide a net contribution to the fields of climate change and rural and regional planning by integrating these fields using a vulnerability-based (bottom-up) approach into local development planning. This serves as an alternative to the current scenario-based approach to vulnerability and adaptation assessment, which is the dominant approach currently adopted by climate scientists (Permpibul and Routray, 2009).

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Two different domains could be identified as being cross-sectoral institutional arrangements, i.e. climate change institutions, on the one hand, and institutional settings concerning disaster risk reduction, on the other hand.

Climate Change

Thailand guides its economic and social development with the 5-year National Economic and Social Development Plans. Also among its environmental policy can be found the 5-year Environmental Quality Management Plans; both have incorporated climate change issues into social and economic development strategies and the National Committee on Climate Change has played an important role in drawing up a national strategy to address climate change issues. An Expert Committee on Climate Change has been established to provide technical recommendations to the Committee.

In 2004, the Office of Natural Resources and Environmental Policy and Planning (ONEP), which forms part of the Ministry of Natural Resources and Environment was designated as the national climate

change focal point. In 2007, Thailand established the National Board on Climate Change Policy, and the Climate Change Coordinating Unit under ONEP (See Figure 34). The country further established the Greenhouse Gas Management Organization (TGO) as a public organization under the Ministry and the Designated National Authority (DNA) for Clean Development Mechanism (CDM) projects (MRC, 2009).

The membership of the National Board on Climate Change Policy is wide and includes representatives of line ministries, research institutes and the economic interests. The Board is chaired by the Ministry of Natural Resources and Environment.

Thailand Initial National Communication under the UNFCCC

Thailand ratified the UNFCCC in March 1995; later, in August 2002, ratified the Kyoto Protocol. From 1997 to 2000 the country developed the Initial National Communication to UNFCCC, which was funded by Global Environment Facility. In 2006, the Second National Communication to UNFCCC was commenced.

The initial communication recalls the contribution of the country to the international efforts on climate change, as a non-Annex I country. The document is an overview of Thailand's situation regarding climate issues and capability to respond to it together with mitigation options; also it reviews vulnerability and adaptation strategies, policies and measures taken, and the areas where Thailand still lacks the capacity to address climate change problems.

The contents of the communication are divided into nine chapters, starting with the introduction chapter and finishing with the epilogue. Between both, there is a description of the country characteristics, socio-economic aspects, climate and topography, energy, etc. doing afterwards a review of the inventory of Green House Gases, and the projections for all of them, as well as the available mitigation options. Subsequently, it goes through vulnerability and adaptation issues, always focusing in five sectors, which are natural forest, water resources, agriculture, coastal resources and health. The rest three chapters are devoted to policies and measures, financial resources, technology transfer and capacity building and education and public awareness.

National Action Plan on Climate Change and National Strategy on Climate Change

The National Action Plan on Climate Change of Thailand, which was completed in 2000, enables the country to establish a national framework on climate change for mitigating emissions of GHGs and adapting to the adverse impacts. National goals and objectives were established for the formulation of the action plan. The adaptation plans were designed based on available information from systematic assessments of the key sectors described for the initial national communication: forests; water resources; coastal resources; health and agriculture (MRC, 2009).

The Action Plan involved the establishment of the National Climate Change Office (NCCO) and the National Climate Change Fund (NCCF) to facilitate its implementation.

The Thailand's Strategic Plan on Climate Change 2008 – 2012 (B.E. 2551- 2555 (2008-2012)) was approved in January 2008 and formulated by the Ministry of Natural Resources and Environment to respond to climate change challenges. It aims to be country's first response to climate change, to remove existing barriers to climate change implementation, and to promote an integrated approach of problem-solving by relevant agencies in various sectors. The main objective of Thailand's Strategic Plan on Climate Change (2008-2012) is to provide a guideline of national responses to climate change challenges. It is essential that national-level and local-level agencies with relevant mandates develop their own action plan that corresponds to the guidelines set forth in the Strategic Plan. The Ministry is now initiating the Action Plan Development Process among relevant agencies, expected to be completed this year (MRC, 2009). It outlines measures that need to be undertaken by various agencies, which include (ONEP, 2008):

- **Strategy 1:** Build capacity to adapt and reduce vulnerabilities to climate change impacts
- **Strategy 2:** Support greenhouse gas emissions reduction and add more carbon dioxide sinks on integrity development, which objective is to reduce greenhouse gas emissions and improve production technology base to clean technology
- **Strategy 3:** Support research and development to better understand climate change, its impacts and adaptation and mitigation options
- **Strategy 4:** Raise awareness and promote public participation

- **Strategy 5:** Build capacity of relevant personnel and institutions and establish a framework of coordination and integration
- **Strategy 6:** Support international cooperation to achieve the common goal of climate change mitigation and sustainable development

National Climate Change Knowledge Management Centre

The Government of Thailand launched the National Climate Change Knowledge Management Centre under the Ministry of Science and Technology (MOST) last December (2009). There are no documents available that are translated into English yet.

Institutional Settings Concerning Disaster Risk Reduction

Situation of Disaster Risk Management

The Department of Disaster Prevention and Mitigation (DDPM) together with the ADPC aim to set up a Total Disaster Risk Management (TDRM) approach to develop and implement suitable programmes in Thailand. Other organizations will be encouraged to evaluate the risk that disaster pose to their activities and also to act to prevent and reduce them. The different needs of each of these organizations requires a flexible risk management approach (Noson, 2005).

The Thailand National Development Plan sets the basis for policy for prevention and mitigation programs. It is necessary that the national plan includes prevention and mitigation actions into development practices to incorporate effectively the TDRM approach into it; and it is DDPM the one that is in charge to reach this, which aims to promote a risk management culture at national, provincial, district and community level. DDPM is one of the six departments located into the Ministry of Interior. Each of the 20 ministries that conform to the Thai Government reports to the Cabinet Council that is held by the Prime Minister. The five enterprises within the Ministry of Interior also have important roles to develop national and community disaster resistance. The DDPM has five bureaus and centres that address policy, research on safety control measures, training and education, warning and coordination, and victim assistance. Twelve Disaster Prevention and Mitigation Regional Centers provide education and advice to government, private organizations and local communities. Also DDPM supports and assists local –level prevention and mitigation activities and

emergency exercises, giving also disaster assistance after a disaster. Local communities can prepare their own plans, carry out their own exercises and provide relief to victims without the approval of the government (Noson, 2005).

Other tasks held by the DDPM is to ensure cross-organizational cooperation and participation of all the roles that each Thai Ministries, departments and state agencies, as well as local communities, have regarding disaster risk management. The Department of Public Works and Town and Country Planning (DPWTCP), which is also under the Ministry of Interior, is in charge of developing and implementing building codes and land –use plans, which both must be approved by the department and are important prevention and mitigation measures. Cooperation and coordination between DDPM and DPWTCP is necessary to reduce disaster risk in the country. DDPM has establish the following government agencies: Civil Defense Division of Local Administration, Office of National Safety Council of Thailand Office of the Prime Minister, Division of Disaster Victim Relief, Department of Social Welfares; Technical Assistance Centre, Community Development Regional Centres, Departments of Community Development and Accelerated Rural Development Management; which are all involved with disaster management (Noson, 2005).

Thailand has some activities focused preparedness to natural disaster that the MRC report summarizes (MRC, 2009):

- The Royal Projects for relief of flooding
- The Royal Projects relief of drought (Royal Artificial Rain Projects)
- The Royal Projects to construct dams and water reservoir
- The Royal Projects to plant vetiver grass to prevent soil erosion
- The establishment of the National Committee on Water Policy for flood and drought crisis relief
- The establishment of the Information Centre on Environmental Disasters under the Ministry of Natural Resources and Environment
- The establishment of the National Disaster Relief Centre under the Ministry of Information, Communications and Technology

In addition to national level responses, Thailand has knowledge and experience at the local level on coping with climatic variability and extreme weather events such as floods, and drought. Within

different sectors a range of approaches, particularly structural interventions, like large scale irrigation for agriculture, and flood protection, and warning systems have been researched and developed (MRC, 2009). Government ask for participation to community leaders to carry out local risk reduction projects. Ideally government and local leaders will work together towards community safety.

The BMA report mentions some measures for the city of Bangkok related with Extreme weather events (wind storms, prolonged rain, river flooding, and drought). For Community infrastructure and operations the measures are emergency preparedness plans, construction or improvement of levees and dykes, elevate buildings, land use planning (e.g. consider adequacy of flood plain zones), diversify power supply, upgrade transmission lines, implement tree-trimming policy and strengthen emergency communications. Among business and commercial measures can be found flood proof buildings, reschedule production and marketing and business resumption and restoration planning. Last, in residential health and general population the measures considered are flood-proof homes, build elevated basements, move power-supply boxes upstairs publicly sponsored flood insurance (for areas outside of flood plains) and advocate 72 hours of self sufficiency (such as having emergency supplies on hand, canned food, water, medical, back-up power supplies, generator, fuel, radio with batteries) (BMA et al., 2009).

Gaps Identified

Overlapping and unclear lines of responsibility often occur among organizations while trying to achieve risk reduction, for a healthy and sustainable nation and communities.

The support Knowledge and disaster resistance provided by the DDPM through the department's bureaus, centres and the twelve Disaster Prevention and Mitigation Regional Centres at local levels require community involvement to be effective. The community is the front line of risk management in prevention and mitigation and without its participation and proposals, actions taken in regard of prevention and mitigation will not reflect local values, concerns, resources and culture; making implementation and maintenance impossible.

Among the literature reviewed, there are specific strategies and project assessment on topics such as the Tsunami of 2004 or other frequent disasters as floods or landslides, but no national documents

devoted just to disaster risk management have been found. All the policies and strategies are included in the National Development Plan, which is not only concern about disaster management.

The 26 December 2004 tsunami hit Thailand's 954-kilometre Andaman Coast - killing more than 5,300 people and affecting the livelihoods of tens of thousands of households in six coastal provinces. Initial assessments estimated that it damaged 13% of the sampled coral reef area, particularly the shallow-water reefs, but the sea-grass beds and mangrove forests were less affected. Concerning the tsunami event, the Government has acknowledged the need for a more comprehensive assessment along with monitoring and rehabilitation of coastal habitats and natural resources as well as development of high technology early warning system. In addition to the rehabilitation effort, the Government should also take this opportunity to undertake long-term integrated management of coastal resources, work on the allocation of proper land rights, promote sustainable tourism, and build the capacity of officials at both local and national levels (UN, 2005).

Recent Projects Concerning Disaster Risk Reduction

There are some Thai Community based programs initiated in communities themselves. For example, at the community named Bo-Poa, Nakorn Thai District in Phitsanulok province, where community encounters to flood and landslide, the community established a team to solve problems by themselves. The community leaders also requested the government some support.

The Asia Disaster Reduction Center good practices published in March 2008 contains the Community Base Landslide Watch Network in Thailand, which is established by the Department of Mineral Resources (DMR). Historically, landslide disasters have usually occurred in the Northern and Southern Regions causing human and material damages. The local watch networks use trained village volunteers working as guards to check points to observe signs of landslides; they are only in duty when heavy rain is approaching or they are receiving landslide watch information from DMR. The aim of the network is to improve the self-protection capability and landslide awareness and knowledge of the people in vulnerable areas. The first local network was established in 2003; now in Thailand there are approximately 8500 volunteers working in networks linking more than 1000 communities in 22 provinces. Because of the good performance of the initiative, DMR has the

support of the government to establish more local networks in other 29 provinces (ADRC, 2008).

The United Nations Environmental Programme has a regional project, in which Thailand is included, titled “Capacity Building to Integrate Disaster Risk Reduction into Coastal Zone Management”. The aim of the project is building DRR capacities of coastal zone managers for designing and implementation of projects that enhance the protection of lives while improving environmental quality. The project encompasses national (India, Indonesia, Sri Lanka) and regional (Maldives, Thailand, Seychelles) activities. Thailand stakeholders will be involved in the development of training manuals (comments) and participation at regional workshop. The partners involved are EC Aidco, ISDR (Funding) Mangroves for the Future (MFF) Secretariat, National Coordinating Bodies and National Disaster Management Organizations (NDMO).

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Although Thailand has 90 climate stations that meet WMO standards, the country needs to strengthen a network of climate stations to ensure weather forecasting capabilities that can be used for assessing climate change scenarios (Boonprakrob and Hattirat, 2006); limited work has been done to date on climate change predictions at a national level.

Policies and measures concerning adaptation cannot be developed due to the lack of research and development. The adaptation options have been identify in general terms such as the development of genetic properties related to climate change, changes in agricultural practices, and aggressive water resources conservation. The main force in regard to vulnerability and adaptation is to improve research and development capacities in the mentioned areas (OEPP, 2000).

The MRC report gathers a series of gaps and lack in policies, measures and actions that are being done in regard to vulnerability and adaptation to climate change. There is still a lack in institutional strength, capability and availability of reliable data for generating climate scenarios. Although the emergence of threats because of changes in climate is encouraging the government, research institutes and universities to invest in climate change

studies to provide technical knowledge in this area and to develop policies and economics, there are limitations in terms of the technical capacity of experts and sourcing of appropriate funding. There has been progress from private research and academic institutions with expertise that carry out climate change studies and predict scenarios and also international organizations are supporting governments and private institutions to carry out advanced climate change research and assess vulnerability and adaptation options.

Furthermore, there is still a lack of baseline information to understand the interplay between natural and human systems and a gap in information on changes in climate and human systems in different ecosystems and agro-climatic systems. The human dimension, especially livelihood aspects and inter-sectoral relationships have not been incorporated successfully on the national scale assessment. Without this for designing and planning adaptation policies, strategies and programs, decisions on adaptation will stay uncertain and will not conduct to effective results.

Not only is important to understand the effects of climate change and associated enhanced climate variability at the local and national levels, also the capacity to select and apply appropriate methods and tools to prepare for adaptation in essential. In this sense, in Thailand there are several studies that apply GCMs to built future climate scenarios that, also, combined with specific-sector models provide valuable information about impact of climate change in the sectors reviewed in this report (water, agriculture and food security, and socio-economic sectors). The TEI for its country study on climate change uses three models, UK89, UKMO (United Kingdom Meteorological Office) and GISS (Goddard Institute for Space Studies). The Initial National Communication uses the scenarios created by the ECHAM4 GCM, elaborated by the Max Planck Institute, to analyze the impacts on water resources. The study on extreme hydrological events and changes in water resources elaborated by SEA START uses the regional climate scenario CCAM (Conformal Cubic Atmospheric Model) developed by CSIRO in Australia; to study the impact of the climate changes on hydrological regime, the Variable Infiltration Capacity Hydrological Model is used and to study impacts on agriculture the DSSAT version 4.0. To study the impacts on the agricultural sector, the MRC and the Initial National Communication use four models, which are CSIRO global coupled ocean-atmosphere-sea-ice model, HadCM2 model,

ECHAM4 model and CCCMA's First Generation Couple GCM. In the socio economic sector, SEA START report makes an evaluation of the impacts caused by climate change based on field interviews and group meetings; Dutta's study, uses the surface and river components of the IISDHM model for flood inundation simulation and the AGENT-LUC Model (Anthropogenically Engineered Transformations of Land Use and Land Cover) for assessing the land use and land cover changes as result of the human activities.

Related to this, should be included the development of technologies for adaptation; the use and integration of traditional knowledge for developing adaptation options; integration of local knowledge and scientific knowledge for technology transfer; and communication of vulnerability and adaptation both to vulnerable communities and policy makers are also essential.

Last, there is a need to build awareness about the potential impacts of climate change amongst potentially affected people, and make stakeholders understand that they have to get involve in order to implement successfully measures on climate change adaptation. There is also a need to develop and disseminate good quality information. Systematic efforts are required to study the impact evaluation of different climatic parameters (MRC, 2009).

The following is the compilation of the gaps found in the literature reviewed for water resources, agriculture and food security, socio economics and risk management.

Water Sector

In water sector there is an urgent need to study changes in the rainfall pattern in all the watershed areas by using more than three climate change scenarios, and to incorporate the results in the government management plans. Besides, there are few studies in Thailand using mathematical models to assess physical property of water resource (water flow conditions, element dispersion, sediment transfer and accumulation), for instance, to plan for water resource management; studies on biological diversity and the impacts of climate change on water resources and fresh water ecosystems using mathematical models need to be included (Boonprakrob and Hattirat, 2006).

Agriculture and Food Security Sector

There is a lack of studies about the most suitable species and varieties to face the changes in temperature and rainfall. The fact that different

species have a unique capacity to endure heat means that it is essential to study individual species to find those that can best accommodate themselves to a changing climate (Boonprakrob and Hattirat, 2006), and therefore, to be sure that rural households can adapt to the changes that are already happening.

A conservation plan is needed in order to conserve genes of wild species, as they possess characteristics that can overcome stress and enemies. On-going studies in Thailand on the impact of climate change on the Mekong river basin utilize one regional climate model incorporated with CERES crop model to predict the yields of a single variety of economically important crops such as rice, corn, sugar cane and cassava. Other climate change scenarios are necessary for such studies in order to apply appropriate adaptation strategies to minimize the impact of climate change.

For livestock production, it is necessary to enhance understanding and to predict the future production of meat and dairy products under climate change conditions are needed.

Socio-economic Sector

In Thailand, as a developing country, the issue of climate change has been given little attention with a more reactive approach rather proactive one; specifically if it is compared to the development concerns such as poverty alleviation, economic growth and environmental degradation. But, climate change is strongly linked with economic activities central in modern societies: energy production and consumption, transportation, and so on. Therefore, it should not be dissociated from the fundamental concerns of human society, such as national economic planning, public administration and human development (Permpibul and Routray, 2009).

Also, as has been seen in the studies reviewed, the role of community level measures has declined or been neglected for household level and national level (Snidvongs, 2006). Current responses to extreme climatic events are viewed more as disaster preparedness and mitigation opportunities rather than as warning signals of much needed long-term adaptation. Existing climate change models do not provide conclusive assessments of the associated impacts at local levels. Therefore there is a need for a bottom-up approach to address the level of vulnerability to the existing and future impacts to improve adaptation alt local level in the long-

term. Adaptation is strengthening capacities of communities in the longer term, and is a context specific; hence require an active and meaningful participation of stakeholders (Permpibul and Routray, 2009).

Disaster Risk Management

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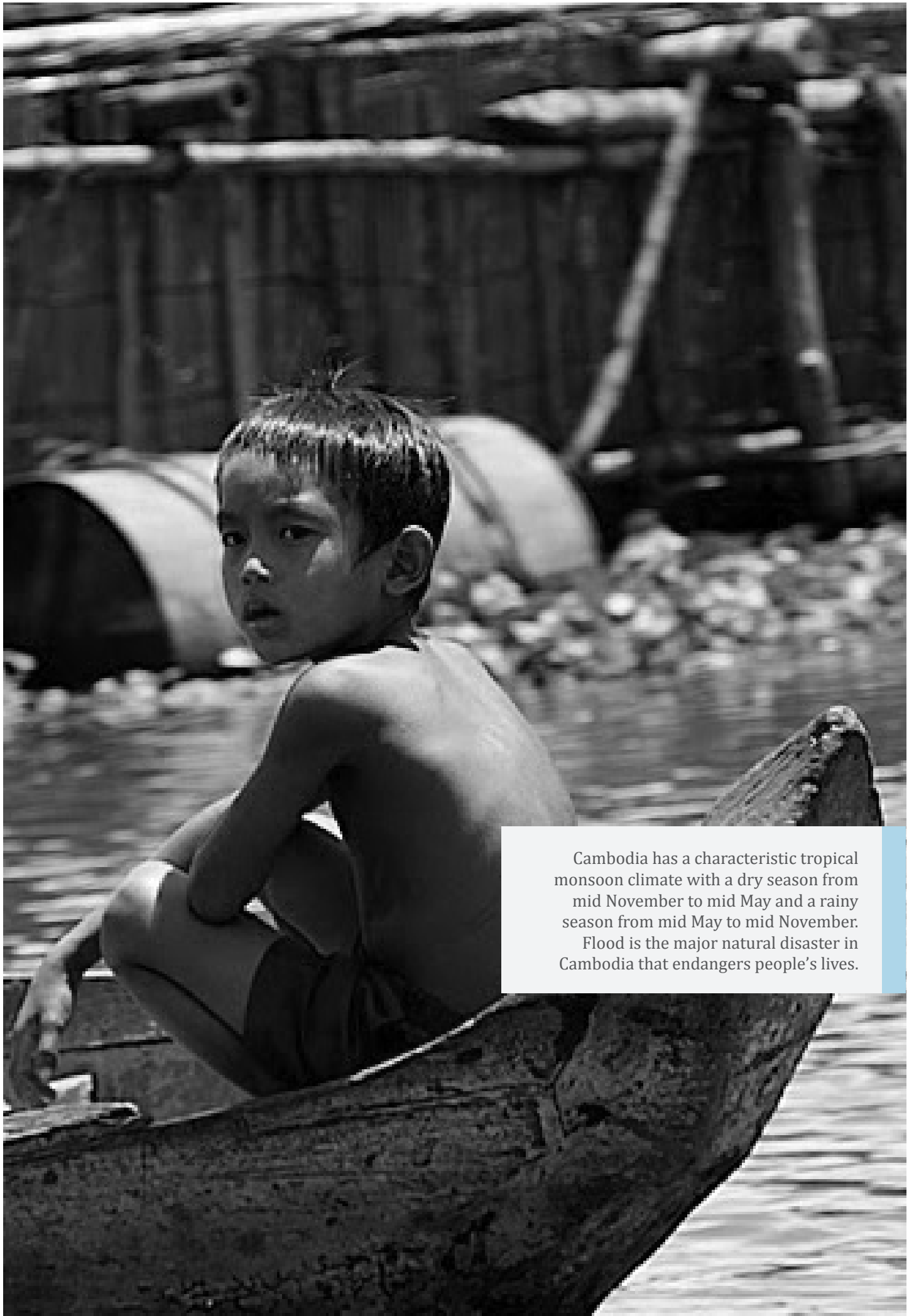
The support Knowledge and disaster resistance provided by the DDPM through the department's bureaus, centres and the twelve Disaster Prevention and Mitigation Regional Centers at local levels require community involvement to be effective. The community is the front line of risk management in prevention and mitigation and without its participation and proposals, actions taken in regard of prevention and mitigation will not reflect local values, concerns, resources and culture; making implementation and maintenance impossible.

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The 26 December 2004 tsunami hit Thailand's 954-kilometre Andaman Coast - killing more than 5,300 people and affecting the livelihoods of tens of thousands of households in six coastal provinces. Initial assessments estimated that it damaged 13% of the sampled coral reef area, particularly the shallow-water reefs, but the sea-grass beds and mangrove forests were less affected. Concerning the tsunami event, the Government has acknowledged the need for a more comprehensive assessment along with monitoring and rehabilitation of coastal habitats and natural resources as well as development of high technology early warning system. In addition to the rehabilitation effort, the Government should also take this opportunity to undertake long-term integrated management of coastal resources, work on the allocation of proper land rights, promote sustainable tourism, and build the capacity of officials at both local and national levels (UN, 2005).

COUNTRY CHARACTERISTICS



Cambodia has a characteristic tropical monsoon climate with a dry season from mid November to mid May and a rainy season from mid May to mid November. Flood is the major natural disaster in Cambodia that endangers people's lives.

RESEARCH SYNTHESIS ON CAMBODIA

The country characteristics cover information on Cambodia's geographical, social, economic and climatic risks. An overview of the country's characteristics is provided in Table 12.

