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Climate Change Adaptation and Livelihoods in Inclusive Growth: A REVIEW OF CLIMATE CHANGE IMPACTS AND ADAPTIVE CAPACITY IN CAMBODIA



NANG Phirun

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Responsibility for ideas, facts and opinions presented in this research paper rests solely with the author. His opinions and interpretations do not necessarily reflect the views of CDRI.

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Acronyms and Abbreviations

AIT	Asian Institute of Technology
CARE	Cooperative for Assistance and Relief Everywhere
CBA	Community-based Adaptation
CBNRM	Community-based Natural Resource Management
CDC	Cambodian Development Council
CDRI	Cambodia Development Resource Institute
CF	Community Forestry
CFi	Community Fisheries
CMA	Cambodia Microfinance Association
CMDG	Cambodia Millennium Development Goal
CPA	Community Protected Area
CVCA	Climate Vulnerability and Capacity Analysis
DANIDA	Danish International Development Agency
FAO	Food and Agriculture Organisation
FWUC	Farmer Water User Community
GDP	Gross Domestic Product
GWP	Global Water Partnership
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
LI	Learning Institute
MAFF	Ministry of Agriculture, Fisheries and Forestry
MOE	Ministry of Environment
MOP	Ministry of Planning
MOWA	Ministry of Women's Affairs
MOWRAM	Ministry of Water Resources and Meteorology
MRC	Mekong River Commission
NAPA	National Adaptation Programme of Action to Climate Change
NTFP	Non-timber Forest Products
OECD	Organisation for Economic Cooperation and Development
PACT	Pact Cambodia
PIMD	Participatory Irrigation Management and Development
REDD	Reduced Emissions from Deforestation and Degradation

RGC	Royal Government of Cambodia
Sida	Swedish International Development Agency
TWGAW	Technical Working Group on Agriculture and Water
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNIFEM	United Nations Development Fund for Women
USAID	United States Agency for International Development
USD	United States Dollar
WEN	Women's Environmental Network
WWF	World Wildlife Fund

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Executive Summary

This review outlines existing knowledge (context-specific and localised) of climate change impacts, vulnerability and adaptation, assesses the limitations of different frameworks and approaches used by various initiatives in Cambodia, and identifies knowledge gaps for future research. It explores the impacts of climate change on livelihoods through three dimensions: (1) agricultural practices, technology, policy, irrigation, credit and markets; (2) community-based natural resources management and the roles of forest, fishery and water-user communities in protecting and managing resources; and (3) gender considerations. Analysis draws on existing literature on climate change impacts and adaptation, natural resources management, agricultural and livelihood development, and governance mechanisms, especially as they relate to climate change adaptation as an opportunity to promote inclusive growth.

Majority of rural Cambodians rely on natural resources – mainly water, fisheries, forests and land – and agriculture for their livelihoods. Inadequate irrigation systems supply insufficient water leaving majority of men and women farmers dependent on rainfall distribution, which is vulnerable to climatic variability. Aware of the threat that climate change poses to food and water security and recognising that future agricultural development depends on effective land and water management, the Royal Government of Cambodia has committed to increasing rice production and to adopting the principles of integrated water resource management.

Good governance and effective water resource management can help minimise the impact of water shortages caused by climate change. Effective irrigation development and management can provide water security for agriculture and protect against natural disasters like flood and drought. Other key adaptation strategies for agriculture include the improvement and development of high-yielding flood-resilient and drought-resistant crop varieties, resource efficient crop management and agricultural practices, capacity to adapt to climate extremes, early warning alarm/alert system, irrigation infrastructure and flood protection in lowland areas, and food crop diversification.

To ensure sustainable natural resources management and inclusive economic growth, government has continuously improved sectoral development strategies to flow social, economic and environmental benefits to all segments of the population, particularly local communities. These efforts involve the creation of community-based natural resource-user management groups (protected area, forest, fishery, and water-user communities) to manage and protect local resources. However, limited human and financial resources constrain communities' capacity to effectively and sustainably manage and protect those resources against the adverse effects of development and climate change.

Households with limited resources or that rely heavily on one livelihood source, likely the poorest dependent on fishing, paddy farming, or collecting non-timber forest products stand to be the most affected by natural system and human-induced changes. Climate change is likely to intensify water demand and supply problems, mainly access to water for irrigation, agriculture, domestic and industrial use. Yet the combined impacts of climate change and economic development on agriculture, natural resources, livelihoods and ecosystems remain largely unknown.