Geographic Situation

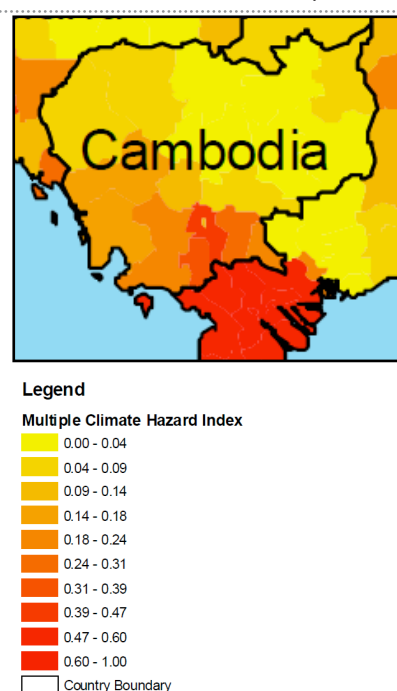
Cambodia extends an area of 181,035 sq km, bordering three countries, namely, Thailand, Lao PDR and Viet Nam, in the east to west parts (Royal Government of Cambodia, 2009). Of its total land area, 53 percent is covered by forest and 21 percent is cultivated. The regions surrounding the Mekong River and the Tônlé Sap Lake are most fertile. The Mekong River, the longest river in Southeast Asia and the tenth largest in the world, flows into Cambodia from the northern border with Lao PDR and runs out through the southern border with Viet

Nam. The Tônlé Sap, the country's principal lake and the largest in Southeast Asia, drains into the Mekong River at Phnom Penh. Every year during the monsoon season approximately between May and October, the amount of water of the Mekong River increases and the river flow reverses and drain into the lake. The lake then expands its size dramatically, flooding the provinces along its banks. When the dry weather returns, the river reverses its flow back again, draining into the Mekong. At the time of the flooding, the Tônlé Sap reaches about four times its size in the dry season. Despite this fluctuation of the

Figure 35: Location map of Cambodia (CIA, 2009)



Figure 36: Climate hazard map of the Cambodia (Extracted from Multiple climate hazard map of Southeast Asia, Yusuf A.A. and H.A. Francisco, 2009))



lake condition, the lake serves as one of the richest sources of freshwater fish in the world (ibid).

Socio-Economic Status

Cambodia is one of the least developed countries (LDC). The country's GDP per capita of the year 2007 amounts to US\$ 598 and the literacy rate of total population over 15 is 74% (UN data, 2009). The agricultural, industrial and service sector accounted for 29%, 30% and 41% of GDP respectively in 2007 (CIA, 2009). Agricultural production is affected by the flooding and recession of the Tônlé Sap Lake and the Mekong River, which brings fertile alluviums to the central plains (Royal Government of Cambodia, 2006).

Cambodia's population of 2007 was 14,444,000, of which approximately 80 percent lived in rural areas (UN data, 2009). Meanwhile, those who have access to improved drinking water sources in rural areas amounted to only 35% of total population in 2004 (WHO and UNICEF, 2006c). Furthermore, 35% of the population lived below the poverty line in 2004 (UN data, 2009).

Climate Risks

The Cambodia-specific climate profile including current climatic conditions and projected climate scenarios are briefly explained as background information to address vulnerability and adaptation issues.

Current Climatic Conditions

Cambodia has a characteristic tropical monsoon climate with a dry season from mid November to mid May and a rainy season from mid May to mid November (Royal Government of Cambodia, 2006). The annual average temperature is 27°C, and it rises up to 38°C in April or May and falls to a minimum of 14°C in January or December. The average annual rainfall is about 1,400 mm on the central plain, and it increases to as much as 3,800 mm in the mountains and along the coast (Royal Government of Cambodia, 2009).

The natural disasters in Cambodia from the period of 1980 through 2009 are summarised in the Table 13, including the type of natural disasters, the total number of incidents and people affected, and economical damages generated by each incident. Flood is the major natural disaster in Cambodia that endangers people's lives.

Climate Projections

Cambodia is expected to experience the increase in temperatures and precipitation, possibly with monsoon seasons wetter and less rainfall in the dry season (Hoanh et al., 2003, Snidvongs et al., 2003, Ruosteenoha et al., 2003 cited in Roth, 2009). The study for the 4th IPCC Assessment demonstrates the detailed projections of temperature rise by 0.7 to 2.7°C by 2060s and the increase in mean annual rainfall mainly resulted from wetter rainy seasons (-11 to +31%) and partially due to offset by drier

Table_12 Cambodia country profile overview

Country level information (UNdata 2009, CIA 2009, WHO / UNICEF 2006, National Institute of Statistics, 2008, Royal Government of Cambodia, 2009)

Surface area (km2)	181,035
Bordering countries	Laos PDR, Thailand, Viet Nam
Population, 2007 (Estimated)	14,444,000
Percentage of population, 2007 (%) in	
- rural areas	79.1
- urban areas	20.9
Population density, 2007 (persons/ km2)	79.8
Population growth rate, 2005-2010 (% per annum)	1.7
Forest cover (% of total area)	53
Arable land (% of total area)	20.44
GDP, nominal, 2007 (million US\$)	8,639
Contribution of agricultural sector to GDP, 2007 (%)	29
Contribution of industrial sector to GDP, 2007 (%)	30
Contribution of service sector to GDP, 2007 (%)	41
Population below poverty line , 2004 (% of total population)	35
Infant mortality rate, 2005-2010 (per 1 000 live births)	62.7
Literacy rate, 2007 (% of total population over 15 that can read and write)	74
Access to improved drinking water sources, 2004 (% of total population) in	
- rural areas	35
- urban areas	64

Table_13 Overview on natural disasters in Cambodia from 1980 to 2009

Top 5 Natural Disasters in Cambodia for the period 1980-2009			
Type of natural disaster	Date/year	No of people affected	
Drought	Jun 1994	5,000,000	
Flood	Jul 2000	3,448,053	
Flood	Aug 2001	1,669,182	
Flood	Aug 2002	1,470,000	
Flood	Sep 1996	1,300,000	
Total Natural Disasters in Cambodia for the period 1980-2009			
Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Storm	2	34,300	10
Drought	5	6,550,000	138,000
Flood	13	9,533,614	328,100
Epidemic	9	417,938	-

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain - Brussels, - Belgium. Created on: Dec-23-2009. - Data version: v12.07

dry seasons (-54 to +35%) (Mac Sweeney et al., 2008 cited in Roth, 2009). Another research anticipates greater temperature rise by about 2.3 to 2.8°C (Lacombe, 2009 cited in Roth, 2009). It also projects a reduction in total rainy days and a decrease in dry season rainfall, interpreting it as a wetter rainy season with increase in intense rainfall events and resulting flood hazards. This study further predicts shifting of the average onset and end of the rainy season by about two days every 10 years.

The projection focused on the sub-basins of the Mekong River Basin shows that annual precipitation along the Tône Sap catchment areas is most likely to increase in a range of 200-300 mm, leading to the a decline of the eastern Kratie catchments (Eastham et al., 2008 cited in Roth, 2009). Although this trend is expected to occur in wet seasons, a small median decrease- about -10 to -14 mm- in dry season rainfall is projected in 2030. The lower Mekong, including the whole area of Cambodia, temperature is predicted to increase by 0.7°C to 0.8°C in 2030 compared to the 1951-2000 baselines.

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

Water Sector

Range of Studies Reviewed and Methods Applied

Most of the assessments of climate change projections employed in this report rely on Global Circulation Model (GCM). Eastham et al. (2008) selected 11 GCMs to build the year 2030's scenarios of temperature and precipitation for the IPCC A1B scenario. The potential impacts of sea level rise in the coastal areas were conducted through Geographical Information System (GIS) techniques. The methodologies for assessing provincial vulnerability to flood and drought are not indicated in the referred study.

The Water and Development Research Group of Helsinki University of Technology (TKK) and the Southeast Asia START Regional Center (SEA START RC) analyses the hydrological impacts of climate change as well as

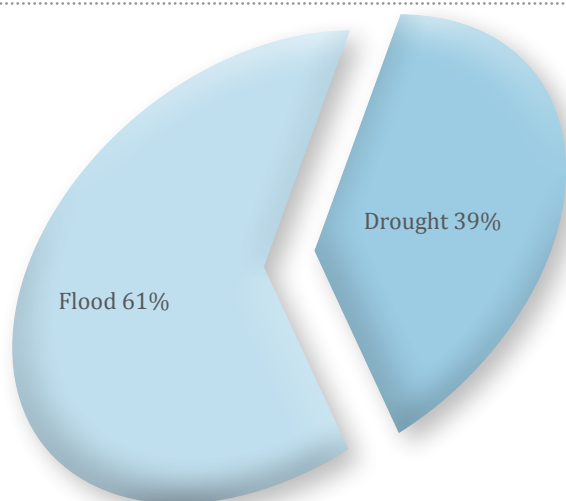
related adaptation strategies in the Tône Sap area of Cambodia (2009). The hydrological impacts of climate change were projected for the period between 2010 and 2049 based on two main phenomena: 1) changed basin hydrology due to climate change-induced changes in temperature and rainfall, and 2) sea level rise. For this study, high resolution future climate projection data was simulated for the 21st Century through the PRECIS regional climate model that employed as input dataset from ECHAM4 Global Circulation Model under two different climate scenarios (A2 and B2), and downscaled it for the Mekong Region.

The National Adaptation Program of Action (NAPA) and the Initial National Communication (INC) indicate the Level of vulnerability to flood and drought by province and recommended adaptation strategies. The local-level autonomous and planned adaptation practices are also touched upon.

Impacts on the Water Sector

Many researchers see increase in frequency and severity of flooding as a primary impact of climate

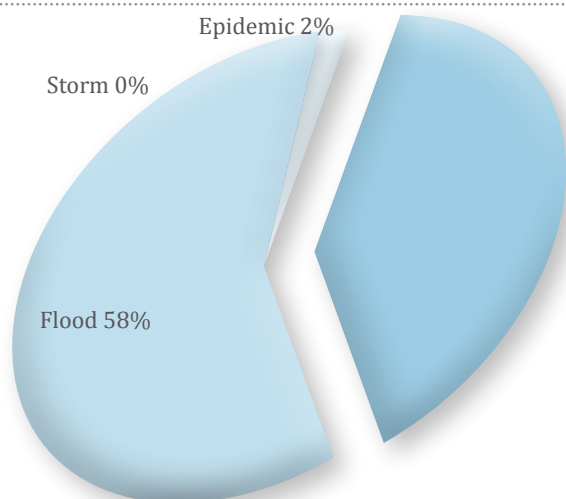
Figure 37: Percentage of people affected
due to top 5 natural disasters
1980-2009



variability on water resources in Cambodia (Hoanh et al., 2003, Snidvongs et al., 2003, Ruosteenoha et al., 2003, Eastham et al., 2008 cited in Roth, 2009). Meanwhile, increased drought-related events including wet season drought spells are seen to be highly expected (Roth, 2009). Although a change in frequency of wet season drought is uncertain, drought in dry season is anticipated.

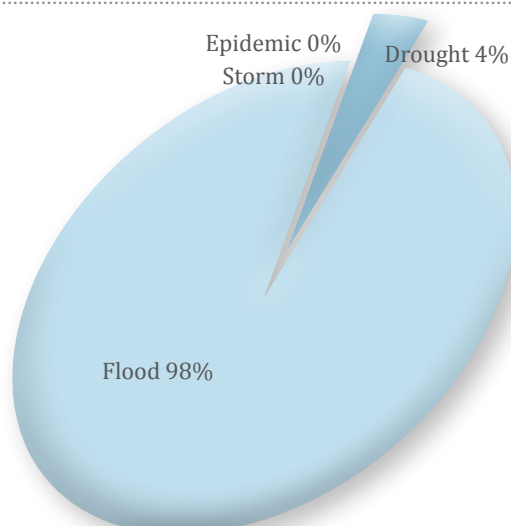
Eastham et al. (2008) indicates potential impacts of climate change at the year 2030 on five areas within catchments of the Mekong Basin in Cambodia: Se San (north-east), Kratie (central), Tônlé Sap (central), Phnom Penh (south-eastern) and Border (southern) (Roth, 2009). According to the study, increase in flooding is projected in 2030 in all the regions, though the level of increase varies. In the Kratie region, for example, frequency of extreme floods will increase from 5% to 76% annual probability, and peak flows, flood duration and flooded area are also predicted to increase. The area of the Tônlé Sap Lake will be more minimised. In Phnom Penh and Border, the flooded area is expected to increase.

Figure 38: Percentage of people affected
due to total natural disasters
1980-2009



The study of TKK and SEA START RC (2009) inspects that the impacts of changing climate in Cambodia are most likely to emerge through changes in the flows of the Mekong River, altering the region's unique but important flood pulse system and the resulting high aquatic productivity of the lake-floodplain system. Most of the simulated climate scenarios show similar results concerning hydrological impacts: the future flood pulse in the Tônlé Sap and the Cambodian floodplains is projected to be wetter with higher water levels, extended flooded area and longer flood duration. Also, the average water level during the dry season is expected to increase (TKK and SEA START RC, 2009).

Figure 39: Percentage of damage (US\$)
due to total natural disasters
1980-2009



In addition to flooding, drought is also expected to occur. A case study of Kyoto University points out that the local communities in Svay Rieng province have the capacity to investigate the long-term changes in the drought-related conditions in their area and their causes such as the decline in rainfall, steep increase in ambient temperatures and decline in biodiversity (MRC, 2009d).

The abovementioned increase in flood and drought events will further have implications for the groundwater resources. Larger wet season water-flows and floods and possibly higher dry season water-flows may lead to greater recharge to aquifers and higher aquifer water levels, thus resulting in potentially greater water resource for use (Eastham

et al., 2008). On the other hand, the projected greater potential evapotranspiration, along with increasing population and the preference for groundwater rather than likely contaminated surface water, will induce greater water demand in the dry season.

In addition to flood and drought, the sea level rise is observed as a consequence of global warming in the coastal zone. The Initial National Communication (Ministry of Environment, 2002) projects that a sea level rise by one meter would submerge approximately 56% of the low-lying city of Koh Kong. In addition, one-meter sea level rise would also submerge the total area of about 44km² permanently. Of the 44 km² affected, 7.7% and 6.8% would be shrimp farm and grassland respectively. Hence, together with a changing climate, sea level rise would have negative impacts on socio-economic activities of coastal communities such as fisheries, tourism and agriculture.

Vulnerability and Adaptation in the Water Sector

The National Adaptation Program of Action (NAPA) demonstrates the provinces that are highly affected by flooding and drought. The former are Kampong Cham, Prey Veng, Takeo, Kampong Thom and Battambang. The latter are Prey Veng, Battambang and Banteay Meanchey (Ministry of Environment, 2006). The level of vulnerability to flood and drought by province are shown in Figure 40 and Figure 41.

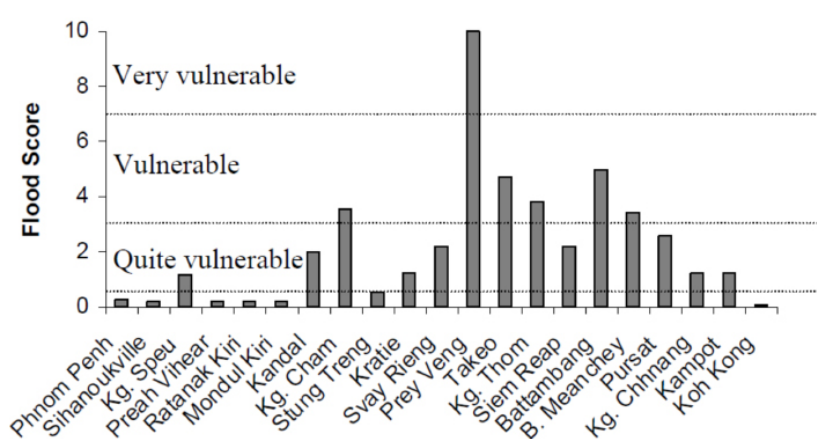
The NAPA also identifies several prioritised activities for climate change adaptation in the water sector, including improvement of rainwater harvesting facilities at villages as well as the design of reservoirs and irrigation channels (Ministry of Environment, 2006). Specifically for the coastal zones, the NAPA suggests several adaptation options such as rehabilitation of multiple-use canals (Banteay Meas district, Kampot province) and coastal protection infrastructure and community-based mangrove restoration and agricultural soil conservation (Srae Ambel district, Koh Kong province).

Prior to the NAPA, the adaptation options to respond to sea level rise on the coastal zone were identified by the Initial National Communication. These are more focused on information and knowledge sharing

and collaborative institutional set-up, including development of computer-based information systems covering the results of surveys, assessments and observations in order to minimize the impact of sea level rise and establishment of cooperation frameworks, training, technology transfer in case of sea level rise (Ministry of Environment, 2002).

Responding to some of the adaptation options recommended by the NAPA and Initial National Communication, the Ministry of Water Resources and Meteorology (MoWRAM) and the UNDP have implemented activities to sustain water supplies through drought management planning, early warning system for floodplain, enhanced irrigation technologies and institutional reforms on integrated water resource management (UNDP, 2009 cited in Solar, 2009). Moreover, in order to mitigate

Figure 40: Level of vulnerability to flood by province (Cambodian Climate Change Office, 2005 cited in Ministry of Environment, 2006)



vulnerability to natural disasters in coastal areas, integrated coastal management as well as ecosystem-based approaches to fisheries have been carried out, including prevention of saltwater intrusion to drinking water sources while maintaining fish protein sources (GEF, 2009 cited in Solar, 2009).

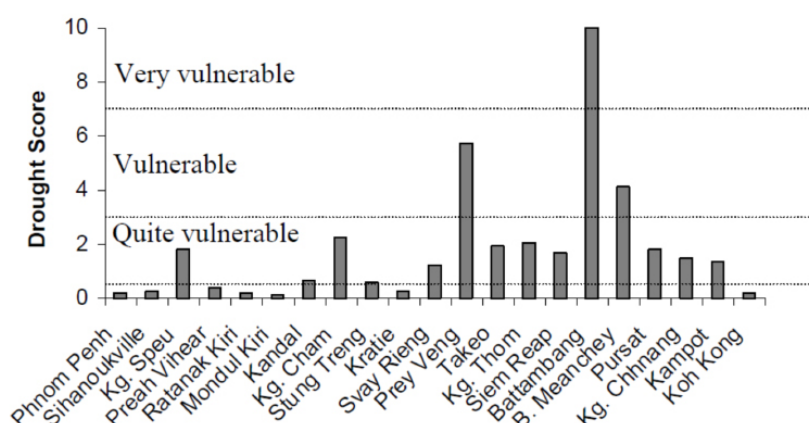
However, the case study on drought management in Cambodia done by Kyoto University presents that drought management preparedness and responses from government agencies does not seem to be well developed in the Svay Rieng province despite the regular occurrence of drought in the area (MRC, 2009d). Although planned options for adapting to drought such as digging wells and providing pumps and better crop seeds are planned by government and some NGOs, no substantial investments in

drought-mitigation programmes are found in the study area.

Indeed, many of above-mentioned adaptation measures are still in the stage of capacity development, including training of 'adaptation experts' among agricultural extension teams, pilot projects implementation in local communities, promotion of rainwater harvesting techniques, enhancement of measures to decrease soil erosion and preserve genetic diversity in rice agriculture, design modification of reservoirs and irrigation channels to prevent risks from increased peak flows, and dissemination of lessons learned to national and international levels (Solar, 2009). A key tool for this process of capacity development is a training manual developed by the International Center for Tropical Agriculture, the Stockholm Environment Institute

The latter activity, an assessment on climate change impacts on the water sector, has been implemented with a focus on the lower Mekong basin including Cambodia by TKK and SEA START RC (2009). Their field studies identify key issues related to adaptive capacity and suggest relevant adaptation strategies. Although local residents are well adapted to enormous seasonal variation of the Tônlé Sap's waters level and flow, their adaptive capacity towards unusual water regimes such as extensively high floods or sudden storms is relatively constrained. In particular, that of the poorest groups is highly limited, since their low living standards and asset-base already worsen their vulnerability to unexpected climatic conditions. Based on the study results, it is recommended to increase the general standard of living and the prerequisites to maintain a productive livelihood. For example, involvement in secondary and multiple livelihoods such as raising livestock and diversifying crop options have allowed them to increase their asset's base and, as a result, their resilience to possible climate changes (TKK and SEA START RC, 2009).

Figure 41: Level of vulnerability to drought by province
(Cambodian Climate Change Office, 2005 cited
in Ministry of Environment, 2006)



and the United Nations Institute For Training and Research that guides and enables trainers to strengthen the capacity of participants engaged in the UNFCCC process, particularly in the domain of vulnerability and adaptation. Moreover, capacity building for development of information systems is also promoted by the Department of Meteorology (DoM), in collaboration with the National Hydraulic Research Institute of Malaysia, with focused areas of data collection and observation related to weather and climate (Solar, 2009). The collaboration further has extended into active engagement in formulating pilot adaptation models that integrate local development processes, and also in joint assessment of climate change impacts on the water resources in the Mekong Delta and Tônlé Sap (MoWRAM, 2008 cited in Solar, 2009).

Gaps Identified in Programmes and Studies

Several gaps related to climate change and the water sector are identified at the workshop on "water and climate change in Cambodia" which was co-organised in Phnom Penh in February 2009 by Helsinki University of Technology, SEA START Regional Center and Royal

University of Phnom Penh. These include uncertainty on the existing estimates on climate change impacts as well as lack of understanding on the changing factors including non-environmental contexts that affect the Tônlé Sap flood pulse system in different timescales (TKK, SEA START RC and RUPP, 2009). These gaps are summarised as follow:

- Uncertainty related to the existing estimates on climate change impacts remains still high owing to complexity of climatic-water systems and the long-term perspective reflected in the estimates. Hence, it is necessary to compare the findings from different estimates and to consider these estimates as one possible projection. Of another importance is to view the long-term climate change separately from

natural variability of climate change. The estimates should not use average figure but rather reflect changes in extremes such as highest water levels, since the seasonal and inter-annual water regime in the Mekong floodplains and the Tônlé Sap highly varies.

- The Tônlé Sap flood pulse system is viewed critical for sustaining the high aquatic production of the lake, and now several different factors poses a risk on changing the dynamics of the system. Climate change is just one of these changing factors that affect the TônléSap, and there exist many other determinant factors including upstream hydropower development and local developments within the TônléSap Basin such as large-scale irrigation projects. This strongly indicates a need for more holistic approach where the impacts to the lake system at different temporal and spatial scales are assessed comprehensively.
- In considering the abovementioned changing factors on flood pulse system, it is also important to reflect on not only environmental, but also social economic, institutional and political factors that could cause environmental or ecological changes. Non-environmental factors are indeed likely to be much more crucial in both shorter and longer term. The different timescales of impacts from both climatic and non-climatic factors such as hydropower development are also essential for the impact assessment.

There is also lack of knowledge that supports an appropriate operational scheme such as real-time information about rainfall and water level, flood forecasts in the wet season (Watt, 2009 cited in Solar, 2009). Similarly, the drought management study of Kyoto University identifies the most significant deficiencies: the absence of reliable drought-forecasting mechanisms, the lack of a clear definition of drought, and the lack of a consistent response mechanism. It is suggested to map the existing capacities of communities and undertake a long-term capacity-building programme. It is also indicated that there is a need for inclusive policy-making process in which communities, governments and NGOs jointly make a policy for drought risk reduction. Community involvement is essential in designing and implementing drought adaptation practices at the local level.

In addition, as the study on the assessment of Mekong Basin water resource reveals, not much research and evaluation of the groundwater resources of the Mekong Basin have been conducted, including the volume, discharge/recharge rate and different use of groundwater and sources, distribution and impacts of groundwater contamination (Eastham et al., 2008). This causes difficulty in quantifying climate change effects on the water sector, leading to generation of water-borne diseases as well as unsustainable management of water demand and supply.

Agriculture and Food Security Sector

Range of Studies Reviewed and Methods Applied

Cambodia's agricultural sector is affected by climate change. The agricultural productivity, for example, heavily relies on the flooding and recession of the Tônlé Sap Lake and the Mekong River, which brings fertile alluviums to the central plains (Royal Government of Cambodia, 2006). This section demonstrates the positive impacts of climate change on the agricultural productivity, vulnerability of and potential threats to the agricultural sector, institutional responses to vulnerability (NAPA), and several key adaptation strategies implemented by the government and non-governmental organisations.

The potential impacts of climate change in the agricultural sector at the year 2030 were indicated under the most likely climate conditions for 2030 assessed based on the output of 11 GCMs (Eastham et al., 2008). The study on assessment of climate change impacts on crop yield was conducted by using the FAO's AquaCrop model (Roth, 2009).

Impacts on the Agriculture and Food Security Sector

Eastham et al. (2008) summarises potential impacts of climate change at the year 2030 on catchments of the Mekong Basin in Cambodia with spatial analysis of five regions: Se San (north-east), Kratie (central), Tônlé Sap (central), Phnom Penh (south-eastern) and Border (southern) (Roth, 2009). According to this study, the above-mentioned first three areas will experience increase in agricultural productivity and food availability in excess of demand decreased, although the minimum agricultural area in the Tônlé Sap may increase. Building on the work by Eastham et al. (2008), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Mekong River Commission (MRC) and the

International Water Management Institute (IWMI) are currently investigating impacts of climate change on crop yield at a finer spatial scale (Roth, 2009). The preliminary result shows that crop yields are predicted to increase than decrease in most of the areas. Furthermore, it would provide benefits to drier agricultural lands if precipitation during the wet season increases, especially along with reduction in frequency and duration of droughts within the season (Roth, 2009).

Vulnerability and Adaptation in the Agriculture and Food Security Sector

As much as climate change impacts can potentially offer opportunities, it also adds threats to the country's agricultural sector and food security, depending on characteristics of impacts, geographical areas and seasons. Paddy cultivation is mainly determined by flood and rainfall patterns. Increase in flooding in wetter areas may generate a risk of preventing rice cropping in low-lying areas if they are frequently flooded. In other words, the shortcoming of expanded irrigation and water harvesting schemes in Cambodia makes the agricultural sector vulnerable to the climate change effects. The followings are examples of current adaptation strategies practiced at the national and local levels as a response to their vulnerability, which can be categorised into four adaptation schemes: decentralisation of irrigation management to communities, adaption of agricultural practices to changing climatic condition, planning for disaster reduction, promotion of information exchanges.

Decentralization of irrigation management to communities

The RGC and IWMI have implemented a project to transfer operation and maintenance of small scale irrigation systems to communities through the creation of water user committees (IWMI, 2008). This project aims at increasing agricultural productivity and improving farmers' incomes through enabling farmers to take over the management of their irrigation systems. The IWMI has assisted in capacity building of the government to adopt and implement the participatory irrigation management and development in 11 pilot irrigation systems whereby water user committees has been formed and served various levels of functionality.

Adaption of agricultural practices to changing climatic condition

The Cambodian Center for Study and Development in Agriculture (CEDAC) has experimented

methodologies on growing vegetables all year around that reflect changing environments of wind, rain and water logging. CEDAC has also introduced the System of Rice Intensification (SRI), which is a method of rice farming that focuses on organic farming practices, such as use of composting under tilling rice husk and seed selection (Solar, 2009). Similar to the concept of small-scale organic farming, is another initiative of the SRI that features the transplant young seedlings singly and widely spaced. International Federation of Agricultural Producers (IFAP) has encouraged farmers to apply SRI that is managed in the processes of a) drainage of rice paddies, b) watering the seedlings by hand if there is no rain to keep the soil moist, c) minimum irrigation; and d) early weeding (IFAP, 2009). It is reported that one of the main drivers for farmers to adopt the SRI is that the yield is higher than the one from the traditional practice and that the SRI requires less seeds. The Development Partnership in Action (DPA) has assisted communities in adaptation of rice with a more resilient trait (Van Aalst, M. K., T. Cannon, and I. Burton, 2008 cited in Solar, 2009).

At the household and individual level, the following adaptation measures have been observed: building of elevated enclosure for livestock, increasing household food stock as well as feedstock for animals, shifting crop planting dates and switching to flood-resistant crop varieties (Royal Government of Cambodia, 2005 cited in Resurreccion et al., 2008).

Planning for disaster reduction

The DPA has encouraged communities to develop a plan to reduce vulnerability to sudden disasters such as crop loss (Van Aalst, M. K., T. Cannon, and I. Burton, 2008 cited in Solar, 2009). This risk management oriented adaptation seems to have been already practiced at the local scale. The study conducted by Resurreccion et al. (2008) indicates that the rain-fed rice farmers in Kandal province respond to increasingly unpredictable rainfall through dividing their rice plots into two- one half for employing conventional wet-paddy rice techniques that are resistant to heavy precipitation and the other half for adopting a system of rice intensification, which is a cultivation technique resistant to drought.

Promotion of information exchanges

The CEDAC has facilitated farmers to participate in climate change adaptation networks and national-level forums so that farmers gain information generated at the national and global levels. The National Fund for Farmer Research and Farmer to Farmer Extension is one example of information exchange venue to involve the farmer in local

research activities organised at the national level (Solar, 2009).

Institutional responses

Approximately 38% of all the adaptation activities proposed in the NAPA are related to the agricultural sector, focusing on enhancement of household-level integrated farming to improve farmers' income and food security, development of rice intensification system to reduce vulnerability to rainfall variability, and the development and improvement of community-level irrigation systems to mitigate the effects of drought, specifically in the Tónlé Sap and along the major Mekong floodplains (Roth, 2009, Solar, 2009). Rehabilitation of coastal infrastructure is also promoted to increase agricultural production and mitigate erosion in coastal zones.

Gaps Identified in Programmes and Studies Research Gaps

There has not been much research focused on farm level adaptation in Cambodia, which reflects the generally weak research capacity (Roth, 2009). However, there is a potential research linkage between the Cambodian Agriculture Research Institute and other institutes, e.g. International Rice Research Institute (IRRI), which promotes genetically modified rice varieties with tolerance to climate variability. The breeding of rice varieties that are highly tolerant to submergence and drought is suggested as potential significant contribution to predominantly practiced rice-based cropping systems in Cambodia.

Meanwhile, it is said that the research processes, including the consultation through operationalisation of research results, does not often entail community farmers. For example, when analysing research data and utilising research findings, common local language or code of standard, which is not necessarily a skill required for reading, is not reflected in relevant materials or considered among agricultural researchers. Hence this builds a barrier against data sharing with local users (Solar, 2009).

Enhanced knowledge bases for decision-making support are missing. This includes 1) improved monitoring, 2) enhanced groundwater mapping and compilation of existing knowledge on groundwater availability and quality, 3) improved availability and accessibility of data for decision-making, and 4) a system for enhancing and expanding management capacity at the province and commune levels as well as at the irrigation scheme level (Watt, 2009 cited in Solar, 2009). This knowledge base would be useful

for irrigation operation that can be maintained and owned by the government and water user groups collaboratively.

Governance Gaps

It has been required to establish a comprehensive institutional mechanism to strengthen the adaptive capacities of small scale producers, including the instruments for tenure security, equitable access to productive assets and infrastructure, a means to enhance accessibility and usability of scientific information on climate patterns at the local level. In order to accomplish this mechanism, the grey areas that are not well understood need to be addressed: for example, how livelihood security of small-scale farmers may be degraded by what kind of adaptation responses and other social and environmental stressors; and which factors and conditions undermine the voices of small producers to be underrepresented and excluded in the national and intermediate-level planning for climate change adaptation (Personal Communications, MAFF-Fisheries Administration cited in Solar, 2009).

It is pointed out that much of rehabilitation work for improved irrigation system financed by RGC and donor usually focuses on rehabilitating dams and reservoirs, head works and the main and secondary channels, but not on the tertiary distribution system that should be connected to these main channels (Roth, 2009). Together with this gap, technical aspects of rehabilitation work need to be addressed, including the design of irrigation structures, lack of drainage management and integrated drainage systems, effective delivery systems to end-users, matching irrigation schedules to crop demands for Cambodian soil and climate conditions (ibid).

Capacity Gaps

Water user groups have the limited capacity to operate the irrigation system since they do not have a strong tradition of irrigation or their social relationships have been weakened due to incidents during the Khmer Rouge period (Roth, 2009).

Recent Projects in the Agriculture and Food Sector

To follow up on the NAPA, one project called "Promoting Climate Resilient Water Management and Agricultural Practices in Rural Cambodia", which relates to both agricultural and water sector, has been facilitated by UNDP and GEF (Roth, 2009). Built on the NAPA, this project focuses on institutional capacity building, demonstration of integrated water resource management and consolidation of best

practice crop management to enable farmers to adapt to climate change. The initial geographical focus of the project is placed on Siem Reap and Battambang provinces with potential expansion to Kratie, Preah Vihear and Ratanakiri provinces, in which the project is planned to link with similar projects designed by International Fund for Agricultural Development (IFAD) (Roth, 2009).

Other donor projects relevant to climate change adaptation in the agricultural sector are briefly presented as follow:

The International Development Enterprises (IDE), an international NGO, has carried out the two-year project on micro-financing for the provision of agricultural extension services with support from the Canadian International Development Agency (CIDA), the World Bank (WB) and the Department for International Development (DFID) of the United Kingdom (Roth, 2009). The IDE provides 35 Farm Business Advisors (FBAs), of whom approximately 7 are women, with training on crop production, harvesting and marketing. The FBAs, after trained as village-based entrepreneurs, offer farmers a service embedded with provision of technical information such as improved seeds, irrigation equipments, fertilisers and pesticides as well as marketing schemes (Roth, 2009).

The programmes of the Australian Government's overseas aid program (AusAID) are rather focused on small-scale poor farmers. The programme recently launched aims to promote practical benefits in the agricultural sector including improved food security, increased income and reduction of the vulnerability of marginalised rice-farmers (Roth, 2009). This programme will be implemented through the window of market-oriented agribusiness development and product diversification along the value chains of the rice, vegetable and fruit. Its geographical targets will be focused on Kampong Thom, Takeo and Kampot provinces.

The AusAID's another five-year programme is a collaborative initiative with World Bank to assist RGC in responding to the recent food price crisis and the economic crisis. The project is composed of piloting cash for work for poor farmers in the most vulnerable provinces and conducting studies for seeking alternative livelihoods for migrants. The AusAID contributes about US\$ 2.5 millions in technical assistance over two years, while WB provides US\$ 13 million financial support to the government.

The Australian Centre for International Agricultural Research (ACIAR) has carried out a research program to assist climate change adaptation at the farm scale; capacity building for more efficient use of soil and water resources in Takeo, Kampot and Kampong Thom provinces (ACIAR, 2009 cited in Solar, 2009). CEDAC is also engaged in farm-level research on small farm holdings. Their research is embodied with carbon storage capacities between traditional methods of rice farming and SRI approach to rice farming. (Personal communication, CEDAC cited in Solar, 2009).

In 2010, Oxfam America will conduct a similar study on understanding the relationship between SRI and its potential for climate change adaptation and mitigation. Additional research projects are to be implemented with a focus on participatory action for micro-savings that assists groups vulnerable to climate change (Personal communication, Oxfam America cited in Solar, 2009).

The WB has launched a US\$ 50 million climate change fund for supporting activities that are in line with RGC's strategic priorities. The WB is currently processing the designing of the pilot programmes that focus on a) agricultural productivity development in poor provinces, especially in the Viet Nam border provinces in the North-East; and b) agriculture and water resource development and rural infrastructure for enhancing climate resilience.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

Little is mentioned about socio-economic aspects of climate change effects in the existing studies on the water and agricultural sectors in Cambodia. In this report, briefly presented are causality between climate change and rice production loss, analysed based on data from 1996 to 2001 (ICEM, 2009) as well as food supply affected from changes in the water flow and level of the Tônlé Sap Lake (Bonheur and Lamberts, 2007 cited in Resurreccion et al., 2008). In addition, the Oxfam's adaptation strategies that focus on vulnerable groups are indicated.

Impacts on Socio-Economic Sector

The agricultural sector is essential for Cambodia's socio-economic development, serving as an income source for approximately 80% of the population

and contributing 29% of the GDP in 2007 (IFAP, 2009). Being an agrarian country, however, the country is economically and socially vulnerable to climate change impacts. As the rain-fed lowland rice production amount to more than 80% of the total rice field, the country is highly affected by flooding, drought, and pest and disease. With an increase in frequency and intensity of floods in lowland areas, farmers are exposed to higher risks of production loss. According to the past 5 years data, approximately 70 %, 20 % and 10 % of rice production loss resulted from the occurrence of floods, drought and others such as pest and disease, respectively (ICEM, 2009). Furthermore, variability in the water flow and level of the Tônlé Sap Lake caused from temperature rise and resulting long dry spells in summers affect the livelihoods of poor populations who subsist from fishing at the Tônlé Sap Lake- the largest freshwater body in Southeast Asia (Bonheur and Lamberts, 2007 cited in Resurreccion et al., 2008). When summers get hotter, the water level of the Tônlé Sap Lake is projected to drop and impede the flood pulse and fish migration, thus, threatening 60% of Cambodia's food supply for at least one million fisher men and farmers dependent on the lake.

Vulnerability and Adaptation in Socio-Economic Sector

The adaptation strategies suggested by Oxfam are centred on the needs of vulnerable groups, especially women. These include (Solar, 2009):

- Provide cash/food vouchers for women to secure immediate needs;
- Assist small-scale female farmers, food vendors, informal workers, pregnant and nursing mothers;
- Increase women's land tenure security;
- Improve women's access to and control of credit, agricultural inputs, storage facilities and technologies; and
- Strengthen women's organizations and leadership that enable women to participate in planning adaptation strategies.

Gaps Identified in Programmes and Studies

There are significant gaps in understanding of autonomous adaptation practices at the individual and household levels, and of underlying socio-economic systems, based on which adaptive capacity are built to carry out adaptation activities (Resurreccion et al., 2008 cited in Solar, 2009). According to the NGO sector, labour mobility, remittances and out-migration can be considered

as autonomous adaptation strategies and need to be researched for further details (Solar, 2009). The identified research areas are as follow:

- Current and future roles of migration and remittances as adaptation strategies;
- Opportunities to strengthen supporting systems such as transport, banking for financial remittances, as well as informal trans-local and transnational social networks that may promote access to opportunities; and
- Assets required for enabling migration, especially the vulnerable groups, who may lack or need financial capital, skills, knowledge and capacities, actions and policies to support them.

On the other hand, it is difficult to research on social networks and informal institutions from which adaptive measures can be facilitated, including social equity, fairness and gender equality issues in the adaptation context (solar, 2009).

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Two different domains could be identified that may play a role on cross-sectoral institutional responses to climate change adaptation: one is climate change oriented institutional setting and the other is institution engaged in climate change issues from a disaster risk reduction perspective.

Climate Change

The Royal Government of Cambodia (RGC) has recognized the climate change issues and made efforts to engage with the global agenda. Cambodia ratified the UNFCCC in 1995 and acceded to the Kyoto Protocol in 2002. Since then, several national-level coordination bodies have been created to facilitate the process of climate change adaptation in Cambodia by initiating relevant activities in line with international and national climate change agenda.

National Coordination Bodies facilitating climate change adaptation *Cambodian Climate change Office (CCCO)*

In 2003, the Cambodian Climate Change Office (CCCO) was established under the Ministry of Environment (MoE), which serves as the national focal point for the Kyoto Protocol (Navann, 2009), and the Department of Planning and Legal Affairs of MoE manages the CCCO's technical body (MoE, 2003 cited in Solar, 2009). The CCCO implements all the technical activities related to UNFCCC and other

international environmental conventions, facilitates donor-funded and private sector-oriented activities related to climate change, and organizes inter-ministerial technical working groups formulated based on both specific sectors, such as energy and forestry, and various themes on climate change, such as mitigation, vulnerability and adaptation and the Clean Development Mechanism (CDM) (Solar, 2009). The CCCO's main responsibilities are summarized, as follows:

- To implement the UNFCCC and other climate change-related tasks;
- To provide information and advice to the Government on negotiation positions, establishment of national climate change policies, plans and legal instrument;
- To identify and assess new technologies appropriate for Cambodia to adapt to climate change or to mitigate GHG emissions; and
- To promote research activities and human capacity building and develop new climate change-related project proposals

Designated National Authority for the Clean Development Mechanism

In the same year as the CCCO was created, the MoE was appointed by the RGC as the Designated National Authority (DNA) for the Clean Development Mechanism whose secretariat was placed under the CCCO (Solar, 2009). The DNA's main responsibilities are summarized, as follows (Ponlok, 2005):

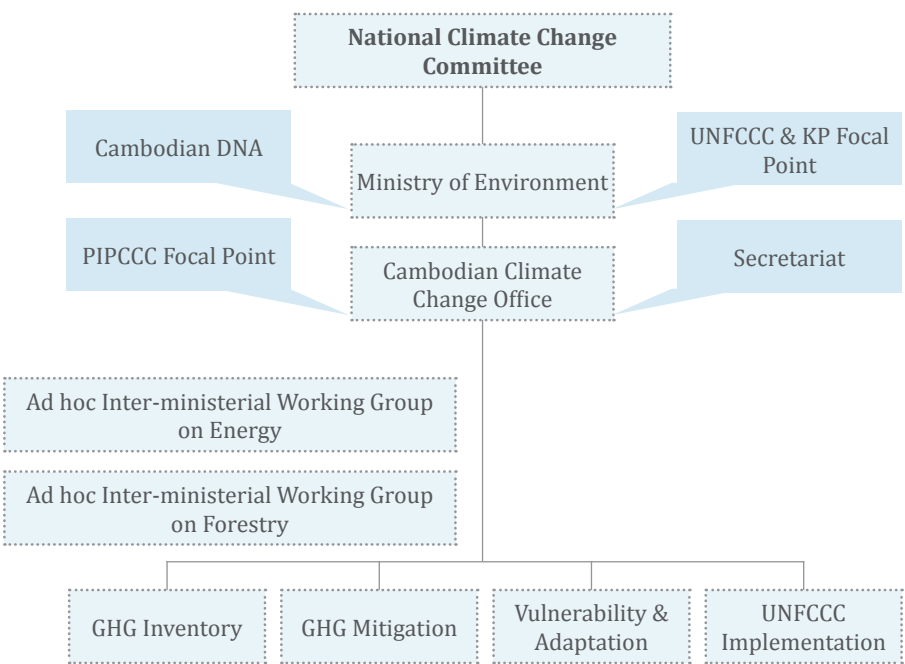
- Develop sustainable development criteria to assess the proposed CDM projects
- Be responsible for establishing the permanent DNA in cooperation with concerned Government Ministries and Agencies and other stakeholders

National Climate Change Committee

The National Climate Change Committee (NCCC) was formulated in 2006 by a Ministerial sub-decree. It is composed of representatives from 19 concerned Government ministries and agencies. It serves as a policy-making body to coordinate the development, implementation and monitoring of policies, plans, strategies and programmes of the RGC to address climate change issues within the country. The NCCC's main responsibilities are summarized as follows, (Mony, K. and C. Thou, 2007 cited in Solar, 2009):

- Develop draft climate change policies, programmes and legal instruments, including climate change adaptation plans, for submission to the Royal Government for approval;
- Promote and encourage broad participation of all stakeholders in the development and the effective implementation of climate change policies, programmes and legal instruments to ensure their linkage with the national development objectives and priorities;

Figure 42: Organisational Structure of National Coordination Bodies facilitating climate change adaptation (Navann, 2009)



- Enhance the integration of climate change concerns into relevant policies and strategies;
- Mobilize resources, in particular grants, for the implementation of these climate change policies, programmes and legal instruments;
- Promote the transfer of appropriate technologies and conservation;
- Coordinate activities concerning the implementation of the UNFCCC and other climate change international agreements;
- Promote education, awareness raising, training and information dissemination on climate change for the general public;
- Coordinate and oversee the implementation of climate change projects; and
- Promote international cooperation in the field of climate change

The above-mentioned three coordination bodies are linked in the following structure:

Action Plans and Programmes supporting Climate Change Adaptation

National Adaptation Program of Action strategic plan

The development of the National Adaptation Program of Action (NAPA) for Cambodia was led by the Climate Change Project Committee of MoE as the Executing Agency responsible for project planning, overall management and outputs delivery (Ministry of Environment, 2006, Resurreccion et al., 2008). The NAPA was endorsed by the RGC in 2006. The main objectives of the NAPA are 1) to understand the main characteristics of climate hazards in Cambodia (flood, drought, windstorm, high tide, salt water intrusion and malaria); (2) to understand coping mechanisms to climate hazards and climate change at the grassroots level; (3) to understand existing programmes and institutional arrangements for addressing climate hazards and climate change; (4) to identify and prioritise adaptation activities to climate hazards and climate change" (Ministry of Environment, 2006). The NAPA is divided into three categories: (1) capacity building/training (2) awareness raising/education; and (3) infrastructure development, and it consists of 39 priority activities including 20 projects for the water resources and agriculture sectors (ibid). Among these activities, 20 projects are identified as high priority, of which 9 are related to water resources and agriculture sector, 5 are coastal zone sector, 4 are health sector and 2 are cross-sectoral projects. Listed here the high prioritised projects in the agriculture, water resources and coastal zone sectors:

Agriculture and Water Resources

- Rehabilitation of a multiple-use reservoir in Takeo province
- Rehabilitation of multiple-use dams in Takeo and Kampong Speu provinces
- Development and rehabilitation of flood protection dikes
- Rehabilitation of upper Mekong and provincial waterways
- Water gates and water culverts construction
- Safer water supply for rural communities
- Development and improvement of small-scale aquaculture ponds
- Promotion of household integrated farming
- Development and improvement of community irrigation systems

Coastal Zone

- Community and household water supply in coastal provinces
- Rehabilitation of multiple-use canals in Banteay Meas district, Kampot province
- Rehabilitation of coastal protection infrastructure
- Community mangrove restoration and sustainable use of natural resources
- Community based agricultural soil conservation in Srae Ambel district, Koh Kong province

Medium Term Strategy for Agriculture and Water 2006-2010

In the same year as the NAPA being endorsed, the National Strategic Development Plan 2006-2010 (NSDP) was approved by the RGC. With its priority on poverty alleviation and economic growth, the NSDP particularly emphasised on enhancement of the agriculture sector and placed the formulation of the agriculture and water resources strategy as the first priority strategy of the NSDP (Royal Government of Cambodia, 2007). To fulfil this requirement, the Medium Term Strategy for Agriculture and Water 2006-2010 was established jointly by donors and members of the Technical Working Group- Agriculture and Water and approved by two Ministries, Ministry of Agriculture, Forestry and Fisheries and Ministry of Water Resources and Meteorology in 2007 (Solar, 2009). Under the eight key components of the strategy, climate change issues were addressed in the component of "mobilise natural resource water, land soils" as a basic strategy for enhancement of the agriculture sector, including assessment of climate change and potential of surface and ground water for crop yields forecasting and seasonal planning for agricultural production (Royal Government of Cambodia, 2007).

Gaps Identified

Integration of climate change issues into national policies and programmes as well as awareness of the climate change issues are limited (ICEM, 2009). In particular, Climate change adaptation has not been a key platform to decide on priority initiatives for the sectors except the agricultural and water resources (Solar, 2009). The approaches toward the disaster risk reduction, such as the Strategic National Action Plan for Disaster Risk Reduction, would be an appropriate entry point for certain actors to assess, negotiate and prioritise initiatives, leading to the integration of climate change adaptation issues across sectors.

There are technical gaps on data management among national bodies. Quality climate data are not available in Cambodia in general and the CCCO, in particular, so there is little scope to generate improved climate change scenarios and projections (Solar, 2009). For example, some data that have been collected by Department of Meteorology (DoM) since 1980s are not digitised, and hence, it cannot be utilised for the development of the Second National Communication nor the DoM can enhance their observation capacities to conduct better projections for climate modelling and early warning.

The challenges continue to remain even after quality data becomes available: rendering the system of climate modelling more applicable and user-friendly by integrating hydrological features required by the Ministry of Water Resources and Meteorology (MoWRAM) and the Ministry of Agriculture, Forests, and Fisheries (MAFF) and also through transferring knowledge and system to the ground level to help farmers adjust their initiative in accordance to climate events (Solar, 2009). In order to tackle this challenge, it has been suggested that the NCCC establish a detailed integrated process of data gathering and analysis as well as dissemination of data to concerned groups. The process needs to be flexible and robust to be incorporated into a system for cross-sector planning and budgeting, or, an integrated system for development planning (Personal Communication, UNDP cited in Solar, 2009).

Recent Project

Responding to the gaps on data restoring and utilisation, Danida, in collaboration with Asian Disaster Preparedness Centre (ADPC), has been supporting improvement of the DoM's manual observation capacities for climate data management, forecasting and automated weather stations (Danida, 2008 cited in Solar, 2009).

The MoE, in collaboration with the UNDP Cambodia and the Council for the Development of Cambodia, has started the project called "Enabling Activities for the Preparation of the Kingdom of Cambodia's Second National Communication to the UNFCCC" (UNDP, 2008). The project aims to assist the RGC in preparing for its Second National Communication to the UNFCCC (SNC) and also to enhance the technical and institutional capacity of the RGC in mainstreaming climate change issues, including adaptation to climate change, into the sectoral and national development planning priorities. The main activities are built on the country's earlier work related to climate change issues, including its First National Communication to the UNFCCC, the NAPA and the National Capacity Self-Assessment. The SNC targets the sectors with the highest Green House Gas emissions such as energy and agriculture as well as the sectors vulnerable to climate change that are identified in the NAPA such as agriculture and water resources (UNDP, 2008).