Men and women likely perceive and experience climate change differently. Women and girls make up majority of the poor and bear a disproportionate burden of climate change

impacts. For example, in flood conditions women have to spend more time collecting food for the household and caring for children, which impinges on their farming and daily income; they are often pushed into debt in order to cope. Similarly, water shortages for agriculture, fisheries, riverbank gardens and floodplain farming severely affect the daily livelihoods and food security of women and marginalised groups. The challenges posed by climate change, especially to food security, are directly relevant to women who play a vital role in food production and provision, child nutrition and income generation.

Rural communities are in the frontline of drought, flood and other climate-related risks since their daily subsistence mainly depends on natural resources. Through long experience of extreme weather conditions, men and women farmers have adopted various techniques and tools in response to climate stresses and hazards, from smallholder inter/mixed-cropping and mixed crop-livestock systems to agricultural intensification and diversification, agroforestry, water efficiency and irrigation management, and better livestock husbandry. Few studies, however, focus on how to strengthen farmers', especially women farmers', adaptive capacity, or identify practical mechanisms to develop local adaptation strategies to build resilience to climate change and development impacts.

Climate change is complex and impossible to address in isolation from natural resource management, agricultural development, livelihood improvement, food and water security, energy poverty, and gender mainstreaming. The integration of social, economic and environmental dimensions into cohesive natural resources management, climate change adaptation, and sustainable agriculture development policies and actions would ensure inclusive economic growth. Sectoral development strategy to bring equitable social, economic and environmental benefits to the population, especially resource-user groups, should be continuously improved and strengthened by government institutions, local authorities and communities, development partners and civil society organisations.

Changes in natural systems and declining availability of and access to main livelihood-supporting resources have intensified the vulnerability of local livelihoods, especially of women and marginalised groups (the poor, female-headed households, people with disabilities). Gender mainstreaming in policy formulation and actions will help ensure that women have access to services, especially agricultural extension services, awareness raising and information on climate change adaptation and resilience.

Climate-smart agriculture improves agricultural productivity and income generation, bolsters livelihood and ecosystem resilience, and reduces and removes greenhouse gas emissions from the atmosphere while offering the potential for sustainable productivity and food security (FAO 2011). Modern irrigation and agricultural technologies and irrigation expansion are essential to improve farming systems, increase productivity, support income generation, and protect against flood, drought and other climate change-related risks.

Policy Considerations and Future Directions for Action

National Level (Policy Makers, Development Partners, Academics)

- Improve cross-sectoral coordination for coherent policy interventions, research and information sharing, incentive mechanisms and financial supports that foster the uptake of new strategies and technologies to cope with the uncertainties of climate change.

- Integrate adaptation initiatives into agriculture and irrigation system development and natural resource management to reduce vulnerability and secure agricultural productivity and sustainability of land, forests, water and fisheries that support daily livelihoods.
- Strengthen community-based natural resource management (CBNRM) and adaptation (CBA) while minimising unfair governance practices, inequalities and lack of livelihood diversification opportunities that weaken resilience.
- Improve women's access to economic opportunities, credit, financial support, research and professional training, and agricultural extension and services that respond to their needs.
- Address challenges to the formulation and implementation of gender-related policies in natural resources management, particularly climate change adaptation and water security for agriculture.
- Promote gender equity, women's livelihoods, and women's political representation.
- Create conditions conducive to women's greater participation in adaptation initiatives, which is critical to building local community resilience and eradicating poverty.
- Apply a "gender lens" to all aspects of policy formulation and development planning, particularly in the agriculture sector, to ensure that benefits reach both men and women.

Sub-national Level (Practitioners, NGOs, CSOs, Private Sector)

- Build capacity to manage the environment, reduce disaster risks, and adapt to climate variability and unexpected climate changes in the short and medium term.
- Strengthen coordination between and within state departments, community organisations, private sector agencies, CSOs and research/academic institutions to improve CBNRM and CBA.
- Heighten law enforcement to eliminate illegal activities that threaten natural resources and the environment.
- Monitor economic development activities to ensure they follow state policies aiming at sustainable natural resources use and local livelihood and national economic improvement.
- Invest in smart-agriculture development and climate resilient livelihoods, and explore new opportunities, practices and technologies that help farmers cope with climate change impacts.
- Upgrade agricultural extension services and weather and climate variability forecasting and information sharing.
- Support gender mainstreaming and women's greater participation in decision-making and implementation processes for climate change adaptation.