The Royal University of Phnom Penh (RUPP) is currently implementing a research that focuses on mainstreaming climate change adaptation at the operational level within relevant ministries (Solar, 2009).

Institutional Settings Concerning Disaster Risk Reduction

Apart from the climate change issues, cross-sectoral institutional arrangements are initiated in view of disaster risk reduction. The Country's National Poverty Reduction Strategy (NPRS) recognises natural disasters, specifically floods and droughts, as crucial factors that increase socio-economic vulnerabilities of the rural poor, especially women (Solar, 2009). In this context, national coordination mechanisms as well as national strategy are demonstrated in this section.

National Coordination Bodies facilitating Disaster Risk Reduction

Responding to the natural disaster events and hazards, particularly those of flood and drought, the national-wide coordination mechanism has been enacted since 1990s and has incorporated the disaster management at the provincial, district and commune level. The institutional structure of Cambodia's disaster management coordination agencies is illustrated in Figure 43. The National Committee for Disaster Management (NCDM) is the national institution that is responsible for preventive

as well as ad-hoc actions related to disaster management, including development of measures to mitigate the loss of life and property and provision of emergency relief after disaster (Solar, 2009). The NCDM was established in 1995 as an inter-ministerial agency, consisting of members from line ministries and the armed forces. Since then, provincial and district level committees for disaster management have been formed. In 2006, a decree establishing Commune Committees for Disaster Management (CCDMs) was issued by the RGC with an aim to strengthen the institutional capacities to cope with disaster risks at the local level. The CCDMs' key responsibilities are summarised as follows (Solar, 2009):

- Manage data of disaster risk and report on disaster situations;
- Propose the level of resource reserves for disaster interventions and emergency responses;
- Provide capacity building and human resource development on disaster management;
- Coordination in implementation of disaster management policies;
- Exchange and sharing of information; and
- Coordination and mobilization of resources for disaster responses

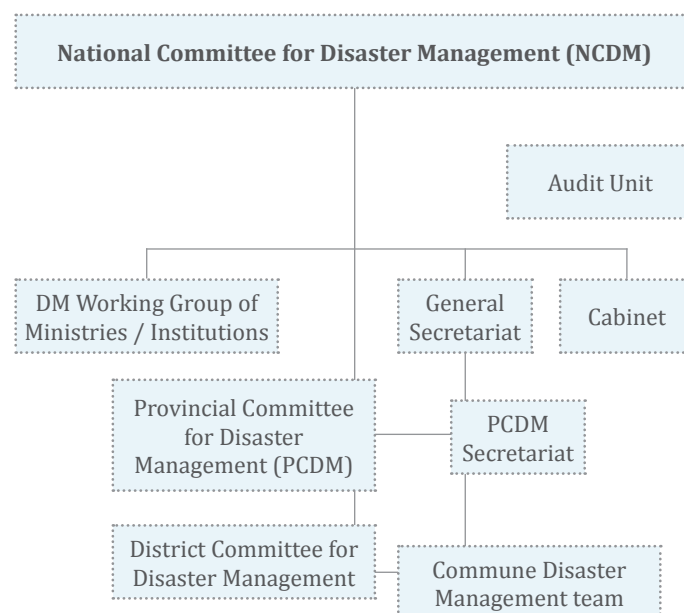
Action Plans and programmes supporting Disaster Risk Reduction

Strategic National Action Plan 2008-2013 for Disaster Risk Reduction

In 2009, the RGC introduced the Strategic National Action Plan 2008-2013 for Disaster Risk Reduction (SNAP-DRR) with disaster risk reduction integrated into sector policies and investment planning of key ministries such as the Ministry of Land Management, Urban Planning, and Construction (MoLMUP), the Ministry of Water Resources, the Ministry of Forestry and Fisheries, the Ministry of Rural Development and the Ministry of Health (Solar, 2009). The following are the key elements of SNAP-DRR (Danida, 2008 cited in Solar, 2009).

- Contribute to a common understanding, knowledge and awareness of disaster risk reduction;
- Provide a comprehensive framework to guide and monitor the implementation of disaster risk reduction initiatives;

Figure 43: Organisational structure of disaster management in Cambodia



- Mainstream disaster risk reduction into development plans, policies and projects;
- Enhance coordination and cooperation between disaster management stakeholders; and
- Improve the efficiency of resource allocation and utilization in disaster reduction.

Gaps Identified

The disaster risk reduction issues have not been integrated properly in the guidelines and building codes for school building construction of the Ministry of Education Youth and Sports (MoEYS) (Solar, 2009). As a result, the schools recently constructed under the World Bank and ADB funds are not embedded with schemes to mitigate disaster risks. Importantly, these guidelines should be generated by the MoULUPC in consultation with the Ministry of Public Works and Transport. With relation to this shortcoming of institutional arrangement, the guidelines for emergency planning as well as disaster risk reduction education needs to be formulated at all levels of educational systems and communities, through a consultation with the Cambodian Red Cross. It is highlighted not just to focus on those schools and communities that have suffered from disasters or investigated as high risk areas but must be all inclusive. The suggested entry point for this is to involve the community managing the health and nutrition sector (Solar, 2009).

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS

AND CHALLENGES

The projected exposure to climate change impacts seems relatively less severe in Cambodia than that of other countries (Roth, 2009). However, taking into consideration, vulnerability to climate change as a result of not only exposure but also adaptive capacity, the country still remains highly vulnerable with its relatively lower level of adaptive capacity (Yusuf and Francisco, 2009 cited in Roth, 2009).

Water Sector

There is lack of knowledge that supports an appropriate operational scheme such as real-time information about rainfall and water level, flood forecasts in the wet season (Watt, 2009 cited in Solar, 2009). On the other hand, there is still an issue of uncertainty related to the existing projections of climate change impacts, which demonstrates different information on climatic variability for different timescales (TKK, SEA START RC and RUPP, 2009). Due to strong seasonal and inter-annual variation of the water regime in the Mekong floodplains and the Tônlé Sap Lake, it is indicated as more important to reflect on changes in extremes, for example, of highest water levels, rather than expected average figure. Moreover, there is a need for more holistic approach to climate change impacts and adaptation that integrates broader socio-economic, institutional and political contexts and different temporal and geographic scales (ibid). It is estimated, for example, that relatively radical changes to the Tônlé Sap flood pulse system are predicted to occur in more immediate timescale due to upstream hydropower development rather than climate change.

In addition, not much research and evaluation of the groundwater resources of the Mekong Basin have been conducted including the volume, discharge/recharge rate and different use of groundwater and sources, distribution and impacts of groundwater contamination (Eastham et al., 2008). In order to assess impacts of the current and projected climate change conditions on the groundwater resources in various countries of the Mekong River region, it is required to develop regional models of the groundwater systems that allow quantification of the groundwater resources (ibid). This entails the detailed hydrogeological and geophysical investigations of the aquifer systems in various countries and regions of the Mekong Basin as well as the groundwater monitoring network.

Agriculture and Food Security Sector

The strategies to intensify and/or sustain agricultural productivity in Cambodia are often suggested as an adaptation measure. However, the strategies are not being driven by climatic impacts, but to a greater extent by the inflow of foreign investment for the purpose of extracting land concessions for large-scale agricultural enterprises (Roth, 2009). The increasing demand for agricultural products from neighbouring countries, such as, Thailand and Viet Nam are also a determinant factor of the changes in agricultural practices. These drivers could serve as an opportunity, if aligned with climate change adaptation needs, and could prove to be an effective mechanism, if adapted. This would require a policy research that provides recommendations on how best to mainstream the climate adaptation agenda into the broader development policies of Cambodia (Roth, 2009).

Institutional Settings concerning Climate Change

Integration of climate change adaptation issues into national policies and programmes as well as awareness of the climate change issues are limited to agricultural and water resources sector (Solar, 2009). The approaches toward the disaster risk reduction would be an appropriate entry point for certain actors to assess, negotiate and prioritise initiatives, leading to integration of climate change adaptation issues across all the sectors.

There are technical gaps on data management among national bodies. Quality climate data that have been collected, for example, by Department of Meteorology (DoM) are not digitised, and hence, CCCO cannot utilise them for the development of the Second National Communication or the DoM cannot enhance their observation capacities to conduct better climate change projections (Solar, 2009).

There remains a challenge on applications of climate modelling. For example, the system of climate modelling is not applicable and user-friendly, and not integrating hydrological features required by the Ministry of Water Resources and Meteorology (MoWRAM) and the Ministry of Agriculture, Forests, and Fisheries (MAFF). Also, knowledge and system of climate modelling are not brought to the ground level, and hence, farmers cannot adjust their initiative in accordance to climate events (Solar, 2009). In order to address this challenge, it is suggested that the NCCC establish a detailed integrated process of data gathering and analysis as well as dissemination of data to concerned groups and incorporate the

process into a system for cross-sector planning and budgeting, or, an integrated system for development planning (Personal Communication, UNDP cited in Solar, 2009).

Disaster Risk Management

The disaster risk reduction issues have not been integrated properly in the guidelines and building codes for school building construction of the Ministry of Education Youth and Sports, not embedded with schemes to mitigate disaster risks (MoEYS) (Solar, 2009). It is also pointed out that these guidelines should be generated by the MoULUPC in consultation with the Ministry of Public Works and Transport. In addition to the building codes, the guidelines for emergency planning as well as disaster risk reduction education need to be formulated at all levels of educational systems and communities, through a consultation with the Cambodian Red Cross. The entry point suggested for this is to involve the community managed health and nutrition sector (Solar, 2009).

Cross-cutting Issues

Mentioned here are gaps examined in the study of Mekong River Commission's report on climate change adaptation in the lower Mekong basin countries (ICEM, 2009). These gaps are not exclusive of the agriculture and water resource sectors that this report focuses on, but the overall climate change scenario. Nonetheless, it is worth indicating the generic gaps.

Low capacity of the general public to adapt climate change: A large section of the community relies on agriculture for sustaining their livelihoods and may have an understanding of climate events such as floods and droughts. However, the causes and projected impacts of climate change on their livelihoods are not well recognised. There is a knowledge gap in climate change adaptation practises, leading to low capacity of villagers to prepare for and adapt to climate extremes.

Lack of technical knowledge of climate change among line ministries and NGOs: The Ministry of Environment's Climate Change Office and a few environmental organisations have gained technical knowledge of climate change, while other line ministries and many development NGOs with only a basic understanding of climate change science still have limited understanding on climate change

impacts on Cambodia as well as the available adaptation technologies.

No integration of climate change issues into development agenda: With the exception of the NAPA, climate change issues have not been fully included into the national development agenda. Due to lack of technical knowledge, policy-makers are not able to mainstream climate change issues into national development planning.

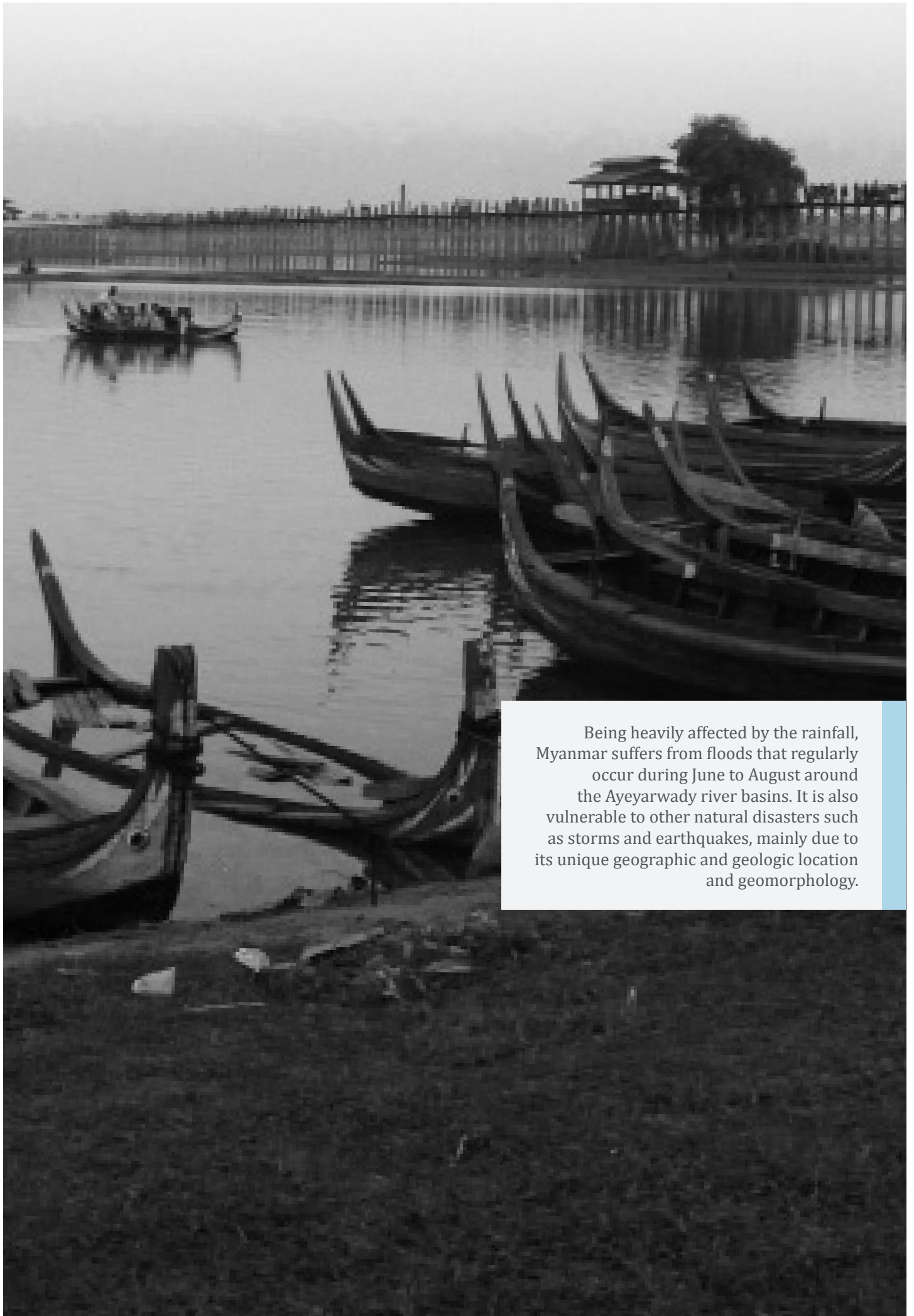
Non-availability of climate change related documents translated into Khmer language: Except for only a few relevant documents such as the NAPA and the Initial National Communication, there are not many international documents or technical terminologies that are translated into their own language.

Shortcoming of analytical studies on climate change impacts: There is an absence of relevant information on predicted outcomes and the potential impacts of climate change in sectors such as agriculture, water resources, fisheries and rural development that could be utilised for developing targeted policy responses. There is a need to dramatically improve national meteorological observation and forecasting capacities to enhance climate models and early warning systems.

Progress in implementation of NAPA: Up to date, only one project has been implemented among the 39 adaptation programmes that are ranked high by NAPA. The RGC has failed to attract donor interest in financing other adaptation activities.

Furthermore, TKK, SEA START RC and RUPP (2009) highlights coordination and information sharing as the main knowledge and action gaps on climate change adaptation in Cambodia, finding it particularly critical to bring different adaptation initiatives together as well as to avoid unnecessary duplication and repetition. One suggestion was to establish a Cambodian climate change adaptation platform or forum that would bring all the different stakeholders and provide a space for sharing activities as well as for recognising future research and policy needs.

COUNTRY CHARACTERISTICS



Being heavily affected by the rainfall, Myanmar suffers from floods that regularly occur during June to August around the Ayeyarwady river basins. It is also vulnerable to other natural disasters such as storms and earthquakes, mainly due to its unique geographic and geologic location and geomorphology.

RESEARCH SYNTHESIS ON UNION OF MYANMAR

In this section, country characteristics of Union of Myanmar are reviewed, including geographic attributes and social, economic and climatic conditions. An overview table on the country's characteristics is given in Table 14.

Geographic Attributes

The Union of Myanmar is the largest country in mainland Southeast Asia with a total area of 676,578 sq. km². Of the total land area, approximately 50% are covered with forest. It borders India and Bangladesh in the west, China in the north and north east, and Lao PDR and Thailand in the east and southeast while it is faced with the Bay of Bengal and the Andaman Sea in the west and the south (see Figure 44).

Figure 44: Location map of Union of Myanmar (UNdata, 2010)



Socio-Economic Status

The projected population of Myanmar is 48 million in 2007, of which approximately 80 percent resided in rural areas and about 32% earned their life below poverty line (UNdata, 2009, CIA, 2009). The population growth rate of 2005-2010 is estimated to be 0.9 % per annum. The population density ranges from 595 persons per km² in Yangon Division to 14 per km² in Chin State (ADPC, 2009). 80% of the rural and urban population respectively had access to improved drinking water sources in 2006 (WHO and UNICEF, 2006).

Figure 45: Countries most affected from extreme weather events 1990-2008 (Source: Germanwatch and Munich Re NatCatSERVICE® cited in Harmeling, 2009)

1.	Bangladesh
2.	Myanmar
3.	Honduras
4.	Viet Nam
5.	Nicaragua
6.	Haiti
7.	India
8.	Dominican Republic
9.	Philippines
10.	China

Regarding the economic activity, the total Gross Domestic Product (GDP) of Myanmar amounted to US\$ 18,510 million in 2007, of which 40.9 % were provided through the agricultural sector, 19.8% through the industrial sector, and 34.2% through the service sector (CIA, 2009). The GDP growth drastically fallen from 2.5% in 2007 to only 0.1 % in 2008 mainly as a consequence of the sever tropical cyclone Nargis striking the country.

Climate Risks

The climate profile of Myanmar including current and projected climate conditions are briefly explained as background information for addressing vulnerability and adaptation issues.

Current Climatic Conditions

Union of Myanmar has a characteristic of tropical climate with the rainy, winter and summer seasons. The rainy season starts with the southwest monsoon in mid-May, lasting till mid-October and followed by the winter season from mid-October to mid-February. Afterwards, the summer season continues till mid-May (ADPC, 2009). The average annual rainfall ranges from 4,000 to 5,600 mm in the coastal regions, while that of the Ayeyarwady Delta is approximately 3,300 mm (ibid). The central dry area, covering about 10% of the country's total area, receives the rainfall between 600 and 1400 mm. The average temperature of the delta ranges from 22°C to 32°C, while it does between 20°C to 34°C in the central zone. According to the IPCC Fourth Assessment Report, increase in hot days and warm nights and decrease in cold days and nights were observed between 1961 and 1998 in South-East Asia (Manton et al., 2001, Cruz et al., 2006, Tran et al., 2005 cited in Parry et al., 2007).

The natural disasters in the Union of Myanmar from the period of 1900 through 2010 are summarised in the Table 15, including the type of natural disasters, the total number of incidents and people affected, and economical damages generated by each incident. Being heavily affected by the rainfall, the country suffers from floods that regularly occur during June to August around the Ayeyarwady river basins. It is also vulnerable to other natural disasters such as storms and earthquakes, mainly due to its unique geographic and geologic location and geomorphology. Particularly with its long coastal line of about 1,930 km spreading through almost the entire east coast of the Bay of Bengal as well as

its extensive lowland areas, the country is highly exposed to cyclones. According to the IPCC Fourth Assessment Report, the total number of cyclones deriving from the Bay of Bengal and Arabian Sea has decreased since 1970 but the intensity has increased (Lal, 2001 cited in Parry et al., 2007).

Climate Projections

One particular climate model with finer spatial scale predicts that Myanmar will become wetter by the end of the century with increased rainfall intensity

Table_14 Union of Myanmar country profile overview

Country level information (UNdata, 2010, CIA, 2009, WHO/UNICEF, 2006)	
Surface area (km2)	676,578
Bordering countries	Bangladesh, China, India, Lao PDR, Thailand
Population, 2007 (Estimated)	48,798,000
Percentage of population, 2007 (%) in	
- rural areas	68.1
- urban areas	31.9
Population density, 2007 (persons/ km2)	72.1
Population growth rate, 2005-2010 (% per annum)	0.9
Forest cover (% of total area)	49.0
Arable land (% of total area)	14.9
GDP, nominal, 2007 (million US\$)	18,510
Contribution of agricultural sector to GDP, 2008 (%)	40.9
Contribution of industrial sector to GDP, 2008 (%)	19.8
Contribution of service sector to GDP, 2008 (%)	39.2
Population below poverty line , 2004 (% of total population)	32.7
Infant mortality rate, 2005-2010 (per 1 000 live births)	66.0
Literacy rate, 2007 (% of total population over 15 that can read and write)	89.9
Access to improved drinking water sources, 2004 (% of total population) in	
- rural areas	80
- urban areas	80

Table_15 Overview on natural disasters in Union of Myanmar from 1900 to 2010

Top 5 Natural Disasters in Cambodia for the period 1980-2009

Type of natural disaster	Date/year	No of people affected
Storm	May 2008	2,420,000
Flood	Jul 1974	1,400,053
Storm	Oct 1965	500,000
Flood	Aug 2002	359,976
Flood	Jun 1976	200,000
Storm	Apr 1936	150,000
Flood	Aug 1997	137,418
Storm	May 1978	132,000
Storm	May 1976	130,200
Flood	Jul 2007	101,920

Top 10 Natural Disasters in Union of Myanmar for the period 1900-2010

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Earthquake	6	15,860	500,000
Epidemic	3	800	-
Flood	18	2,427,378	134,955
Mass move-ment (wet)	9	1,367	-
Storm	16	3,675,795	4,022,388
Wildfire	2	78,588	11,000

Source: EM-DAT (2009): The OFDA/CRED International Disaster Database, www.emdat.be - Université catholique de Louvain - Brussels - Belgium.

(World Bank, 2009c). The maximum amount of rainfall during any 5-day period, equivalent to an extreme storm event, is projected to increase. The maximum period between rainy days is most likely to increase.

However, in the regions of upper Myanmar's dry zone that receive less than 30 centimetres of rain per year, the annual rainfall is reduced to less than 10 centimetres (NAHRIM, unknown). According to local meteorologist, average rainy day is also reduced from 145 to 110 (ibid).

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

Water Sector

Range of Studies Reviewed and Methods Applied

The impacts of current and projected climate changes in flood, drought and sea-level rise are described, employing climatic information from the world bank and IPCC fourth Report. The World Bank uses Japanese High Resolution GCM with finer spatial scale to project rainfall intensity and the amount of rainfall. The IPCC Fourth Assessment Report refers to the Atmosphere-Ocean GCMs for projection of temperature and precipitation under SRES A1FI and B1 pathways. The major causes of flooding in certain parts of Myanmar are also remarked.

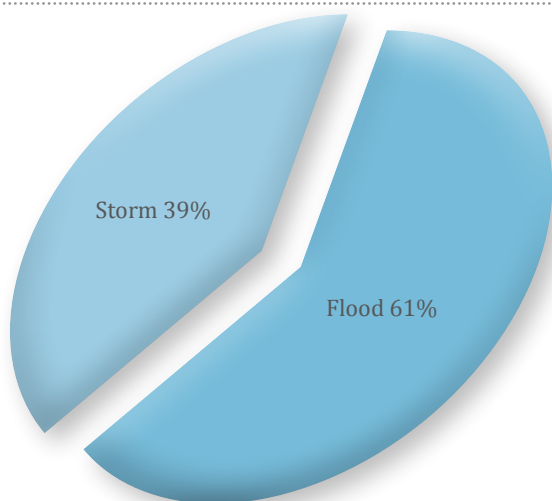
Center for Refugee and Disaster Response (2008) estimates areas and populations vulnerable to Cyclone Nagris using Geographic Information Systems (GIS) based models that were overlaid with spatially distributed population data. Geographic vulnerability were analysed based on storm path, projected storm surge generated from the cyclone data, and elevation. Models included all townships within 250 km of the cyclone path.

Finally, the current local practices of flood prevention were described. The prevention measures have been implemented through multi-level participation as well as use of local knowledge on flood events and traditional technique of protecting a dyke. These are documented as good practices by the ADRC (2008).

Impacts on the Water Sector

Most of studies on climate change impacts on the water sector highlight the Ayeyarwady river basin, one of the major rivers covering about 60% of the total area of Myanmar. The Ayeyarwady river basin is divided into the upper and lower parts with the river confluence with the Chindwin River. The Ayeyarwady river flows from north to south,

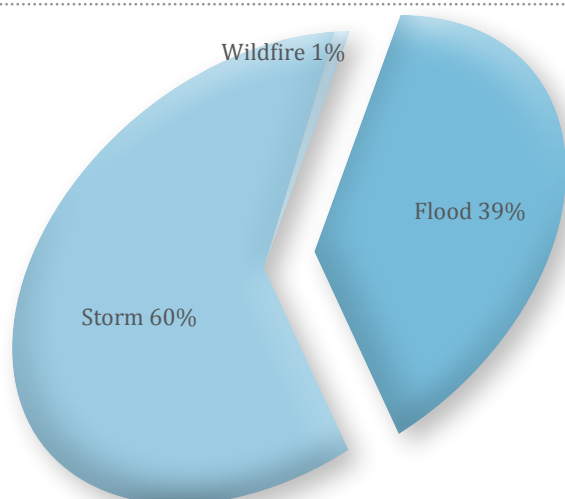
Figure 46: Percentage of people affected
due to top 10 natural disasters
1900-2010



draining through nine deltas into the Indian Ocean. The Ayeyarwady delta region is nowadays observed to be affected from increased frequency of floods and cyclones due to climate change (Khin Thein Htwe, 2009).

Floods generally occur during the southwest Monsoon season of June through October due to intense rainfall that is resulted from the low pressure waves superimposed on the general monsoon. Particularly in the lower Ayeyarwady river basin, the main cause of flooding is tropical cyclone. Tropical cyclones are at times very destructive due to the three main constituents: strong winds (above 150 km/hour), heavy rainfall (above 30 to 40 cm in 24 hours), and storm surges (above 4 to 5 m).

Figure 47: Percentage of people affected
due to total natural disasters
1900-2010



Flood incidents could become worse in Myanmar given the projected changes on intense rainfall, temperature and cyclone intensity in Myanmar and around the South-East Asian region. As mentioned earlier, rainfall intensity as well as the amount of rainfall caused by an extreme storm event are projected to increase (World Bank, 2009c). In addition, according to the fourth IPCC report with regional specifics in projected climatic changes, annual precipitation is projected to increase along with mean winter and summer precipitation in South-East Asia for the three times slices, namely 2020s, 2050s and 2080s (Lal, 2003, Rupa Kumar et al., 2003, Kwon et al., 2004, Boo et al., 2004, Japan Meteorological Agency, 2005, Kurihara et al., 2005 cited in Parry et al., 2007). Also, an increase in occurrence of extreme weather events including intense precipitation is expected (Emori et al., 2000, Kato et al., 2000, Sato, 2000, Lal, 2003, Rupa Kumar et al., 2003, Hasumi and Emori, 2004, Ichikawa, 2004, May, 2004b, Walsh, 2004, Japan Meteorological Agency, 2005, Kurihara et al., 2005 cited in Parry et al., 2007) along with an increase in the inter-annual variability of daily precipitation during the summer monsoon (Lal et al., 2000, May, 2004a, Giorgi and Bi, 2005 cited in Parry et al., 2007). Furthermore, South-East Asia will face gradual temperature rise with a similar level to the global mean warming over the same time slices (Ruosteenoja et al., 2003, Christensen et al., 2007 cited in Parry et al., 2007). Regarding tropical cyclone intensities, the IPCC Fourth Assessment Report also indicates an increase of 10 to 20% along with a rise in sea-surface temperature of 2 to 4°C. As a result of abovementioned projected changes on intense rainfall, temperature and cyclone intensity in Myanmar and over South-East Asia, the frequency

Figure 48: Percentage of damage (US\$)
due to total natural disasters
1900-2010

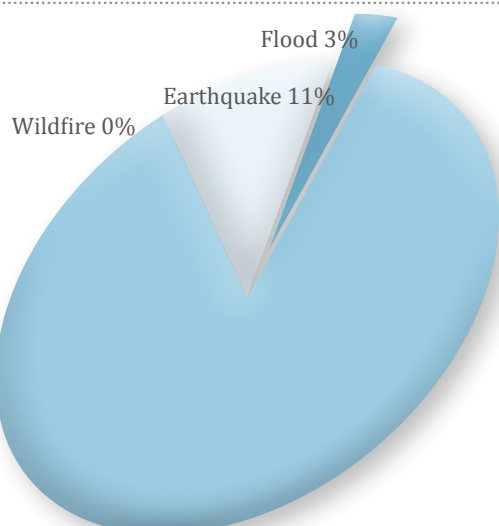
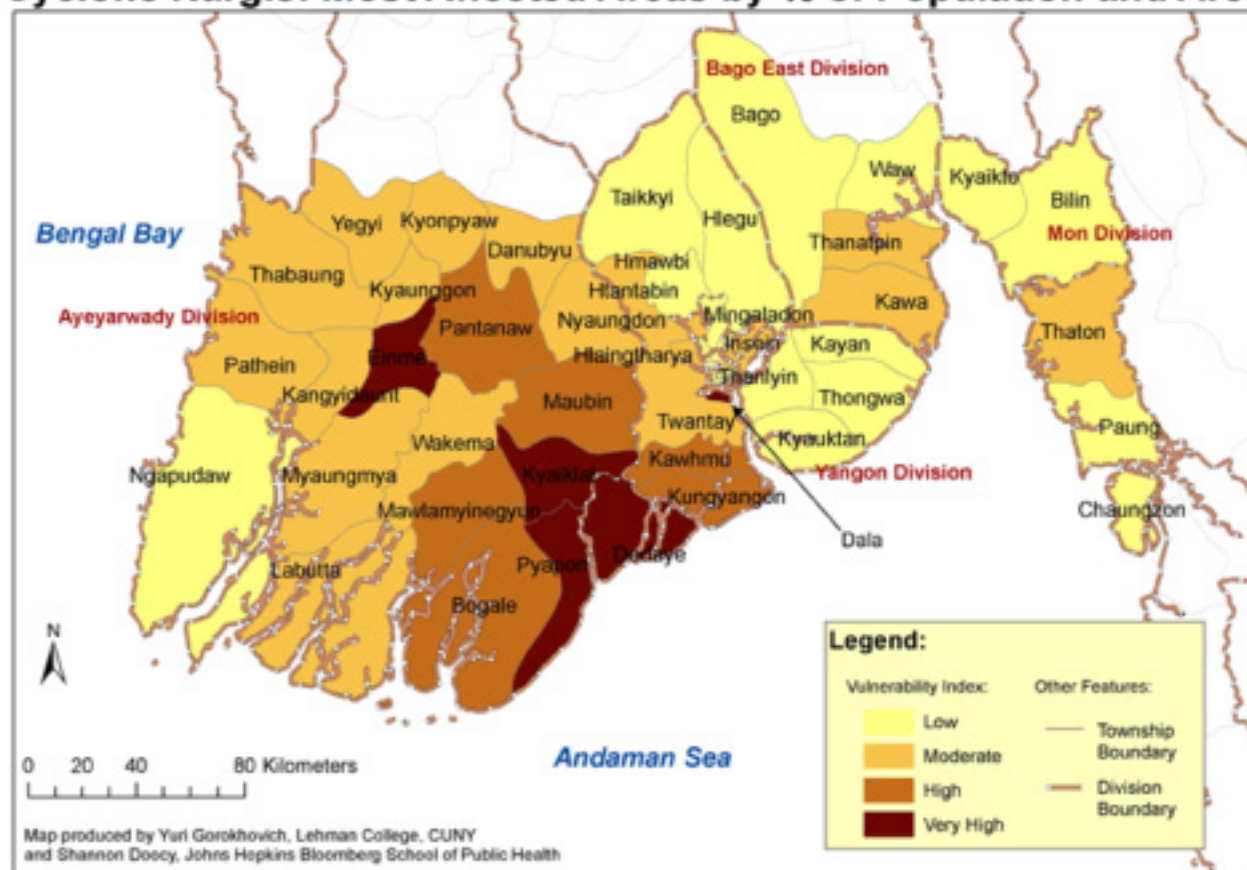


Figure 49: Cyclone Nargis Vulnerability Estimates by Township (Center for Refugee and Disaster Response, 2008)

Cyclone Nargis: Most Affected Areas by % of Population and Area



and extent of flood events may become worse, generating worse impacts on livelihoods.

Meanwhile, increasing droughts or near-drought conditions have been observed in Myanmar in the years following El Nino/La Nina Southern Oscillation events (Alam et al. 2007; PAGASA 2001; Kelly and Adger 2000 cited in Resurreccion et al., 2008). This may result from changes in rainfall patterns, with combination of management of flow regimes and increase in groundwater extraction. People in the Dry Zone, situated in the centre of Myanmar, are most likely to suffer from water shortages.

In addition, the coastal areas of Asia, in general encounter the sea-level rise between 1 to 3mm per year, which is marginally greater than the global average (Dyurgerov and Meier, 2000, Nerem and Mitchum, 2001, Antonov et al., 2002, Arendt et al., 2002, Rignot et al., 2003, Woodworth et al., 2004 in Parry et al., 2007). It is further indicated that the rate of short-term sea-level rise has accelerated in comparison with the long-term average: 3.1mm per year over the past decade compared to 1.7 to 2.4mm

per year over the 20th century as a whole (Arendt et al., 2002; Rignot et al., 2003 cited in Parry et al., 2007).

Vulnerability and Adaptation in the Water Sector

The Bay of Bengal is an area of higher number of tropical cyclones (unknown source). The North Indian Ocean (NIO) cyclones formed in the Bay of Bengal are not severe in terms of storm intensity, but devastating due to the physical and social vulnerabilities remained in the coastal zones of the Myanmar. The coastal areas are the low-lying areas, which can be easily flooded by a storm surge. Building materials and living infrastructure are of low quality. Furthermore, population density and poverty level is high in the coastal villages. Consequently, these physical and social characteristics of the coastal areas could cause high death toll when a cyclone strikes. Approximately 80% of death from all tropical cyclones in the world is induced due to the cyclones in the NIO. In the case of Myanmar, 60% of people affected by natural disasters occurred during 1900-2010 resulted from the storms (see Figure 47).

According to one of the estimates, 16.2 million people lived in the region affected by the Cyclone Nargis which occurred in 2008. Out of 16.2 million, 3.2 million people were directly affected by the cyclone, the majority of which were in the administrative divisions of Ayeyarwady (1.8 million) and Yangon (1.1 million) (Center for Refugee and Disaster Response, 2008). It was identified that the Ayeyarwady Division suffered from its hardest hit with approximately 36 % of the population affected. The townships of Labutta and Bogale located in the coastal zones are also of great importance for paying attention since the greatest impact of a cyclone is anticipated in areas where the storm first lands. The estimated vulnerability by townships is shown in Figure 49. As briefly explained above, tropical cyclones like Nargis cause intense flooding. Thus, the areas identified as vulnerable to cyclones are also highly vulnerable to floods.

As mentioned earlier, tropical cyclones cause severe flooding. Of the top 10 natural disasters of the period between 1900 and 2010, more than 60% of people affected suffered from floods (see Figure 46). Responding to the chronic flood events, good practices on flood prevention have been implemented at the community level. They are not recognised and documented as adaptation measures to reduce climate change impacts on floods. However, it is worthwhile presenting in this report these coping strategies toward flooding.

The Asian Disaster Reduction Center (ADRC) introduced flood prevention measures that have been practiced through the multi-level participation of state and local authorities, and also by utilising the country's traditional techniques of protecting dykes called "Yaing Khway" (2008). Based on past experiences on flooding, state and local authorities have accumulated knowledge that a flood in the upper part of the Chindwin river basin induces the Ayeyawady River in Hinthada township to reach its danger level 7 to 10 days later. This knowledge has enabled local authorities and relevant departments to initiate flood preventive measures and the Department of Meteorology and Hydrology to issue information on water level and daily rainfall. During the monsoon season of 2004, the Ayeyawady Division Peace and Development Council mobilised a total of 35,000 volunteers from local authorities, armed forced personnel, police department, NGOs and students to participate in flood prevention activities including flood-monitoring and public warning using modern communication equipment such as mobile

phones and walkie-talkies, inspection of dykes and flood patrols. In addition to the abovementioned flood management and active participation of local inhabitants, the traditional method of preserving dykes called "Yaing Khway" was effectively functioned. Being made of bamboo or mangrove poles, bamboo matting and sand, the Yaing Khway control the flow of water through a hole in a dyke by keeping water inside a ring of bamboo matting and sand, preventing the dyke to collapse. At the end, these prevention methods saved 5 million people and 500,000 acres of farmland from the damages of flooding (ADRC, 2008).

At the national level, the Irrigation Department have implemented dam construction projects to adapt to projected changes in rainfall pattern and sea-level rise (NAHRIM, unknown). Irrigation engineers recognise the climate change affects that water level in the rivers will be reduced due to draught, that water level in the Delta Region will rise due to the change of sea level, and that people in the Dry Zone will suffer from water shortages. Responding to the projected climate change and impacts, Irrigation Department has conducted three dam projects in the tributaries, Myittha Hydropower Project, Manipu Hydropower Project and Yarzagyo dam project. On the river Chindwin, the Tamanthi Hydropower Project is studied. A national dialogue is completed with relation to Environmental Impact Assessment, social impacts, possible increase in river flow, water level in the main river, effects of pushing back of saline instruction line to the sea, reduction of water level in the Delta Region due to impounding of rainy season flow in these dams. The dam projects could allow for irrigating 242,000 hectares of land in the Dry Zone and also for providing drinking water to people and their draught animals. For this project, cost benefit analysis has been carried out.

In addition to the climate change adaptation initiatives, the Irrigation Department has developed prevention measures for seasonal disasters, including operation and maintenance of irrigation, through building capacity, knowledge and awareness (NAHRIM, unknown). They are not necessarily addressed as a response to climate change, but they can be utilised as a fundamental resource on which climate change adaptation measures may be developed. A series of capacity building training for engineers have been conducted at the Irrigation Technology Center (ITC). Hydrology, geology, Canal Act, Embankment Acts, care and maintenance of embankments, account code, department code and administration etc. are taught in the training. The

Irrigation Department also established another ITC at Mandalay, where pre-service and in-service are given. The department also set up a Mechanical Training Centre (MTC) in Yangon, whereby the basic courses on operation, maintenance and repairs of heavy machinery as well as GPS and Remote Sensing are conducted. Some senior engineers also attend the Disasters Management Training given by the Ministry of Health. Apart from the engineers, the Irrigation Department also provides special training courses to field staffs, such as canal and drainage inspectors from state and division, and also to local people who take a coordinating role during the flood season to build their capacity on flood fighting.

In addition to the capacity development, the awareness and knowledge building has been initiated, including creation of pamphlet emphasizing flood prevention and guidance on reporting when boils, slips and subside are found (NAHRIM, unknown).

Gaps Identified in Programmes and Studies

While traditional practices have remained to mitigate flood risks caused by climate change, new challenges appear and evolve as the country's land development and as commercialisation continue along the Ayeyarwaddy delta. In 1929, when few people lived and no ongoing development work was implemented in the east bank of the river, government constructed embankments for keeping the height lower for emergency spill of flood to save the west bank protected area (NAHRIM, unknown). Since 1988, however, the area of the east bank has been developed with high way and railway line extended and the private sectors involved. Now with low land rice cultivation field, fish ponds, gas field, it is commercially important, and receives high concern on safety of the east bank. However, flood management is not as simple as before any more. New challenge would be institutional cooperation among local governments who cover their administrative responsibility along the delta. The east bank is administered by Yangon Division and Bago Division and the west bank is by Ayeyarwaddy Division. Continuous reporting on flood levels among the Divisions and the relevant ministries need be carried out (NAHRIM, unknown).

Recent projects in the Water Sector

The Water, Research and Training Centre (WRTC) presented a research proposal on flood risk

reduction at the M-Power 2009, Annual Meeting of the Network Partners in February, 2009 (Khin Thein Htwe, 2009). The study focuses on the cyclone Nargis affected areas in the Ayeyarwady Delta with the first pilot study in the Pyapon Township. The objectives of the study are to a) assess the flood risk awareness of the community; b) evaluate the preparedness of the community before the floods; c) examine the response of the community during the floods; d) assess the capacity of the community in rehabilitating the floods; and e) formulate policy recommendation.

Agriculture and Food Security Sector

Range of Studies Reviewed and Methods Applied

NAHRIM documents the impacts of one flood event that occurred in 1991 on the agricultural sector in Myanmar with the figures of affected land, drought animals and people. Among the agricultural products, rice accounts for 60% of the country's total cultivated area and 97% of total food grain production. Matthews et al. (1997) studies the climate change impacts on rice production in Asian countries including Myanmar and evaluates adaptation options. They used two models of rice growth, ORYZA1 and SIMRIW, which were calibrated for the indica variety IR64 for all sites in Myanmar. Historical daily weather data containing measurements of solar radiation and temperature were employed as the baseline for input into the crop models. Potential rice yields were projected under 15 different scenarios of changed climate, including 'fixed-increment' changes in CO₂ only, and also under scenarios predicted for a doubled-CO₂ climate by three GCMs, namely, General Fluid Dynamics Laboratory (GFDL) model, Goddard Institute of Space Studies (GISS) model and United Kingdom Meteorological Office (UKMO) model. Both the ORYZA1 and SIMRIW models were also applied together with the same input data files to evaluate the effect of selecting more tolerant genotypes of rice under three GCM scenarios.

Also, NAHRIM demonstrates potential risks of climatic change on food security in the central dry zone, whereby the annual rainfall is already low. It implies the importance of considering the climate change impacts on the area of the Ayeyarwaddy River.

Impacts on the Agricultural and Food Sector

Myanmar is considered as an agriculture-based country with the agriculture sector's contribution to the GDP of 40.9% in 2008. The country being prone to natural disasters such as flooding and cyclones, potential impacts from the natural disaster in the agricultural sector can be devastating. In 1991, for example, the breach of Hteinngu embankment on the Ngawun River, a branch of the Ayayarwaddy River affected 2.8 million acres of paddy land, 167,520 acres under other crops, 67,306 houses, 74,674 draught animals, 326,926 people from 269 villages, and 8 townships (NAHRIM, unknown).

The study of Matthews et al. (1997) demonstrates the overall effect projected by both crop models of changes in temperature and CO₂ levels on potential yields, averaged across all sites, seasons and years. It is predicted that all CO₂ levels, an increase in temperature would cause a decline in yields, and that at all temperature increments, an increase in CO₂ would increase yield. The country-specific data projects that the estimated changes in total rice production under two crop models and three GCM scenarios ranges between -13% to 21% (IRRI, 1993 cited in Matthews et al., 1997). Furthermore, the total rice production in Myanmar is estimated to increase with a range of 28% to 32% given varietal adaptation on rice production. This results show that the use of more temperature-tolerant genotypes of rice could offset the negative effect of increased temperatures on yields (Matthews et al., 1997).

Food security is expected to become more unstable and unsustainable in the Central Dry Zone of the Ayayarwaddy River owing to the projected reduction of annual rainfall and the number of rainfall days. The region has climatic attributes of an extreme dry and seasonal climate. The farmers hardly receive enough rain to grow dry crops, leading them to rely on the protein from fishes that are caught in the Ayayarwaddy river (NAHRIM, unknown). The reduced rainfall may change ecological system inside the river, posing a risk in their livelihood sources.

Vulnerability and Adaptation in the Agricultural and Food Sector

Rice is the single most important crop, accounting for 60% of the country's total cultivated area and 97% of total food grain production (IRRI, unknown). Given this fact, the potential option on creation of new rice variety identified by Matthews et al. (1997) can be one of adaptation strategies. The scientists of Myanmar and IRRI put this option into a practice. They released fifty-two modern rice varieties between 1966 and 1997, allowing the country to

increase national production to 14 million tons in 1987 to 19 million tons in 1996 (IRRI, unknown).

At the governmental level, neither NAPA nor National Communication has been produced yet to address the details on vulnerability and adaptation strategies in the agricultural sector. However, the country recognises significant effects of climate change on the agricultural sector particularly in the dry zone, as noted in the speech of Maj. Gen. U Htay Oo, Minister of Agriculture and Irrigation of Myanmar (UNESCAP, 2009). "To mitigate such pressure we are implementing short-term and longer term measures, such as promoting access to irrigation water to increase productivity, and developing resource-based as well as knowledge-based sustainable agriculture and livelihoods built on existing infrastructures" (ibid). Due to the limited access to the governmental documents, no further information of the short-term and longer term measures are provided in this report.

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

There has been little research on socio-economic aspects of climate change effects on the water and agricultural sectors in the Union of Myanmar. Nonetheless, UNDP (2007) conducted a national level assessment on disaster risks and adaptive capacity in the context of climate change, particularly economic and mortality risks from cyclones and storms, drought and flood. Data on baseline climate risks and GIS datasets describing the spatial extent and relative intensity of mortality and economic risks are employed from the study by Dilley et al. and the Columbia University Center for Hazards and Risk Research's Hotspot website respectively. Spatial data are demonstrated in a 2.5' x 2.5' global grid, which presents relative risks for various hazards, incorporating physical hazard intensity, historical loss rates and population/GDP density. The level of the adaptive capacity is classified into four categories (Higher, Moderate, Low, Very Low) based on the index of adaptive capacity developed by Malone and Brenkert, for which an indicator model integrating proxies for economic, human and environmental capacity is used. Data on climate change projection is applied from the Fourth Assessment Report of the IPCC, and climate change risks were assessed in terms of the likely impact of climate change on existing hazards (increasing or decreasing stress).

NAHRIM depicts a case of social conflict over the islands in the Ayayarwaddy River that were formed as a result of the changed water flow after flooding.

The process and key issues needed to solve the social conflict are explained.

Impacts on Socio-Economic Sector

According to UNDP (2007), the baseline risks of cyclones/storms, drought and flood on the Myanmar's economy are all high, and the climate change impact on each hazard is projected to increase. This implies that the economic risk from the natural hazards is projected to be much higher in the future. In terms of mortality, on the other hand, the baseline risks of cyclones/storms and floods are low and that of drought is moderate. Given the increasing climate change impacts of each hazard, it can be indicated that the risk of mortality is also expected to be increasing in the future. However, the adaptive capacity of Myanmar to both risks-economy and mortality-from all the natural hazards are classified as higher (UNDP, 2007). No further details or description of adaptive capacity of each country is presented in the study of UNDP.

Meanwhile, the social impact from flood, one of the major natural disasters in Myanmar, is described in the study of NAHRIM. In the areas of the Ayeyarwaddy Delta, flood and its resulting change in physical formation of the river pose an indirect societal consequence. Flooding changes river courses, and it brings scour in one side and deposition in the other side of the river (NAHRIM, unknown). New fertile islands are also formed inside the river. After the subsiding of river water level, the residents from both sides of the river occupy the newly formed lands and confront each other for the ownership of the new land. It is reported that their friction sometimes turn from single arguments to furious fighting and murder in the worst case (ibid).

Vulnerability and Adaptation in the Socio-Economic Sector

The institutional capacity seems to be a key solution to mitigate the second and third impacts of climate change such as the abovementioned social conflicts. Responding to the dispute over the newly formed land, there seems to be coordinated efforts to stop the conflict first among police forces, township authorities, village authorities (NAHRIM, unknown). The Settlement and Land Record Department of the Ministry of the Agriculture and Irrigation and Directorate of Water Resources and Improvement of River Systems also collaborate with the conflict

resolution party to take a measure of the thalweg⁷, and finally, local authorities decided the ownership of the new islands.

Gaps Identified in Programmes and Studies

Despite the research capacity to differentiate climatic risks by location, it is necessary to use the most accurate methods to estimate exposure under risks, covering community populations, physical community assets and livelihoods. Investigating social exposure such as population break-up by gender, age, disability and ethnicity is an essential aspect to develop social vulnerability. Especially special disadvantaged groups within a community, including mentally and physically handicapped people, women and the elderly, need to be focused since they have higher levels of social vulnerability. Exposure of physical assets including residential buildings, infrastructure, hospitals and public buildings needs to be estimated for developing physical vulnerability functions. Vulnerability of livelihoods to climatic risks should entail information on agriculture, small business, handicrafts and households such as major crop areas, land utilisation and ownership, number of small industries and their employees. In order to make this assessment, the gaps in available data on climatic hazard footprints (e.g. the extent and depth of storm surge and scenario events of wind speed) and flood hazard variables (e.g. extreme flow frequency and inundation areas) need to be filled.