Community Level (Local Authorities, CBNRMs, NGOs, CSOs, Private Sector)

- Improve coordination between provincial departments, NGOs and private sector agencies to build the capacity of resource-user communities and foster their greater involvement in decision-making on natural resource management and climate change adaptation.
- Minimise unsustainable agricultural practices and encourage the adoption of climate-smart agricultural techniques and technologies and livelihood diversification to ensure livelihood resilience.
- Develop community capacity to manage natural resources and adapt to climate change impacts.
- Strengthen community ownership, legitimacy, co-management roles and responsibilities, and local participation (men and women) to ensure the success of CBNRM.
- Establish mechanisms to raise awareness and provide training to men and women in resource-user communities and other vulnerable social groups to enable their participation in and improve the effectiveness of CBNRM and CBA.

Knowledge Gaps and Future Directions for Research

- Water governance, irrigation management and development, fisheries and forest management, agricultural extension services and technology transfer are crucial to securing sustainable agriculture and land, forest, water and fisheries resources that support daily livelihoods. Yet few studies focus on strengthening the capacity of farmers and resource-user communities or designing mechanisms and policies for agricultural development that builds local adaptation and resilience to climate risks. This underscores the need to assess the impacts of climate change on food security and livelihoods and identify opportunities for developing CBNRM and CBA, including measures and options to bolster community livelihoods and capacities to cope with climate hazards. Such study should examine the status of key livelihood-supporting resources and their trends, and ways in which the CBNRM model could contribute to or consolidate community adaptive capacity. Findings can contribute to policy and climate change adaptation and vulnerability reduction measures for integration into land and water management practices that ensure sustainable agricultural development, food security and livelihood improvement.
- People have learned to adapt to seasonal variations in water and related resources in their locality, but their capacity to adapt to rapid environmental changes is weak. The poorest are most at risk because of their homogenous livelihood structures, limited livelihood opportunities, and unjust governance practices. Cambodia is composed of four main agro-ecological zones – Tonle Sap plain, Mekong plain, Mountains/Plateau, and Coastal area – that represent heterogeneous agricultural activities, populations and livelihood systems (MOE & UNDP 2011). This necessitates research into the challenges affecting agriculture and livelihood-supporting natural resources to identify better ways for people facing different local conditions to adapt to climate change. Study should focus on agricultural technologies and practices, adaptive capacities and adaptation strategies within each zone to determine the effects of climate change, the areas and communities most at risk from climate

hazards, and location-specific adaptation strategies. Findings would help shape climate adaptation strategies to better support households and communities and build resilience in those areas.

- Government has committed to using the REDD+ mechanism to protect forests and to improve the livelihoods of communities living in or near forest areas. More recently, the MOE reported that Cambodia plans to expand carbon credit in protected areas and community-protected areas to two million hectares. This highlights the need for research on the potential involvement of the state in CBNRM (organisation, structure, roles and responsibilities) and on carbon credit and REDD+ related policies/mechanisms so that initiatives benefit local communities and the state through livelihood and food security improvement as well as global carbon emission reduction and mitigation. Such study will help identify technical measures to ensure that REDD+ initiatives (and economic development activities) provide short and long-term revenues for the state and local communities as well as practical mechanisms that encourage local communities to protect and conserve the resources they rely on.
- Various studies have reported farmer water-user communities' success and effectiveness in water and irrigation management, but have failed to consider the constraints hindering women's participation in water governance, especially in the context of climate change. Gender mainstreaming in agriculture and water management is critical to ensure that women have equal access to services, especially agricultural extension services, awareness raising and information on climate change adaptation and resilience. Further study on women's roles and gender issues in water and irrigation management in the context of climate change adaptation is vital to identify the critical issues women face and the responses that can best support them. Women's significant roles on community committees and in local administration as well as issues of gender mainstreaming, gender disparities and constraints affecting women's access to resources should be examined. Findings will support the integration of gender-sensitive approaches into water and irrigation management strategies that will help minimise the issues affecting women farmers.

Review findings raise additional questions for future research to answer:

- What are the gaps in agricultural technologies and practices for climate change adaptation?
- What are the roles of women in integrated water resources management and participatory irrigation development and management in the context of climate change adaptation?
- What is the adaptation capacity of rural people facing different conditions in the main agro-ecological zones – Tonle Sap Lowlands, Lower Mekong Plains, Mountains-Plateau and Coastal area?
- How can the CBNRM model be developed to improve climate change adaptation and food security?

1

Introduction

Climate change is recognised as one of the most complex and dramatic challenges facing the world. Universal action to minimise potential damage is critical and it is urgent that actions are taken now. Developing countries, despite efforts to alleviate poverty and promote economic growth, remain the most vulnerable to climate change impacts. Aware of this, policymakers, local communities, private sector actors and researchers have identified and applied a range of adaptation programmes of action on climate change at local, national, regional and international levels.

This literature review summarises existing knowledge of climate change impacts, vulnerability and adaptation and assesses the strengths and weaknesses of the different frameworks and approaches applied by various initiatives in Cambodia. The review is directly related to study conducted under the Cambodia Development Resource Institute (CDRI)/Swedish International Development Agency (Sida) partnership research programme 2011-15, which seeds new research projects on emerging issues of inclusive growth and climate change and associated initiatives for Cambodia's development. The aim of the study is to build on existing knowledge and offer a set of recommendations that may help bridge identified knowledge gaps and address the limitations of existing adaptation frameworks.

The report starts by outlining the climate and the state of agricultural development in Cambodia. Then it looks at the impacts of climate change on livelihoods, agriculture and natural resources, and discusses climate vulnerabilities, existing adaptation strategies and measures, gender issues, and national policies related to sustainable development and inclusive growth. The paper concludes by identifying knowledge gaps, policy issues and future directions for research and action to mitigate climate change impacts and strengthen adaptive capacity in the country.

Methodology and Analytical Framework

2.1. Methods

Desk review was the primary method used to gather information from various secondary sources such as research publications, journal articles, and in-country project reports. Personal communication with key resource persons at national and commune levels provided insights into good experiences, best practices, lessons learned, and gaps and needs on a range of issues concerning climate change impacts, vulnerabilities, adaptation measures and policies.

Knowledge and empirical evidence compiled from the desk review and key informant interviews was used to examine the combined impacts of natural climate changes and anthropogenic changes¹ on natural ecosystems, particularly forests, fisheries (marine and freshwater) and water resources, and agriculture. Analysis of the interactions between human and natural systems helped identify existing adaptive capacities, feasible measures and appropriate strategies to reduce vulnerability and build more adaptive and resilient communities. The impact of climate change on livelihoods and social and environmental factors was also explored. In addition, the status of essential livelihood resources (natural, physical, financial, social, human and political resources) was overviewed to help identify practical adaptation measures and their limitations.

The integration of social, economic and environmental dimensions into cohesive natural resource management, agriculture and climate change adaptation policies ensures inclusive economic growth that shares benefits and responsibilities among all sections of the population (men, women and the marginalised), including local resource-user communities (GWP 2001; WWF 2006; DANIDA 2008; UNDP 2011; Nang *et al.* 2011; OECD 2013). Based on this assumption, the study examined climate adaptation from the perspectives of sustainable development, inclusive growth, good governance and smart agriculture. To identify the limitations of adaptation strategies and gaps in adaptive capacity, the study looked at the application of these four dimensions under different existing natural resource management and climate change adaptation frameworks and approaches: community-based natural resource management (CBNRM), integrated water resource management (IWRM), participatory irrigation management and development (PIMD), climate vulnerability and capacity analysis (CVCA) and community-based adaptation (CBA).