CROSS-SECTORAL INSTITUTIONAL SETTINGS

Two different domains are important to consider while looking at cross-sectoral institutional responses to climate change adaptation: one is climate change oriented institutional setting and the other is institutions engaged in climate change issues from the perspective of disaster risk reduction. For the case of Myanmar, the country has just started to formulate institutional arrangements for climate change response to global mandates. On the other hand, it has the well-laid institutional mechanism for disaster management at various levels- from national to village.

Climate Change

⁷ The thalweg represents the deepest continuous line along a watercourse. This can be used as a principle that defines the border between two states separated by a watercourse as lying along.

The Government of Union of Myanmar ratified the United Nations Framework Convention on Climate Change (UNFCCC) on November 1994 and its Kyoto Protocol in 2003. The National Commission for Environmental Affairs (NCEA) is a focal point for both UNFCCC and Kyoto Protocol (Htwe Nyo Nyo, 2009). Myanmar is currently in the process of preparing the Initial National Communications (INC) and the National Adaptation Programs of Action (NAPA).

The NCEA is currently preparing the INC with financial assistance from GEF and UNEP. A Project Management Team (PMT) and 5 National Study Teams (NSTs) were established under the auspices of the NCEA to conduct the INC project, including vulnerability and adaptation assessment and GHG inventories (Ne Winn, 2007). A National Climate Change Committee (NCCC) was also formed with a chair from the Secretary of the NCEA to prepare the INC.

Meanwhile, the preparation of the NAPA has been implemented since 2009 by the Department of Meteorology and Hydrology, and the Ministry of Transport (Htwe Nyo Nyo, 2009). The Multidisciplinary Integrated Assessment on several sectors including water resources and agriculture has been carried out by the following working groups:

- Water resources (Water Resources Utilization Department)
- Agriculture (University of Agriculture)
- Energy, transport and industry (Myanmar Engineering Society)
- Biodiversity and Forestry (Academy of Forestry Science)
- Coastal zones (Department of Fishery)
- Public Health (Department of Health)

Gaps Identified

The major gaps identified by the NCEA are as follow (Ne Winn, 2007):

- Lack of capacity building (e.g. training on relevant methodologies) and expertise in the area of vulnerability and adaptation assessment;
- Lack of vulnerability assessment such as the integrated and quantitative vulnerability assessment as well as assessment of impacts of climate variability and extreme weather events on key socio-economic sectors;

- Lack of cost-effective analysis of various adaptation options including adaptation technologies
- Lack of national strategies and action plan for climate change adaptation and its related disaster prevention and preparedness

Institutional Settings Concerning Disaster Risk Reduction

As a county prone to natural hazards, Myanmar has focused on disaster management, rather than climate change adaptation. Underpinned by the existing 'Action Plan on Disaster Risk Reduction, Preparedness, Relief and Rehabilitation', also known as 'Master Plan for Disaster Preparedness,' multi-layered disaster management institutional arrangements have been initiated. This report presents the country's disaster preparedness committees and plans developed at various levels, and also introduces key gaps and recommended activities identified by ADPC (2009) for strengthening the current institutional arrangements.

Disaster Preparedness Committees of Myanmar

Myanmar has prepared institutional arrangements for disaster management from national to village levels (ADPC, 2009). At the national level, the National Disaster Preparedness Central Committee (NDPCC) was constituted in 2005 with 37 members, including the Prime minister as a chairman. The main responsibilities of the NDPCC are:

- To constitute committees at various levels to lay down disaster management policy, guidelines and review progress
- To design policy and guidelines to utilization national resources for emergency relief measures
- To set basic principles for receiving foreign aid
- To provide relief assistance where it is necessary through managing the national budgets and resources
- To enact and issue laws, acts, decrees and regulations for effective disaster management activities

As a subordinate body of the NDPCC, the National Disaster Preparedness Management Working Committee (NDPMWC) supervises the implementation of disaster management activities in compliance with NDPCC and also facilitates the activities of NDPCC. The NDPMWC is chaired by Secretary (I), State Peace and Development

Figure 50: Organisational structure of national-level disaster management in Union of Myanmar (ADPC, 2009)



Council. Under the NDPMWC, ten sub-committees are constituted with a chair from each Ministry. The organisational structure of national-level committees is illustrated in Figure 50.

In addition, the ministries and departments have been engaged in national disaster management activities at varying degree (ADPC, 2009). The Department of Meteorology and Hydrology is the focal department for warning all the disasters, except fire. The Relief and Resettlement Department (RRD) is responsible for relief distribution and organisation of disaster management training courses. The RRD also serves as the focal point for ASEAN Committee on Disaster Management for Myanmar. The other relevant line ministries such as Ministry of Agriculture and Irrigation, Ministry of Education, Ministry of Health and Ministry of Social Welfare are also involved in the national level disaster management.

At the Division/State, District, Township and Village Tract levels, Disaster Preparedness Committees have been formed with a Chairman from the Peace and Development Council at the respective level. Sub-committees and Working Groups have been constituted varyingly to conduct specific assignments to assist the Disaster Preparedness Committees in fulfilling the responsibilities (ADPC, 2009).

Disaster Preparedness Plans of Myanmar

The Disaster Management Plan have been developed at the national, state, division and township levels, stating the purpose and objectives of the plan and describing the area-specific hazards and disaster risks (ADPC, 2009). It also calls for constitution of disaster preparedness committees, sub-committees and working groups at each level.

Apart from the disaster management plans, the Standing Order (SO) on disaster preparedness was prepared in 2009 by a 33-member National Disaster Preparedness Standing Order Drafting Committee under the chairmanship of the Minister of Transport. The SO defines the duties and responsibilities to be implemented at the national and state/division levels for the different phases of disaster, namely, pre-disaster, during disaster, relief, rehabilitation and reconstruction period (ADPC, 2009).

Gaps and activities Identified in the programmes

Although the institutional arrangements for disaster management have been established at various levels in Myanmar, some experts have addressed the capacity gaps, such as application of disaster preparedness plans into practice at the ground level (Khin Thein Htwe, 2009) and operationalisation of the institutional mechanisms between and among

the committees and working groups (ADPC, 2009). The ADPC suggests several key activities for filling the gaps, including disaster management legislation or law, training and capacity building, awareness generation, better coordination and information exchange and regular updates of disaster preparedness plans. The following are the steps to be taken for each suggested activity (ibid):

Legislation and implementation of standing order on disaster management

- *Creation of Disaster Management Law:* such legislation would assist Ministries and Departments to smoothly and quickly discharge their duties on disaster management and also allow for enhanced inter-ministerial/departmental coordination.
- *Identification of disaster risk reduction mandates of each ministry:* there is a need to link ministerial and departmental disaster management roles and responsibilities with the 'Action Plan on Disaster Risk Reduction, Preparedness, Relief and Rehabilitation' and facilitate a common approach to disaster risk reduction.
- *Implementation of the standing orders:* along with the capacity building of government officers at all the levels, the operationalisation of SO needs to be carried out at the nation to village tract levels.
- *Assessment of hazard and vulnerability at the national and sub-national levels:* this should be undertaken through identification of people, resources and assets potentially exposed to the hazard prone areas investigated in the SO, followed by the detailed vulnerability and capacity assessment including demographic characteristics and means of livelihood.
- *Standardisation of the disaster management terminology:* as encouraged by the United Nations International Strategy for Disaster Reduction, standardised terms for disaster preparedness plans and committees need to be generated and consistently used at different administrative levels, which would promote better coordination and information sharing.

Capacity Building and training

- *Training and capacity building for disaster preparedness and mitigation:* strategies and approaches toward disaster risk reduction are

required to be shared among governmental officers of committees, sub-committees and working groups to respond to disasters properly, for example, through experience sharing workshops organised by a ministry. Also, the good practices on disaster risk reduction from neighbouring countries should be shared with committee members. The training and capacity building would allow governmental officers to integrate risk reduction into development planning.

- *Mobilisation of agencies and resources:* there is a need to enhance the capacity of the respective ministerial or departmental focal points within disaster preparedness committees at the national and division/state levels, for example by conducting technical trainings and inter- and cross- departmental visits. This could facilitate implementation of roles and responsibilities identified by disaster preparedness committees within the respective ministries and departments.
- *Review of training course curriculum for a trainer:* the Ministry of Social Welfare, Relief and Rehabilitation have carried out disaster management trainings since 1977. These training courses need to be reviewed and consolidated to the international standard as participants of the courses receive updated information and approaches and provide as a trainer training programmes at township and village tract levels.
- *Improvement of disaster management training resource kit:* participants of the training courses are provided with the kit that introduces basic terminologies and types of disasters. This resource kit should entail lesson learned from past disaster events in other countries, mainstreaming disaster management in development planning.

Better coordination and information exchange

- *Involvement of civil society:* although several institutions, including the Myanmar Red Cross Society, Auxiliary Fire Services, Union Solidarity and Development Association, Myanmar Women Affairs Federation, Myanmar Fishermen Federation and Maternal and Child Care Association, have been included in some of disaster preparedness committees, sub-committees and working group at various levels. Though more local Non-Governmental Organisations should be involved.

- *Information, Education and Communication (IEC)*: IEC is addressed as one of the intervention for preparedness in the existing SO as well as at some committees at the various levels. IEC should be elaborated though determining activities undertaken for specific hazard in specific areas, with consideration of wider cultural contexts.

Regular updates of disaster preparedness plans

- *Updating of SO*: It is important to update the SO with the responses of different disaster preparedness committees, sub-committees and working groups as well as the list of hazard prone areas.
- *Early warning dissemination*: the steps for early warning dissemination need to be addressed in the Standard Operating Procedure to enhance quick dissemination conducted by a sub-committee or working group at different levels. It is also essential to clarify and document the collaboration linkages with communities for early warning dissemination.
- *Multi-agency mock drill*: mock drill, identified as one of the activities of the disaster preparedness sub-committees or working groups, should be organised among sub-committees and departments to consolidate coordination and reporting mechanism for effective disaster response.

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Water Sector

The strategies and practices applied to mitigate disaster risks in one place need to be reviewed and adjusted if necessary, before these strategies turn out to be mal-adapted, causing human induced disasters. As in the case of the east and west banks of the Ayeyarwaddy delta, the speed and level of land development varies in each area, depending on the governmental policy. The strategy of construction of embankments employed in 1929 for protecting the west bank is now posing the flood risks on the east bank, which has developed into commercially important areas. Key challenges demonstrated from this case are better collaborative mechanism between

and within relevant national and local governments and disaster preparedness committees.

Agriculture Sector

Recognising great contribution of rice in Myanmar's food grain production (97%), the private research institute and scientists of Myanmar have put their efforts on creating new rice varieties to adapt projected climate change impacts on rice production. The Government also articulates high concern on climate change effects on the agricultural sector particularly in the central part of Myanmar, namely, the Dry Zone, and is implementing the short-term and longer term measures, such as enhancing access to irrigation water to increase agricultural productivity and promoting resource-based as well as knowledge-based sustainable agriculture based on existing infrastructures. In collaboration with the research institutes that has developed the capacity for generating rice varieties, the government can further elaborate the adaptation measures to increase resilience toward climate change especially in the vulnerable areas. Moreover, the preparation process for documenting the Initial National Communications and the National Adaptation Programs of Action needs to be accelerated for providing the guidance on the detailed adaptation practices to be taken.

Socio-economic aspects

The most accurate methods to estimate exposure under climate risks should entail social and physical vulnerability, covering vulnerable groups of community populations, exposure of physical community assets such as residential buildings and infrastructure, and vulnerability of livelihoods including information on small business and household levels. In order to make vulnerability assessment, the gaps in available data on climatic hazard footprints such as the extent and depth of storm surge and flood hazard variables such as extreme flow frequency and inundation areas need to be filled.

Institutional Settings concerning Climate Change Adaptation

While institutional arrangements for disaster risk reduction have been well placed at various levels—from national to village levels, climate change adaptation is yet to be coordinated. One of the key issues would be a linkage between disaster risk reduction and climate change adaptation. Within the

climate change adaptation regime, the major gaps identified by the government are the following (Ne Winn, 2007):

- Lack of capacity building (e.g. training on relevant methodologies) and expertise in the area of vulnerability and adaptation assessment;
- Lack of vulnerability assessment such as the integrated and quantitative vulnerability assessment as well as assessment of impacts of climate variability and extreme weather events on key socio-economic sectors;
- Lack of cost-effective analysis of various adaptation options including adaptation technologies
- Lack of national strategies and action plan for climate change adaptation and its related disaster prevention and preparedness

Institutional Settings concerning Disaster Risk Reduction

Meanwhile, the well-laid institutional arrangements for disaster management still need to be enhanced by filling the gaps in capacity building for better intra- and inter- collaboration among the committees and working groups and also in application of formal governmental policy into practice at the ground level. The ADPC (2009) suggests several key activities, as follows:

Legislation and implementation of standing order on disaster management

- Creation of Disaster Management Law for assisting Ministries and Departments to smoothly discharge their duties on disaster management and allowing for enhanced inter-ministerial/departmental coordination;
- Identification of disaster risk reduction mandates of each ministry to link ministerial and departmental disaster management roles and responsibilities
- Implementation of the standing orders;
- Assessment of hazard and vulnerability at the national and sub-national levels through identification of people and resources and assets potentially exposed to the hazard prone areas, followed by the detailed vulnerability and capacity assessment including demographic characteristics and means of livelihood;

- Standardization of the disaster management terminology

Capacity Building and training

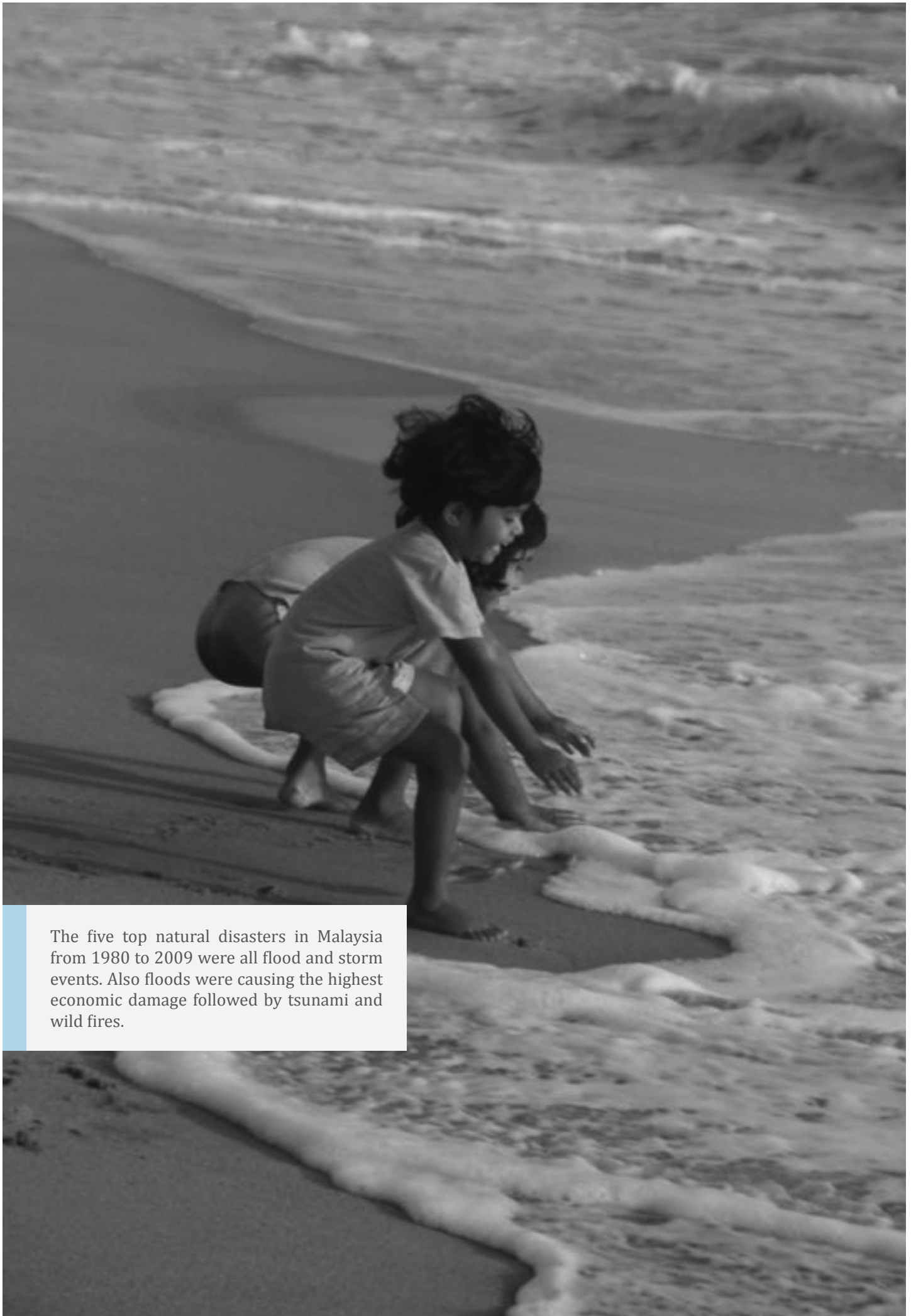
- Training and capacity building on disaster preparedness and mitigation for governmental officers of committees, sub-committees and working groups;
- Mobilisation of agencies and resources to enhance the capacity of the respective ministerial or departmental focal points within disaster preparedness committees at the national and division/state levels, for example by conducting technical trainings and inter- and cross- departmental visits;
- Review of training course curriculum for a trainer to the international standard as participants of the courses receive updated information and approaches and provide as a trainer training programmes at township and village tract levels;
- Improvement of disaster management training resource kit entailing lesson learned from past disaster events in other countries, mainstreaming disaster management in development planning

Better coordination and information exchange

- Involvement of civil society including local Non-Governmental Organizations;
- Enhancing information, education and communication for disaster preparedness though determination of activities to be undertaken for specific hazard in specific areas, with consideration of wider cultural contexts

Regular updates of disaster preparedness plans

- Updating of the standing orders with the responses of different disaster preparedness committees, sub-committees and working groups as well as the list of hazard prone areas;
- Identification of the steps for early warning dissemination and documentation of the collaboration linkages among communities for early warning dissemination;
- Organisation of multi-agency mock drill among sub-committees and departments to consolidate coordination and reporting mechanism for effective disaster response



The five top natural disasters in Malaysia from 1980 to 2009 were all flood and storm events. Also floods were causing the highest economic damage followed by tsunami and wild fires.

RESEARCH SYNTHESIS ON MALAYSIA

COUNTRY ATTRIBUTES

In the following presented country characteristics cover country information concerning Malaysia's geographical, social, economic and climatic risk situations. An overview table on the country's characteristics is given below in Table 16.

Geographical Situation

Malaysia is located in Southeastern Asia, and its land is divided into the Malaysian peninsula and the northern of the island of Borneo (one-third corresponds to the country), bordering with Brunei (381 km), Indonesia (1,782 km), Thailand (506 km), Singapore, and the South China Sea in the south of Viet Nam (UNDP, 2009). From its total land area of about 329847 km², approximately 63.6% is tropical forest, much of it on a central mountain range. Coastal plains dominate the Borneo states and the interior is mountainous. Its lowest point is the Indian Ocean (0m) while its highest point is Gunung Kinabalu (4,100m). It has a total coastal line of 4,675 km, of which 2,068km are in Peninsular Malaysia and 2,607km in East Malaysia.

Socio-Economic Status

According to the UN data, the population of Malaysia is 26.6 million inhabitants, resulting with 80.6 people per square kilometre (UN data, 2009). The population growth rate per annum between 2005 and 2010 was about 1.7%. Malaysia's age structure for 2008 was 29.8% of inhabitants are less than 15 years of age, 45.5% are between 15–60 years of age, and 15.7% are 60 and older. Around 69.6% of the Malay population lived in urban areas. According to the country profile, Malaysia has a multiethnic and multicultural population composed of Malays (50.4%), Chinese (23.7%), Indian (7.1%), other indigenous peoples (11%) and others (7.8%). The

Table_16 Malaysia country profile overview

Country level information (UNdata, 2009; WB, 2009, UNDP, 2009; indexmundi, 2009)	
Surface area (km ²)	329,847
Bordering countries	Brunei, Indonesia, Thailand, Singapore
Population growth rate, 2005-2010 (% per annum)	1.7
Forested area (% of total area)	63.6
Agricultural land (% of total area)	2005
GDP, nominal, 2007 (million USD)	186,720
Contribution of agricultural sector to GDP, 2007 (%)	10
Contribution of industrial sector to GDP, 2007 (%)	48
Contribution of service sector to GDP, 2007 (%)	42
Percentage of population, 2007 (%) in - rural areas % - urban areas %	30.4 69.6
Poor population (2002 est.) (% of households)	5.1
Infant mortality rate, 2005-2010 (per 1 000 live births)	8.9
Adult literacy rate, 2008 (% of people ages 15 and above)	92

country's poverty shows that 5.1% of households are living below the poverty line in 2002. The adult literacy rate was 92% in 2008. In the UN Human Development Index, Malaysia ranks 66th out of in total 182 countries in 2009. Regarding the economic activity, out of the total US\$ 186,720 million GDP in 2007, 10% was provided through the agricultural sector, 48% through the industrial sector, and 42% through the service sector.

Climate Risk Situation

Current Climatic Conditions

The general characteristic features of the climate of Malaysia are uniform temperature, high humidity and copious rainfall. Seasonal variations in climate are more evidently marked by rainfall patterns; the north-eastern monsoon is dominant from November to March, bringing moisture and more rain, and between June and September, the south-western monsoon winds blow. The seasonal variation of rainfall in Peninsular Malaysia is of three main types depending of the area: east coast states, southwest coastal area and the rest of the Peninsula. The three areas concur on having June and July as the driest months, while there are more differences in the wet months. October and November register high rainfall for all areas; April and May also do with the exception of the east coast states. The seasonal variation of rainfall on the states located in Borneo (Sarawak and Sabah), the high variations among their territory make difficult to establish a common pattern. More than 3550 mm of rainfall a year is recorded in the

lowlands. As for temperature distribution, although the annual variation of the daily mean temperature may be small (about 2°C to 3°C) the diurnal variation may be as large as 12°C. Mean temperature in the lowlands ranges between 26°C and 28°C (MMD, 2009).

Table 17 gives an overview on further natural disaster statistics. The five top natural disasters in Malaysia from 1980 to 2009 were all flood and storm events. Floods were among the most severe in the top 5, with 89% (see Figure 52), and when it comes to all the events of climatic disasters occurring between 1980 and 2009 (one drought, twenty nine flood, six storms, one tsunami and four wild fires), the flood are still the events that affected the highest number of people (90% of all people affected, see Figure 53), followed by storms with a 8%. Also floods were causing the highest economic damage followed by tsunami and wild fires (54%, 27% and 16% respectively, see Figure 54).

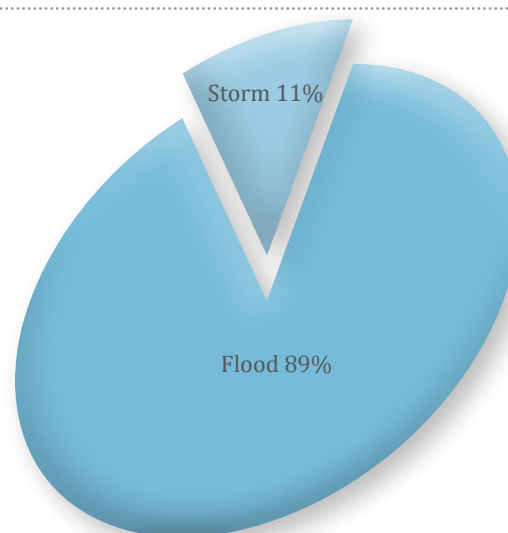
Climate Projections

Outputs generated by the AOGCMs, in the Scientific Report elaborated by the MMD, show that all the models projected an increase in temperature but the degree of increase varies from model to model: for Peninsular Malaysia is between 1.1°C and 3.6°C, for Sabah and Sarawak between 1.0°C and 3.5°C. The range of temperature increases at the end of the 21st century over the 3 domains. An ensemble mean of the entire nine AOGCM models indicate an increasing temperature trend for the 3 domains of 2.8°C for Peninsular Malaysia, and 2.6°C for Sabah and Sarawak. As for the change in rainfall, there is

Figure 51: Location map of Malaysia (Undata, 2009)



Figure 52: Percentage of people affected due to top 5 natural disasters 1980-2009



no clear trend shown by all of the selected models due to the high variability in the precipitation-modulating factor. Based on the MMD's surface observation stations data, annual rainfall change

(percentage) for the periods 2000 - 2007 relative to the period 1990 - 1999, indicate that west coast of Peninsular Malaysia has an increase of 6 - 10 % in rainfall amount, whereas a decrease of 4 - 6% of rainfall amount over central Pahang and coastal Kelantan. As for East Malaysia, Sarawak has an increase of 6 - 10 % in rainfall amount and Sabah has an increase of more than 10% (MMD, 2009). Also, more extreme hydrological conditions may be expected.