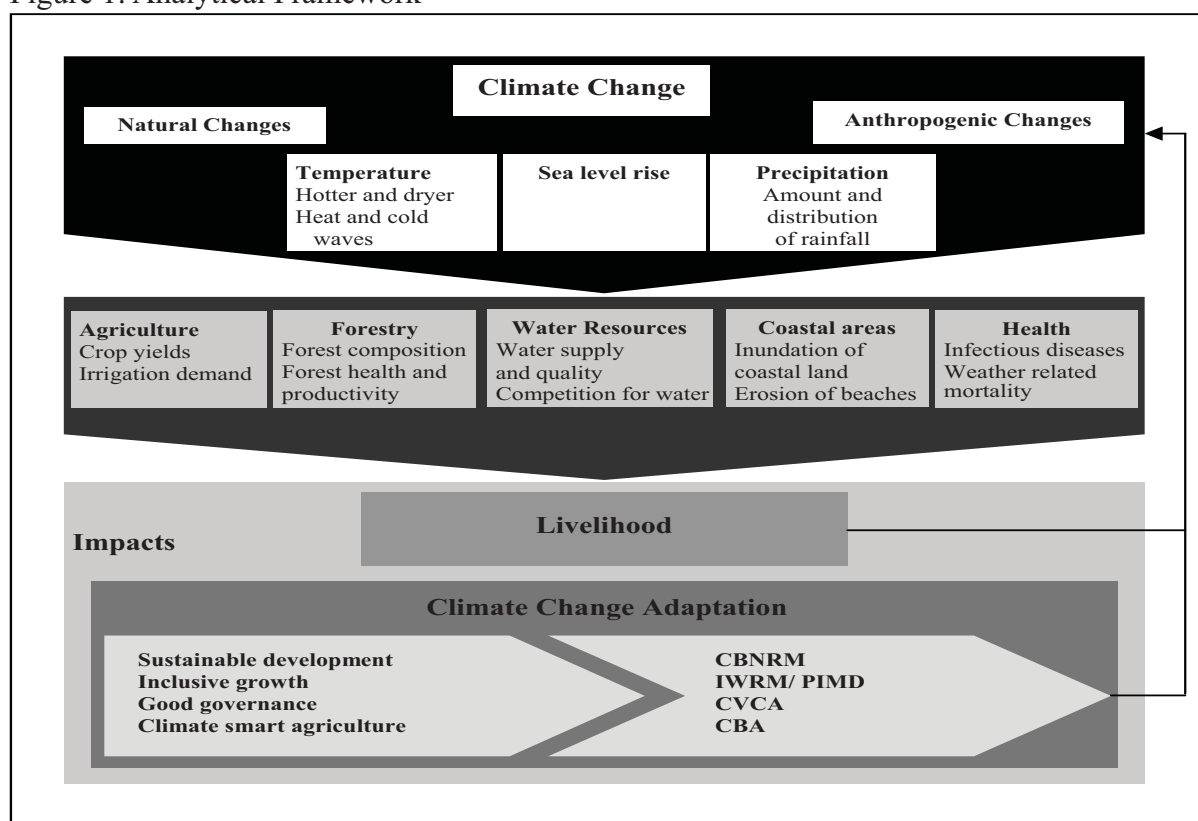
Climate change impacts on men and women differently. To ensure the study outcomes articulate men's and women's vulnerabilities and adaptive capacities equally, gender issues related to water and agriculture formed an important part of the study's approach. Consistent with the Royal Government of Cambodia's directives, in particular CBNRM, the study looked closely at the relationship between climate change adaption and the co-management of natural resources by user groups, namely community protected areas (CPA), community fisheries (CFi), community forestry (CF) and farmer water-user communities (FWUC). The study also reviewed gender mainstreaming activities and the adaptation strategies of women and vulnerable groups as well as their ability to cope with the impacts of climate uncertainties and extremes on their farming and other livelihood activities.

¹ Anthropogenic change refers to environmental changes resulting from human activity.

2.2. Theoretical Perspectives

Climate changes occur as a result of natural variability within the climate system and external factors – both natural and anthropogenic. The influence of these two factors on climate can be compared using the concept of radiative forcing² (IPCC 2001). Besides natural changes (in precipitation, solar output, tropical cyclones, storm surges and so on) that can cause radiative forcing, human activities have also gradually modified ecosystems (ibid.). Some human activities have produced greenhouse gases and aerosols, such as those emitted through the burning of fossil fuels and biomass, which have dramatically altered the composition of the atmosphere. Likewise, economic developments, including land use change for settlement, urbanisation and agricultural expansion, have severely degraded the physical and biological properties of the top soil. These activities have caused increases in radiative forcing and had a remarkable impact on regional and global climate patterns (ibid.). Increasing average temperatures (global warming) drive changes in global weather patterns that create stronger storms, alter the amount and frequency of rainfall and increase sea levels. Climate variability can have tremendous impact on natural ecosystems, agriculture, commercial forests, water resources, coastal areas, and animal and human health (Karl *et al.* 2009; IPCC 2012a).

Figure 1: Analytical Framework



Source: adapted from Rekacewicz (2013)

Note: CBNRM: Community-based natural resources management

IWRM: Integrated water resources management

PIMD: Participatory irrigation management and development

CVCA: Climate vulnerability and capacity analysis

CBA: Community-based adaptation.

² “Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, and is an index of the importance of the factor as a potential climate change mechanism. It is expressed in watts per square meter (W/m²)” (IPCC 2001:36).

“Climate changes will lead to changes in geophysical, biological and socio-economic systems” (Schneider *et al.* 2007:781). Flooding, drought, windstorms and vector-borne disease outbreaks are expected to occur more frequently in the near future. Adaptation to climate change is vital for livelihood security as well as ecosystem integrity. Climate change, however, is complex and cannot be addressed in isolation from sustainable development, natural resource management, good governance, energy poverty, and water and food security (DANIDA 2008; Drexhage & Murphy 2010). In this regard, adaptive capacity is commonly examined through CBNRM and CBA frameworks (GWP 2001; WWF 2006; Cap-Net 2009; UNDP 2009; Chishakwe *et al.* 2012).

CBNRM is an international model for natural resources management. It has gained popularity over the last 20 years as a resource management approach that considers social justice as well as environmental protection (Brosius 1998 cited in Gruber 2013: 1). It is also known as a mechanism for the management of common property and natural resources that people live with and depend on, and which can potentially solve some of the problems within community areas (WWF 2006). The important realisation of CBNRM is that to protect the natural resource base, the people who live with and use natural resources should have authority over their management and benefit from using them because they have a direct interest in the sustainability of the resources upon which they depend (*ibid.*). At the core of CBNRM framework are the principles of participatory democracy and of building networks and linkages both within and among stakeholder groups, levels of government and economic sectors as well as between different disciplines (Gruber 2013). CBNRM promotes cooperative decision-making on access to, control over, entitlement and ownership of community processes and assets. It enables local communities to participate in common property resources management and development initiatives while ensuring equitable opportunities for all community members, including men, women and marginalised groups most vulnerable to the impacts of climate change (Chishakwe *et al.* 2012).

In response to the need for multi-stakeholder (men and women) participation to improve rice production, irrigation systems and livelihoods, the government has incorporated the principles of integrated water resources management (IWRM) with water sector policy. IWRM centres on the sustainable management and development as well as the planning, monitoring, operation and maintenance of water resources to achieve local social, economic and environmental objectives (GWP 2001; Cap-Net 2009). Within IWRM, water development and management takes a participatory approach involving users, planners, policy-makers and implementers at all levels to improve water allocation. The approach provides practical tools for securing equitable access to water and protecting the environment for future generations. IWRM, therefore, can help local communities cope with or adapt to climate changes that challenge water security (excess water or flooding and water scarcity or drought) (*ibid.*).

Recognising the need for greater participation from stakeholders, public and private sector agencies and civil society organisations, participatory irrigation management and development (PIMD) has been incorporated into policy-making and planning. An important aspect of this approach is irrigation management transfer, where responsibility for water allocation and irrigation operation, maintenance and management is transferred from state agencies to local communities or private sector water management/irrigation firms. Within this approach, FWUCs are responsible for the allocation of water and operation of irrigation schemes. Importantly, both PIMD and IWRM promote women’s participation in water and irrigation management.

Climate vulnerability and capacity analysis (CVCA), based on a framework of enabling factors for community-based adaptation (CBA), is used for assessing community vulnerability and adaptive capacity to climate change to design adaptation initiatives that can be integrated into livelihood and natural resource management programmes (CARE 2009). There must be bottom-up approaches to building resilience because the local community is the core factor determining suitable measures to respond to climate change impacts (Chishakwe *et al.* 2012). The essential elements of CBA are capacity building and awareness raising to help build community ownership that underpins the success of adaptation initiatives and community resilience (UNDP 2009).

Community-based participatory frameworks are fundamental for the integration of indigenous and scientific knowledge, and in the process potentially strengthen community adaptive capacity and resilience. Moreover, the frameworks are sensitive to specific challenges faced by vulnerable groups (women and the marginalised) that lack resources to adapt to climate change (GWP 2000; PACT 2009; CARE 2009).

2.3. Some Definitions

Climate change is defined variously in the literature. This study follows the Intergovernmental Panel on Climate Change (IPCC), which describes climate change as “any change in climate over time because of both variation and change in nature or human activity” (McCarthy *et al.* 2001: 984).