Table_17 Overview on natural disasters in Malaysia from 1980 to 2009

Top 5 Natural Disasters in Malaysia, 1980-2009

Type of natural disaster	Date/year	No of people affected
Flood	11 Jan 2007	137533
Flood	19 Dec 2006	100000
Flood	12 Nov 1988	60000
Storm	6 Nov 2004	40000
Flood	23 Nov 2005	30000

Total Natural* Disasters in Malaysia for the period 1980-2009

Type of natural disaster	Total no of events	No of people affected	Damage 000 US\$
Drought	1	5000	No data
Tsunami	1	5063	500000
Flood	29	535183	1012500
Storm	6	47949	53000
Wild Fire	4	6291	302000

Source: EM-DAT (2009): The OFDA /CRED; International Disaster Database; www.em-dat.net - Université Catholique de Louvain - Brussels, - Belgium.

CLIMATE CHANGE IMPACTS, VULNERABILITY AND ADAPTATION

Water Sector

Malaysia is located within the humid tropic and has abundant water resources. Total annual rainfall is 990 billion m3 while the annual surface runoff is approximately of 566 billion m3 - 147 billion m3 in Peninsular Malaysia, 113 billion m3 in Sabah, and 306 billion m3 in Sarawak. The groundwater recharge is estimated at 64 billion m3 annually, while the balance 360 billion m3 returns to the atmosphere via

Figure 53: Percentage of people affected due to total natural disasters 1980-2009

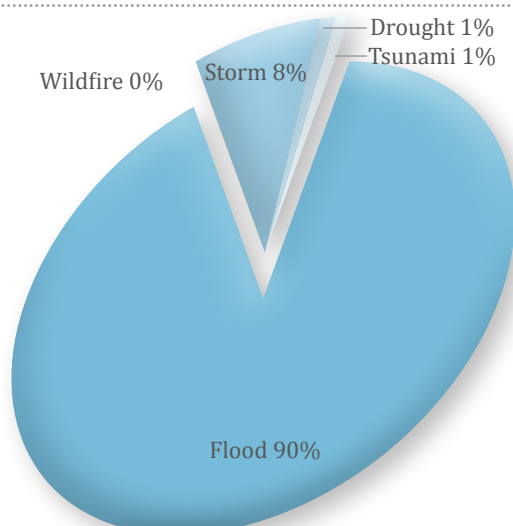
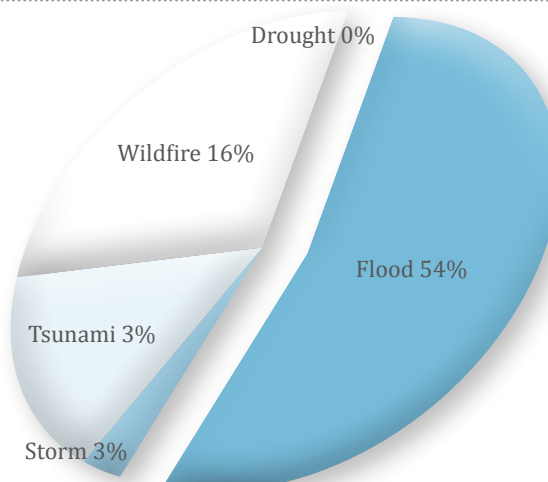


Figure 54: Percentage of damage (US\$) due to total natural disasters 1980-2009.

* Not complete data available



evapotranspiration. The fresh groundwater storage is estimated at 5,000 billion m³ (MOSTE, 2000)

Range of Studies Reviewed and Methods Applied

A range of studies and applied methods were reviewed for analyzing the Indonesian water sectors' situation in view of climate change and are shortly presented in the following.

A regional hydrologic-atmospheric model of Peninsular Malaysia called 'Regional Hydroclimate Model of Peninsular Malaysia (RegHCM-PM)' was developed by the National Hydraulic Research Institute of Malaysia (NHRIM) to downscale the global climate change simulation data (Canadian GCM1 current and future climate data) that are at very coarse resolution (~410km), to Peninsular Malaysia at fine spatial resolution (~9km) and to be able to quantify the impact of the complex topographical and land surface features of Peninsular Malaysia on its climate conditions (Zakaria and Jamalluddin, 2007).

In the climate change scenarios developed by the Malaysian Meteorological Department, the impact of global warming on the monsoons over the Malaysian region is studied by using twelve coupled Atmosphere-Ocean General Circulation Models (AOGCMs). However, for temperature and rainfall analysis, only nine different AOGCMs were chosen in this study. The AOGCMs used in this study are from the contribution of the Coupled Model Inter-comparison Project (CMIP) to the IPCC 4th Assessment Report. The AOGMs and the institution which developed them are: CNRM3 by Meteo-France, MRCGCM by the Meteorological Research Institute from Japan, FGOALS by the Institute of Atmospheric Physics from China, FCM20 by NOAA/GFDL from USA, HADCM3 by Hadley Centre from UK, MIHR by JAMSTEC from Japan, MPEH5 by Max Plank Institute from Germany, NCPCM by NCAR from USA, CSMK3 by CSIRO Atmospheric Research, CGMR by Canadian Centre for Climate Modelling & Analysis, and MIMR by University Of Tokyo. All the models start their integration from the '20th Century Climate in Coupled Model' (20C3M) run, in which the level of anthropogenic forcing is based on historical data of the late 19th century through the 20th century.

Impacts on the Water Sector

The Initial National Communication gathers some of the main impacts on water resources because of the change on climate that result for the data of the models described before. Under the 2 x CO₂ scenarios

there may be an increase of 10% to 20% in storm magnitude that would result in double designed storm frequency or return period. These preliminary results provide at least a qualitative trend of the climate change induced impact on rainfall intensities that will end up in more frequency and severity of floods due to extreme events. Taking into account that erosion and sedimentation rates increase during and after strong storm, there will be a higher risk of slope failures of riverbanks and hills, faster rate of sedimentation of reservoirs and channels, and more extensive loss of soil nutrients. For example, in the Kelantan River, a 20% of increase on discharge would cause a sediment load increase of 33%. In Sabah and Sarawak, an increase of 20% in high flow magnitudes and frequencies will translate to a 44% surge in sedimentation loads (MOSTE, 2000). There are aspects of land use and climate change in the long term such as, soil erosion or chemical poisoning that combined with some others related to daily quality of life such as, water pollution, shortage of food or resources, produce effects difficult to predict such as, natural and environmental catastrophes in recent times- floods, landslides, long periods of drought etc. The floods incidence happened in the southern states of Malaysia, involving Negeri Sembilan, Melaka, Johor and Pahang. Johor was the worst affected, heavy rainfall in Southern Malaysia, was exaggerated because of with poor drainage systems. Without adequate measures floods may cause displacement of people, damaged infrastructures and losses of agricultural production from eroded and inundated lands (Kamal, 2007).

Annual rainfall will increase a 10% for Kelantan, Terengganu and Pahang and decrease 5% for Selangor and Johor. Also is expected an increase in mean monthly rainfall over the North East Coastal region and over Kelantan while over Selangor and Johor a decrease is expected (Zakaria and Jamalluddin, 2007). Because of changes in climate conditions, the total surface runoff will also be affected inducing at the same time variations on water availability. In the Initial National Communication is set that for a 1°C increase in temperature there is an increase in the potential evapotranspiration (PET) of between 3% and 9%; for a 3°C the PET is expected to rise from 9% to 13%, which represents potentially about 170 mm of extra moisture loss. In wet months, for an increase of 1°C to 3°C, the long-term runoff will be reduced between 1% and 5% and between 2% and 17%, respectively, but in dry months, the scenarios show a reduction between 1% and 16% and between 1% and 24% respectively. With a reduction in rainfall of 10%, the runoff will be reduce between 12% and

31% in wet months while in dry months the range will increase from 13% to 38%. If a combination of temperature and rainfall changes is considered, for the scenario of a 10% less rainfall and an increase of 1°C, the runoff will be reduced between 13% to 35% and 14% to 43% during the wet and dry months, respectively; when temperatures rises up to 3°C, the reduction in runoff ranges from 13% to 48% and from 17% to 53% during the wet and dry periods, respectively (MOSTE, 2000). Zakaira and Jamalluddin (2007) study shows that future monthly flows will be significantly higher (11%-43%) for maximum monthly flows in Kelantan, Terengganu and Pahang and the minimum monthly flows will be significantly lower (31%-93%) for Selangor and Johor. Also there will be an increase in inter-annual and intra-seasonal variability with increased hydrologic extremes (higher high flows, and lower low flows) in Kelantan, Pahang, Terengganu and Kedah watersheds.

Because of the impacts described above, the water resources in the country need to be managed in order to provide supply in long dry periods improving the storage capacities by dams and reservoirs. If the storage supply is insufficient, agriculture will be affected, especially wetland paddy, the principal source of the nation's food supply, which is dependent on irrigation. Other forms of cultivation as well as competing needs by industry and households will place further strain on the available water supply. During dry spells the low rate of runoff will also lead to deterioration in river water quality. Apart from presenting itself as a problem to the water authority, there is the more immediate threat to aquatic life as a result of water quality degradation in rivers (MOSTE, 2000).

Droughts have been a severe disaster in Malaysia; in 1991 drought in Malacca caused the drying up of Durian Tunggal Dam and resulted in prolonged water rationing in most parts of the state. There have been a lot of drought events in the past, but the most significant one was the 1997/98 El Nino related drought, which caused extensive impact to environment and social activities across the whole nation. Many parts of the nation including the state of Selangor, Sarawak and Sabah were threatened by extensive wild forest fire due to prolong dry weather condition. The local situation coupled with that happened in the neighbouring country had resulted in months of hazy atmosphere that threatened the health of every citizen (Kamal, 2007).

Sabah was perhaps the most affected state by the 1998 drought. All the Divisions suffered extremely

high rainfall deficits (some as low as 90% of long term mean) for a period ranging from 4 to 9 months, affecting more than 2,797 km² and 170,000 people. About 1580 km² was engulfed in wild fire, of which more than 100 km² were agricultural lands. More than 7,200 farmers were affected with an estimated loss of about RM⁸ 7 million. A number of districts had to go for water rationing to ease off the situation. In few villages, their hill padi crops were totally wiped out prompting the authority to send in food supply to the affected areas. Similar situation was experienced in the North Eastern part of Sarawak near Miri region. The prolonged and extreme dry spells had resulted rampant wild fire that had destroyed a sizable area of agricultural crops (Kamal, 2007). During the particularly dry period of the 1997/98 El Nino related drought, almost the whole of Sabah was experiencing more than 75 % rainfall deficit compared to the long-term mean (for a period of between 4 to 9 months), and in some areas the deficit was as high as 90 %. In Miri, Sarawak, one of the rainfall stations recorded more than 100 no-rain days, the longest drought recorded so far (Husaini, 2007). Due to changes in climate conditions, there will be more droughts in dry years (i.e. 2028, 2029, 2034, 2042 and 2044). More extreme hydrological conditions may be expected, including floods and droughts (Zakaria and Jamalluddin, 2007).

Vulnerability and Adaptation in the Water Sector

Rapid urbanization and the location of major towns throughout the country in coastal regions, which are low-lying and flat, make settlement patterns vulnerable to potential floods. Extensive investments have gone into building these towns and property values have surged to very high levels (MOSTE, 2000). Parallel to the growth in population and the good economic environment based in industrialization, agricultural activities also were consider the third engine of growth for the economy; thus, these have imposed an increasing water demand and caused water stress to certain regions of the country. As water is a finite resource, its per capita availability in future will definitely decrease due to these factors. Also the sources of water supply in Malaysia are not very diversified, almost all the water used comes from surface water sources with ground water contributing only about 3 %. Although the annual rainfall is very high (3,000 mm average) there are large variations both in time and in space, and river flows are prone to large fluctuations as well. Hence Malaysia is subject to prolong dry periods, which can easily affect its freshwater supply (Husaini, 2007).

In general, options for reducing stresses on water resources include increasing reservoir capacity, changing the operating rules of water resources systems, promoting use of groundwater, and improving long- and short-range hydrologic forecasting; also changing land use practices to reduce sediment and nutrient loss to surface and groundwater could significantly enhance water quality. In particular, Malaysia has taken progressive steps towards a better watershed management by the implementation of EIA, Environment Management Plan (EMP), River Catchment Management Plan (RCMP) in major water resources and land development projects, the establishment of the National Water Resources Council in 1998, and the proposed establishment of river management authorities. The National Water Resources Study in 1982 was the first effort of the Government to establish long-term plan for integrated water resources development. Since then, a number of the recommendations made have been taken up and followed through by the Government. It has been developed a second National Water Resources Study II (2000–50) (MOSTE, 2000)

Education and awareness programmes to promote the idea of conservation and protection of the environment and water resources among the general public, especially the younger population, are other effective long-term strategies to mitigate the impacts of climate change on Malaysia's water resources (MOSTE, 2000).

Among some non-structural measures that have been implemented, the Urban Stormwater Management Manual (MSMA), published by DID in 2000, puts emphasis of peak discharge control at source to prevent floods. In 2001, the Cabinet approved that local authorities, public and private development projects implement and compile it. It provides control at-source measures and recommendations on flood control by means of detention and retention, infiltration and purification process, including erosion and sedimentation controls. To achieve the objectives of the guideline, DID has reviewed previous drainage master plans, upgrade old drainage systems in stages, provided network cooperation and support from other government, organized training courses for engineers, and imposed Erosion and Sedimentation Control Plan as mandatory approval for earth works development plan (Husaini, 2007). Some practical measures implemented by the Government were i.e.

the collection of rainfall from roof of buildings to be re-cycled for domestic use, which also will reduce the run-off and thus the frequency and magnitude of floods; later the installation of 6-liter toilet flushing cisterns were introduced in new buildings to reduce the volume of water required per flush. Individually the amount of water saved may seem insignificant, but collectively the total amount will be considerable, especially in times of serious drought.

Zakaira and Jamalluddin (2007) study gives three types of adaptation measures: structural measures for inland water resources, non-structural measures for inland water resources, and measures for coastal resources. Among the structural measures are listed dams, river improvements, levees, diversions, detention storage and pumping installations to mitigate increased flooding, and for those places where climate change reduces rainfall there is a need to upgrade our existing infrastructure for water storage. To complement structural flood measures various non-structural measures can be taken such as flood zoning and flood risk mapping, flood proofing and resettlement of affected population. Also, to sustain economic growth and human well being, it is needed that the water resources plan of affected basins are reviewed to improve the effective use of water resources, the adoption of improved water management practices in water supply, irrigation and hydropower generation, the development of rules and guidelines to account for climate change impacts in the nation's infrastructure, the employment of risk management approach in dealing water shortages due to droughts via the development of drought plans, and the sensibilization of the public to the problems of water wastage and to introduce policies or taxes that would cut waste and constrain demand, i.e. through public awareness and education programs.

The current existing policy related with Water Resources Management is the Third Outline Perspective Plan (OPP3) 2001-2010 and the Ninth Malaysia Plan (9MP) 2006-2010. Malaysia climate projections are required in assessing vulnerability and adaptation; NAHRIM, the Malaysian Meteorological Department (MMD) and UKM are actively looking at climate change projections in Malaysia, the RegHCM-PM (NAHRIM's Regional Hydro-climate Model of Peninsular Malaysia) is the basis for the vulnerability assessment and consequent adaptation measures for the 7 vulnerable sectors, and similar study has been started for East Malaysia (Sabah and Sarawak) (July 2007) (Zakaria and Jamalluddin, 2007).

Gaps Identified in Programmes and Studies

Information that is needed to forecast water availability includes improved estimation of regional population growth, land use changes, and likely shifts in water demand as a result of demographic and economic changes. In addition, improved information on the likely range of climatic conditions is an important prerequisite for a better formulation of adaptive and abatement measures (MOSTE, 2000).

Although it can be said that Malaysia has sufficient water resources to meet population needs, there are some water-related problems, related with managing water effectively to achieve objectives. In some river basins, there is already the problem of water shortage especially during periods of prolonged droughts, and conversely, the problem of excessive water and floods during the wet season. The most challenging issue is to coordinate activity from various government agencies and private sector in managing the watershed. River basin should be the basic planning unit but now, rivers are managed on political or administrative boundaries, which do not provide an overall engineering solution (Husaini, 2007).

Reduction of flood and drought losses has to involve a number of government agencies and often the private sector. For example, reservoirs for irrigation, water supply and flood mitigation have conflicting operational rules. Development of common objectives and definition of clear roles for each of the stakeholders as well as close cooperation and understanding is needed to be efficient and successful. Also, the implementation and formulation of flood and drought management action plans cannot be done without cooperative integration of all stakeholders. (Husaini, 2007)

The MSMA is only a guideline, and DID has no legal authority to enforce the manual as mandatory procedure to local authorities, developers, contractors etc. Although at present proposed development programs have been based on those master plans, few problems arise during the implementation: local authorities are facing insufficient technical expertise and financial limitation to provide adequate maintenance of constructed drainage systems; developers consider the utilization of the manual as an increase to the project's cost; contractors find that maintenance of erosion controls and sediment traps are not common works to them; consultants are still very weak on the concept of urban stormwater design. Without

widespread application of the manual guidelines, effective flood and drought management for urban areas will continue to be hindered (Husaini, 2007).

The Ninth Malaysia Plan is missing a full chapter on sustainable water resource management in the country, that includes a holistic and integrated approach on water resources management (IWRM and IRBM). Also on how economic development, unless properly planned and executed, can exacerbate pollution, floods, forest fires, develop extreme climate events following climate change. And how better integrated, managed, monitored and enforced development of infrastructure can provide not only better returns but provide better managed environment, including, water supply, flood and pollution abatement in those very areas. The National Water Resources Study (for Peninsular Malaysia) Mac 2000 and the Master Plan for the Development of Water Resources in Peninsular Malaysia (2000-2050) did not take into account potential change of hydrologic regime and water resources due to climate change (Zakaria and Jamalluddin, 2007).

The NHRIM recalls that Climate Change projection have to be studied further and translated into how it will impact the social and economic sectors (agriculture, forestry, bio-diversity, coastal resources, water resources, public health & energy) of Malaysia. Expected changes in water availability by the year 2050 requires a review of the current water resources plans in the various sub-sectors and states of Peninsular Malaysia. Further downscaling studies using other GCM's (ECHAM5- MPI Germany, MRI-CGCM2.3.2- MRI Japan, CM2.1-GFDL USA, CGCM3.1-Canada) are needed and also further research on the future hydrologic regime is required (rainfall/streamflow characteristics at finer temporal and spatial timescales) (Zakaria and Jamalluddin, 2007).

"What is needed is a framework for managing water resources in a sustainable manner with climate change mitigation and adaptation measures embedded in it", and its goals should be equal distribution of water between the sectors, clean and vibrant rivers and water bodies, Malaysia's biodiversity recognized, protected, thriving and contributing to the country's economy. Floods, erosion, landslides and other land & water related challenges (including due to climate change), should be well managed and under control; all to reach a Water Resources Management fully integrated throughout the country (Zakaria and Jamalluddin, 2007).

Agriculture and Food Security Sector

Agriculture in Malaysia contributes to about 10% of the total GDP and at least a third of the country's population depends on the agriculture sector, with some 14% working in farms and plantations. Changes in climate will affect the agriculture sector in term of production as well as the impacting socio-economic problems to the people involved in the sector and the nation as a whole (Kamal, 2007). From the land use perspective, about 39.2% of total land use or about 5.18 million hectares are planted with tree crops like rubber, oil palm, cocoa, coconut, fruits and vegetables.

Range of Studies Reviewed and Methods Applied

No methods were found in the studies reviewed, the studies include, Siwar et al., Kamal (2007), Ramadasan et al. (2001), Ziska et al. (1997), Al-Amin and Chamhur (2008), etc., which all consider and review the impacts of climate change on Malaysian agriculture, as a key economic sector, and establishing linkages with sustainability and poverty.

Impacts on the Agricultural and Food Sector

Agriculture is one of the sectors that is greatly affected by extreme climate change and it is proved that it has an important role on crop development. The climatic factors like the amount of rainfall, sunshine hours, temperature, etc. result in year-to-year variability of crop production, as well as physical damage, lost of crop harvest, drop in productivity, vigour and others. Also high temperatures and reduction of rainfall induce loss of soil moisture, reducing the water available for irrigation and damaging crop growth in non-irrigated regions (Siwar et al., 2009). Climate change is one of the major potential threats to national food security and agriculture for a country. As the change of climate is a continuous and long-term process, its impacts will continue for long successive years.

Changing climate affects the agriculture industry; for example, increasing rainfall is not good for rubber, which will also suffer due to lost of tapping days and crop washouts. However, some other crops like oil palm could flourish with higher rainfall, considering that excessive rainfall is detrimental but may be negatively affected in temperature raise scenario that causes drought (Ramadasan et al., 2001). It was reported that flood related problems in southern Malaysia had decreased the production of crude palm oil to 1.1 million metric ton or 26.3% in December 2006 (Kamal, 2007).

The impact of climate change on agriculture (rice) production has been a subject to many scientific researches due to its important on human being. The actual farm yields in Malaysia vary from 3-5 tons/ha. The rice crop, in general responds positively to an increase in atmospheric CO₂ concentration; there is an increase in rates of rice crop in CO₂ concentration from 160 ppm to 900 ppm. However the yield response to CO₂ varies with cultivars, location and management practice and also the negative effects occur in unexpected high or low temperature (Siwar et al., 2009). Generally, the effect of increasing temperature above the tolerance limit on rice production is negative because the photosynthesis is reduced, the respiration is increased and the vegetation and grain-filling periods are shortened. The average temperature in rice-growing areas in Malaysia is about 26°C. An examination of the current climate change scenario under different future climate change indicates that temperature above 25°C may decline grain mass of 4.4 % per 1°C rise and grain yield may decline as much as 9.6 to 10%. Similar results were found by Ziska et al. (1997) and they mentioned those flowering and grain-filling periods were affected by an increase in temperature above the present ambient level. It was found on rice production in Malaysia that rice yield declines from 4.6% to 6.1% per 1°C under the present CO₂ level. Greater yield reduction is envisaged with increasing temperature at higher level. However, a doubling of CO₂ concentration (from present level 340 to 680ppm) may offset the detrimental effect of 4°C rise in temperature (Al-Amin and Chamhur, 2008).

The sustainability of food supply can also be affected by climate change because of variations in yields due to changes in rain and temperature that also could fasten the spread of fungus, insects and diseases due to the fact that the range of insects will expand or change, and new combinations of pests and diseases may emerge as natural ecosystems respond to shifts in temperature and precipitation profiles; thus affecting yield. States that are most vulnerable to these changes are in the northern Peninsular Malaysian region as well as the coastal regions of Sabah and Sarawak (Kamal, 2007). The effect of climate on pests may add to the effect of other factors such as the overuse of pesticides and the loss of biodiversity which already contribute to plant pest and disease outbreaks (Al-Amin and Chamhur, 2008).

With regards to irrigation supply for agriculture and food production, water shortages are also experienced in varying degree of severity, and in the past, prolong

droughts have resulted in the delay or cancellation of the paddy planting season. During such occasions, the paddy farmers whose livelihood depends mainly on paddy cultivation would be seriously affected. As for the whole country, the impact of drought on food production can be very serious, given that there are about 322,000 hectare of irrigated paddy fields and another 278,000 hectare of rain-fed paddy fields producing about 2.5 million tonnes of paddy per annum. DID, in fact, is very concerned with the supply of water for irrigation, especially for small irrigation schemes, during a drought. This is because about 70 % of the total water consumption in this country is utilized for irrigated agriculture (Husaini, 2007).

Other impact is related with sea level rise; the nation-wide loss of about 80,000 ha of land planted with rubber due to flooding as a result of the combination of increased rainfall and sea level rise of 1 m; also the abandonment of about 100,000 ha of land planted with oil palm in the event of a 1 m rise in sea level (MOSTE, 2000).

Vulnerability and Adaptation in the Agricultural and Food Sector

Vulnerability is defined in terms of yield, farm profitability, regional economy and hunger considering uncertainty about future climate-change impacts. According to the projection, in the long term, climate change is an additional problem that agriculture faces in meeting national food requirements. Since it is likely that some climate change will occur over the next 50-100 years, 'adaptation' has been suggested as the means to reduce the impact of climate change on individuals and societies (Siwar et al, 2009).

In Malaysia there are some national policies regarding adaptation and mitigation to climate change, but also specific adaptation measures are necessary to manage sectoral impacts. In the agriculture sector, adaptation measures are vital to ensure sustainability of the agriculture activities. These measures include (Kamal, 2007):

- The use of agro-climatic classification in agricultural planning: The Department of Agriculture drafted an agro-climatic map of Peninsular Malaysia based on the agriculture rainfall index (ARI) in 1990. Ten agro-climatic zones were identified according to the number of consecutive dry and consecutive wet months. The agro-climatic maps defined the various regions according to the variations in

environmental requirements of different crops as well as on the regional differences of the natural environment, particularly climate and soils.

- The use of Soil Suitability Criteria for crop production: Physical and chemical properties of the soil affect crop production. Soil depth, texture, clay fraction, soil structure, bulk density and available soil moisture are among the major soil physical properties that affect crop production. Soil reaction, cation exchange capacity and nutrient composition are the soil chemical properties, important in crop production. By considering these properties in soil suitability classification, the success of a crop production endeavour can be ensured with a reasonable margin of safety.
- Others adaptation measures include: develop plant varieties that are tolerant to high temperatures and high water use efficiency; preserve Permanent Forest Reserves and water catchment areas to ensure adequate water supply for agriculture; strengthen agricultural extension services (soil conservation measure and production efficiency); strengthen Integrated Pest Management (IPM) and bio-control procedures to deal incidences of pest and diseases; improve regional and international cooperation on agriculture-climate change related issues; and introduce agriculture insurance to minimize risk related to climate change

Some other strategies proposed by the Malaysian Agriculture and Research Development Institute (MARDI) are changing management and breeding by using alternative species (regarding nutritional quality, social acceptability, environmental suitability), using alternative cropping systems (considering social acceptability and environment suitability) and including water management (in means of conservation, irrigation and water pricing) (Abdullah, 2008).

Gaps Identified in Programmes and Studies

The third National Agricultural policy makes no references to the climate change threat and to the necessity of adaptation.

Regarding rice crops, drought and flood resistant varieties need to be introduced. There is a need to generate crop varieties with improved water-use

efficiency suited to production with reduced water inputs (Abdullah, 2008)

There are still some uncertainties like the magnitude of the change, the technology available, the crop and pest responses, what the adaptation measures are, lack of policies, and lack of methods of assessment (Abdullah, 2008).

Socio-Economic Sector

Range of Studies Reviewed and Methods Applied

The Initial National Communication uses three scenarios for sea level rise (20 cm, 50 cm, and 90 cm) during the year of 2100 were examined. The biophysical impacts were assessed based on previous studies, but updated and aggregated to the national level. The assessment of socio-economic impacts is based on empirical work done on the project scale, and it quantifies the economic implications that come up from the projected biophysical impacts. To solve the difficulty of extending the project scale to national level, a simple linear extrapolation based on shoreline length and area extent was used for aggregation purposes. The projected economic loss associated with increased flooding, which comprises primarily damage to, and replacement/upgrading of, infrastructure, disruption of economic activity, and relocation of flood victims, is to be viewed as the worst-case scenario. (MOSTE, 2000)

Impacts on Socio-Economic Sector

The described impacts on water resources include an increase in the flood intensity and frequency, which may vary the costs of proposed flood mitigation plans to contain flood volumes. The cost and implications for existing plans and drainage systems are more serious due to the fact that double frequency of the design event, means a doubling of the frequency of the system 'failure', which is also a highly social and economic costs on modifying the infrastructure to cope with more frequent and severe flooding (MOST 2000). Consequently, occurrence of such disasters, could impact damaging effect on the economy, social and psychology of the people affected. Floods in Johor (2006-07) displaced 110,000 people, damaging an estimate of RM 0.35 billion worth of infrastructures and RM 2.4 billion of economics losses. An estimate of RM 84 million worth of agriculture produce were damaged or losses affecting 7000 farmers. About 9% of the land area in Malaysia (2.97 million ha) is in flood level and 3.5 million people have become victims. Monetarily, it is difficult to estimate the quantum but a conservative figure of RM 100 million

has been used to estimate the average flood damage per year (Kamal, 2007).

Besides, changes in water availability causing reductions in surface runoff rise up the needing of providing storage capacities by dams and reservoirs, which must be developed to ensure the steady supply of water through a prolonged period of dryness. An estimated cost (in 1995) of providing each cubic metre of water at dam site is RM0.20. Thus, the annual cost of augmenting the 20% loss in domestic and industrial water supply of 3,806 million m³ per annum would be RM152 million (MOSTE, 2000).

Concerning to sea level rise the biophysical impacts are classified in tidal inundation, shoreline erosion, increased wave action, and saline intrusion. In all categories, the worst impacts are found at the highest rate of sea level rise (0.9 cm/year), where mangrove belt is projected to be lost, the shoreline erosion will increase in a 30% to the existing rate, because of a deeper water in the surrounding seas, larger waves are projected to break along the coastline and structural integrity of coastal facilities such as, public infrastructure and installations would be under risk (MOSTE, 2000).

The Initial Communication makes estimation on the cost of the impacts caused by sea level rise. The loss of agricultural production from eroded and inundated lands is estimated on RM 46 million for Western Johor Agricultural Development Project area that accounts for 25% of national drainage areas. Long-term annual flood damage causing displacement and relocation of flood victims with disruption of economic activities resulting is estimated at about RM88 million for Peninsular Malaysia and RM12 million for Sabah/Sarawak based on 1980 price level. If the flood frequency is doubled, the annual flood damage will increase by 1.67 times. Also a loss of fisheries production due to mangrove loss will represent a loss of RM300 million based on 20% loss of mangrove resulting in a loss of about 70,000 tonnes of prawn production (MOSTE, 2000).

Vulnerability and Adaptation in Socio-Economic Sector

The incidence of poverty and hardcore poverty among Malaysians decreased from 8.5% and 1.9% in 1999 to 5.7% and 1.2% in 2004, respectively, due to the successful implementation of poverty eradication programs and favourable economic growth. In Malaysia, the incidence of hardcore poverty shows higher for the states of Sabah, Terengganu, Perlis, Kedah and Kelantan compared to the other states.

From those, Terengganu, Kelantan, Perlis, Kedah and Perak are the most vulnerable states in terms of hardcore poverty and projected temperature and rainfall changes. Also the most vulnerable peoples due to climate change are the poor and hardcore poor who have relatively larger household members (Siwar et al, 2009).

The Initial Communication gives a series of adaptation measures that are based on defence (building bunds/seawalls/levees/dykes/etc.), accommodation, to retreat, which includes the relocation of affected people on a proactive way to avoid adverse impacts. An innovative measure is to transfer the line of defence seaward and reclaim the intervening area. This measure has the added advantage of being able to incorporate the projected sea level rise into its planning and design and has become popular in large segments of the west coast of Peninsular Malaysia. The Coastal Land Buyback is a proactive approach to convert private ownership to public domain and left the land as a nature reserve/corridor within which the natural variation of shoreline movement is permitted to take place. Finally, Malaysia is now in the process of embarking on an ICZM (Integrated Coastal Zone Management) initiative in which the potential impacts of sea level rise are given special consideration in planning, and where previous measures can be considered as components (MOSTE, 2000).

Gaps Identified in Programmes and Studies

The adaptation measures are feasible in the Malaysian context, but additional efforts are needed to quantify them in terms of cost implications. Some of these additional efforts include further research and development in improving the science of prediction of the responses and quantitative bases for estimating impacts and economic costs (MOSTE, 2000).

There is a need to refine the methodology of costing socio-economic impacts through more research as well as to establish a disaster impact inventory. In addition, it is necessary to develop and incorporate economic recovery plans in dealing with disasters. There is also a need to study non-communicable diseases that may result from changes in the climate scenario such as increased stress within residents of small houses or flats as a result of rising temperatures. The management of energy, water and land resources need to be planned to balance demand and supply with adequate emphasis on the management of consumption. More action should be

taken towards providing more information to policy makers to promote information-based decision-making (MOSTI, 2007).

CROSS-SECTORAL INSTITUTIONAL SETTINGS

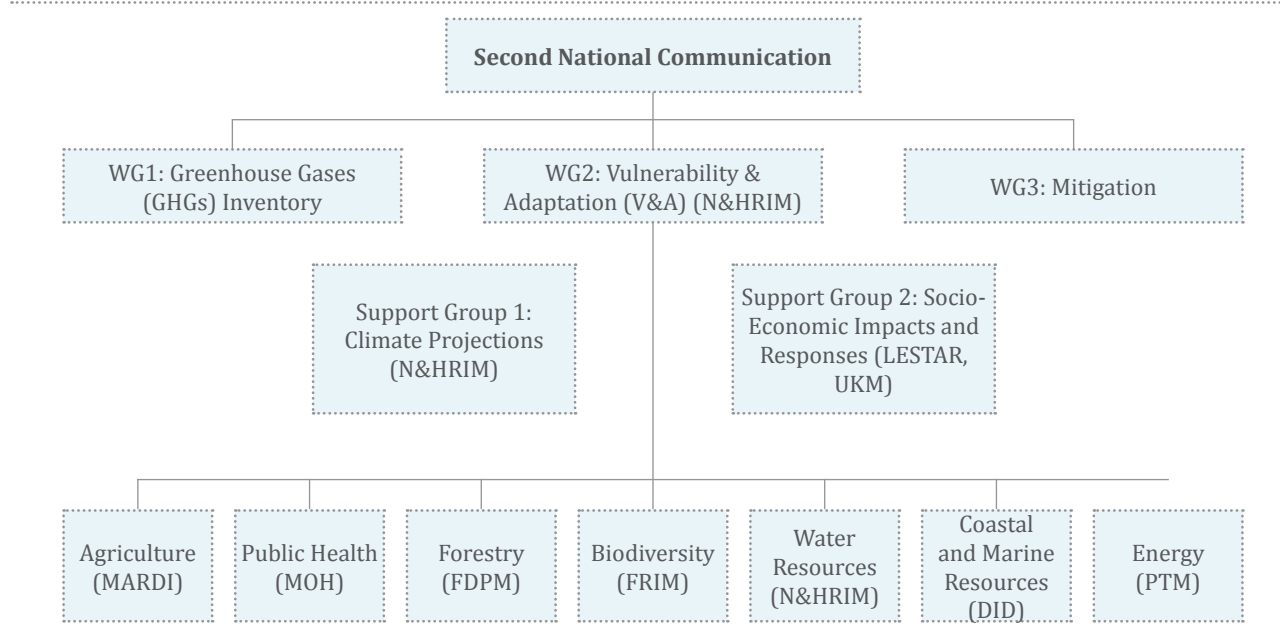
Two different domains could be identified as being cross-sectoral institutional arrangements, i.e. climate change institutions, on the one hand, and institutional settings concerning disaster risk reduction, on the other hand.

Climate Change

Since the Third Malaysia Plan (1976-1980) the environmental concerns are progressively being emphasized in development plans (Hezri and Hasan, 2006). Many ministries formulated policies that have taken into account environmental concerns on sectoral specific context; all these climate related policies in Malaysia include the National Policy on the Environment, National Forest Policy, Biodiversity Policy, National Energy Policy, National Transport Policy (Land) and Third National Agricultural Policy, among others. Although sectoral in nature, these policies also contribute indirectly to addressing climate change (Muthusamy, 2007), however, there is no clear indication of climate change in any of them. Furthermore, there is need for the various policies to be harmonized with each other so that win-win options could be formulated through inter-agency collaboration and coordination for climate change mitigation and adaptation measures. The reviews of the Ninth Malaysia Plan (2006-2010), the currently ongoing development plans, and several national policies reveal some programs that directly or indirectly contribute to managing issues of climate change adaptation and mitigation (Pereira and Tan, 2008).

Climate change is cross-sectoral issue, involving more than environmental concerns, but also affecting economic growth and human well-being. As it has been said, while the past and existing national policies have indirectly addressed climate change concerns under the context of sustainable development, the need to formulate a specific climate change policy is increasingly recognized. In view of this, the Ministry of Natural Resources and Environment of Malaysia in collaboration with the Institute for Environment and Development (LESTARI), University Kebangsaan Malaysia, had conducted the Policy Study on Climate Change. The aim of the study was to develop a

Figure 42: Organisational Structure of National Coordination Bodies facilitating climate change adaptation (Navann, 2009)



National Climate Policy and Strategy on climate change in fostering sustainable development in Malaysia to meet the needs of the country and respond to UNFCCC (Tan et al., 2009) and to guide national activities and strengthen inter-agency collaboration to address climate change. This effort could be further consolidated under the framework of Sustainable Development, which is spearheaded by the Economic Planning Unit.

In general, Malaysia adopts 'precautionary principles' to mitigate and adapt to climate change, even though there are still scientific uncertainties. At the national level, Malaysia has formed a National Climate Committee to formulate and implement strategies on climate change. The strategies drawn include policies on energy usage, public awareness on climate change, food supply and effective forest and coastal management to mitigate deforestation and the rising of sea level (Kamal, 2007).

United Nation Framework Convention on Climate Change: Initial and Second National Communication Malaysia ratified the UNFCCC in July 1994, and in response to obligations under the convention, submitted the Initial National Communication (INC) to the UNFCCC Secretariat in July 2000. The Kyoto Protocol was signed in March 1999 and ratified in September 2002.

Currently the preparation of Second National Communication (NC2) is ongoing to further integrate climate change issues and impacts into

the national and local strategic and development plans. There are three working groups under the NC2: WG 1 - Greenhouse Gases (GHGs) Inventory; WG 2 - Vulnerability Assessment & Adaptation (V&A); and WG 3 - Mitigation (see Figure 55). The WG2 is chaired by NAHRIM and its aim is to undertake an assessment of potential impacts of climate change on several vulnerable sectors and to formulate corresponding adaptation measures. There are seven vulnerable sectors and for each one it has been establish a sub-committee: Agriculture (MARDI), Forestry (FDPM), Biodiversity (FDPM), Water resources (NAHRIM), Coastal and marine resources (DID), Public health (MOH), and Energy (PTM). There are also two support groups under WG2: Climate Projections (NAHRIM) that looks at climate projections studies carried out in Malaysia, based on available climate models and data and Socio-Economic Impacts and Responses (LESTARI, UKM), which looks at socio-economic impact and responses from global warming and climate changes as well as adaptation measures.

Figure 55: Structure for the V&A assessment for the Second National Communication.

Institutional Settings Concerning Disaster Risk Reduction

Situation of Disaster Risk Management

In general, Malaysia has not registered frequent climate related disaster, although lately mild climate

related disasters are being so. These refer to floods and droughts that caused significant socio-economic impacts to the nation while the occurrence of landslides due to excessive rainfall and strong winds happened at the hilly and the latter, at the coastal areas caused minimal damage (Kamal, 2007).

Flood organization: Following the disastrous flood of 1971, which affected many areas in Malaysia, the Government has established the Natural Disaster Relief Committee in 1972 with the task of coordinating flood relief operations at national, state and district levels with a view to prevent loss of human lives and to reduce flood damage. The coordination of relief operations is the responsibility of the Natural Disaster Relief Committee, which is headed by the Deputy Prime Minister of Malaysia in the National Security Council of the Prime Minister's Department (Husaini, 2007).

The committee members consist of various Cabinet Ministers such as the Minister of Finance, the Minister of Social Welfare, the Minister of Natural Resources and Environment, the Minister of Science, Technology and Innovation, senior government officials such as of the Government's Chief Secretary, the Army General, and related government agencies/departments such as DID, MMD, MACRES, Social Welfare Department, Police Department and Fire and Rescue Department (Husaini, 2007).

Procedure in case of risk: In accordance with the Operating Procedure under the flood relief mechanism, when the river stage of any flood warning station reaches the Alert Level, DID begins to monitor closely the flood situation. When it reaches Warning Level, DID will inform the relevant flood control centers so that flood relief mechanism shall be activated. At Danger Level, considerable areas are flooded and will warrant evacuation of flood victims. During the flood season, the respective state DID office shall carry out flood forecast operation using real-time telemetric data (rainfall and river water level) and river forecasting computer models. When the river water level at any forecasting point exceeds critical level, the forecasts shall be transmitted to the Flood Operation Centers and other relevant agencies such as the National Security Division of the Prime Minister's Department and the National and State (Police) Control Centre for flood relief/operation (Husaini, 2007).

To date, DID has established about 335 telemetric rain-gauges and 208 telemetric water level stations in the vicinity of 40 river basins for real time flood

monitoring. At these stations, three critical flood levels are designated, namely Alert, Warning and Danger. In addition, 400 river observation points are provided with manual flood gauges and more than 250 siren stations has been established (Husaini, 2007).

Gaps Identified

The convergence of disaster and climate change management should be mainstreamed into national policies, programmes and plans as both are cross-sectoral issues. Although the institutional capacity in the country is capable of managing disasters, there is still much room for improvement. The existing mechanism for stakeholder consultation is insufficient and requires enhancement as it is both the responsibility of government and the community in dealing with issues pertaining to disasters. In addition, current sectoral approaches need to be changed, with reference to the Hyogo Framework Action, which emphasises mainstreaming disaster management into planning (MOSTI, 2007).

SUMMARY OF IDENTIFIED KEY GAPS, CONSTRAINTS AND CHALLENGES

Along this report some gaps has been detected in the different sectors reviewed. The country faces challenges including the lack of environmental data to monitor environmental policy management and implementation, sustainable transportation fuels and the optimum use of renewable and fossil fuel energy. At the regional level, there is need for climate change adaptive measures (Malaysia, 2007)

Regarding governance, in order to be effective, national policies must be adopted and implemented by the state authorities without amendments. It was highlighted that sound planning can still fail in the absence of enforcement at the operational level. Thus, plans made at the national level need to be implemented effectively at the local level without any political interference. Furthermore, the roles and responsibilities of all stakeholders should be clarified and participation of industry players in addressing climate change should be enhanced.

There are no doubts that the political commitment to manage hazards exists as demonstrated by the construction of the SMART Tunnel, the tsunami recovery plan and the December 2006 flood recovery plan, among others. Notwithstanding this, adaptation measures are necessary and should be given more

priority, especially in the next 20-30 years. In addition, mitigation measures should also be taken into account and the policy options that could be explored may be either regulatory or economic in nature with instruments such as trading permits, carbon tax and tax rebates. Thus, the challenge lies in balancing adaptation and mitigation measures.

At Present there is no specific policy for every economic sector to address the Global Warming-Climate Change Threat as it affects the individual sectors (productivity). At best is to adhere to best practices to minimize environmental degradation and natural resources exploitation as strategized in objectives of the 9th Malaysia Plan and the National Environmental Policy (Salleh, 2007).

Regarding water gaps, information that is needed to forecast water availability includes improved estimation of regional population growth, land use changes, and likely shifts in water demand as a result of demographic and economic changes. In addition, improved information on the likely range of climatic conditions is an important prerequisite for a better formulation of adaptive and abatement measures (MOSTE, 2000).

Although it can be said that Malaysia has sufficient water resources to meet population needs, there are some water-related problems, related with managing water effectively to achieve objectives. In some river basins, there is already the problem of water shortage especially during periods of prolong droughts, and conversely, the problem of excessive water and floods during the wet season. The most challenging issue is to coordinate activity from various government agencies and private sector in managing the watershed. River basin should be the basic planning unit but now, rivers are managed on political or administrative boundaries, which do not provide an overall engineering solution (Husaini, 2007).

Reduction of flood and drought losses has to involve a number of government agencies and often the private sector. For example, reservoirs for irrigation, water supply and flood mitigation have conflicting operational rules. Development of common objectives and definition of clear roles for each of the stakeholders as well as close cooperation and understanding among is needed to be efficient and successful. Also, the implementation and formulation of flood and drought management action plans cannot be done without cooperative integration of all stakeholders. (Husaini, 2007).

The MSMA is only a guideline, and DID has no legal authority to enforce the said manual as mandatory procedure to local authorities, developers, contractors etc. Although at present proposed development programs have been based on those master plans, few problems rise during the implementation: local authorities are facing insufficient technical expertise and financial limitation to provide adequate maintenance of constructed drainage systems; developers consider the utilization of the manual as an increase to the project's cost; contractors find that maintenance of erosion controls and sediment traps are not common works to them; consultants are still very weak on the concept of urban stormwater design. Without widespread application of the manual guidelines, effective flood and drought management for urban areas will continue to be hindered (Husaini, 2007).

In the Ninth Malaysia Plan is missing a full chapter on sustainable water resources management in the country, that includes an holistic and integrated approach on water resources management (IWRM and IRBM); how economic development, unless properly planned and executed, can exacerbate pollution, floods, forest fires, develop extreme climate events following climate change; and how better integrated, managed, monitored and enforcements of infrastructure development can provide not only better returns but provide better managed environment, including, water supply, flood and pollution abatement in those very areas. The National Water Resources Study (for Peninsular Malaysia) Mac 2000 and the Master Plan for the Development of Water Resources in Peninsular Malaysia (2000-2050) did not take into account potential change of hydrologic regime and water resources due to climate change (Zakaria and Jamalluddin, 2007).

The NHRIM recalls that Climate Change projection have to be studied further and translated into how it will impact the social and economic sectors (agriculture, forestry, bio-diversity, coastal resources, water resources, public health & energy) of Malaysia, that expected changes in water availability by year 2050 require a review of current water resources plans in the various sub-sectors and states of Peninsular Malaysia, that further downscaling studies using other GCM's (ECHAM5- MPI Germany, MRI-CGCM2.3.2- MRI Japan, CM2.1-GFDL USA, CGCM3.1- Canada) are needed and also further research on the future hydrologic regime (rainfall/ streamflow characteristics at finer temporal and spatial timescales) (Zakaria and Jamalluddin, 2007).

“What is needed is a framework for managing water resources in a sustainable manner with climate change mitigation and adaptation measures embedded in it”, and its goals should be equity distribution of water between the sectors, clean and vibrant rivers and water bodies, Malaysia’s biodiversity recognized, protected, thriving and contributing to the country’s economy, floods, erosion, landslides and other land & water related challenges (including due to climate change), well managed and under control; all to reach a Water Resources Management fully integrated throughout the country (Zakaria and Jamalluddin, 2007).

In agriculture, the third National Agricultural policy makes no references to the climate change threat and to the necessity of adaptation. Regarding rice crops, drought and flood resistant varieties need to be introduced. There is a need to generate crop varieties with improved water-use efficiency suited to production with reduced water inputs (Abdullah, 2008). There are still some uncertainties like the magnitude of the change, the technology available, the crop and pest responses, what the adaptation measures are, lack of policies, and lack of methods of assessment (Abdullah, 2008).

As for socio economic aspects, the adaptation measures are feasible in the Malaysian context, but additional efforts are needed to quantify them in terms of cost implications. Some of these additional efforts include further research and development in improving the science of prediction of the responses and quantitative bases for estimating impacts and economic costs (MOSTE, 2000).

There is a need to refine the methodology of costing socio-economic impacts through more research as well as to establish a disaster impact inventory. In addition, it is necessary to develop and incorporate economic recovery plans in dealing with disasters. There is also a need to study non-communicable diseases that may result from changes in the climate scenario such as increased stress within residents of small houses or flats as a result of rising temperatures. The management of energy, water and land resources need to be planned to balance demand and supply with adequate emphasis on the management of consumption. More action should be taken towards providing more information to policy makers to promote information-based decision-making (MOSTI, 2007).

The convergence of disaster and climate change management should be mainstreamed into national policies, programmes and plans as both are cross-sectoral issues. Although the institutional capacity in the country is capable of managing disasters, there is still much room for improvement. The existing mechanism for stakeholder consultation is insufficient and requires enhancement as it is both the responsibility of government and the community in dealing with issues pertaining to disasters. In addition, current sectoral approaches need to be changed, with reference to the Hyogo Framework Action, which emphasises mainstreaming disaster management into planning (MOSTI, 2007).

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