Climate change impact refers to “the consequences of climate change on natural and human systems” (McCarthy *et al.* 2001: 989). Changes in weather and climate have been associated with increasing world temperatures i.e. global warming.

Livelihood is defined as “the means by which households obtain and maintain access to the resources necessary to ensure their immediate and long-term survival. These essential resources can be natural, physical, financial, social, human and political. Households use these assets to increase their ability to withstand shocks and to manage risks that threaten their well-being” (USAID 2005:2).

Vulnerability is a key concept in adaptation research. The Mekong River Commission (MRC 2011a: 25) defines vulnerability as “the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity”. Climate vulnerability is an international issue that requires collective action by the global community.

Adaptation is defined by the IPCC as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation” (McCarthy *et al.* 2001: 982).

Adaptive capacity refers to “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences” (McCarthy *et al.* 2001: 982.). Human livelihood systems, economic and natural resources, social networks, institutions, governance and technology can be adapted to build resilience to climate change impacts (Adger *et al.* 2007).

Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN 1987:37).

Inclusive growth is “Growth that not only creates new economic opportunities, but also one that ensures equal access to the opportunities created for all segments of society, particularly for the poor” (Ali & Son 2007:16). It “...is about raising the pace of growth and enlarging the size of the economy, while levelling the playing field for investment and increasing productive employment opportunities” (Saad-Filho 2010: 13). Inclusive growth policies are an important component of various government strategies to ensure sustainable development, poverty reduction, and equal access to opportunities for individuals and firms so they can share the benefits of growth (Ianchonchia & Lundstrom 2009). In terms of economic development, the weaker sections of society including agriculture and small-scale industry must be improved to bring them on par with other sectors (Vighneswara 2010). Growth that distributes benefits more equitably across society is crucial to inclusive growth.

Findings and Analysis

3.1. Climate Change and Agricultural Development

Physiographically, Cambodia is composed of four distinct agro-ecological zones –Tonle Sap, Lower Mekong, Mountains-Plateau and Coastal. Cambodia has a tropical monsoon climate with two seasons: the southwest monsoon brings the rains from mid-May to early October, and the drier northeast monsoon lasts from late October to the end of April. Average temperatures range from 27°C to 35°C in the wet season (May to October/early November) and 17°C to 27°C in the dry season (late November to April) (Chann 2002; Khun 2002). March to May is the hottest time of the year when temperatures reach 29°C to 38°C (Khun 2002). Humidity is 65 to 70 percent in January and February, and 85 to 90 percent in August and September. Annual evaporation of 2000-2200 mm is highest in March and April at 200-240 mm per month and lowest in September and October at 120-150 mm per month. Monthly evapotranspiration averages about 120 mm in the dry season and 90 mm in the wet season (Chann2002). Annual average rainfall is 2000-3000 mm in the mountainous area, about 4000 mm in the coastal region, and around 1400-1600 mm in the Tonle Sap lowlands and Lower Mekong plains (Khun 2002).

In 2012 the agriculture sector contributed about 27.5 percent of Cambodia's GDP (at constant prices 2000) and employed around 70 percent of the rural workforce (MAFF 2013). Rice, maize, cassava, soya beans and mung beans are the main crops. Rice is cultivated in both dry and wet seasons, but agriculture is predominantly rain-fed. Limited irrigation infrastructure means that only 10 percent of Cambodia's agricultural land is fully irrigated (Ngo 2012) even though average rice yield per ha in the dry season (4.2 tonnes) is higher than in the wet season (2.76 tonnes) (MAFF 2011: 19). Effective management of the country's abundant water resources therefore is critical to furthering agricultural development and improving productivity. Government is committed to increasing rice production and ensuring water security along the principles of integrated water resource management (IWRM) (MOWRAM 2007). Recognising the need for greater stakeholder (men and women from public and private sector and civil society organisations) participation to improve irrigation systems, rice production and rural livelihoods, the government has integrated IWRM and participatory irrigation management and development (PIMD) approaches into policy-making and planning.

Agriculture, particularly rice farming, has often been subjected to the forces of nature like floods, droughts and storms. Climate change, however, is increasing the frequency and severity of climate-related disasters and weather hazards. Smallholder households are especially vulnerable to the intensification of weather and climate extremes. For example, the drought in 2002 affected 442,419 households (2,017,340 individuals) (Khun 2002); flooding along the Mekong River in 2000 caused 347 deaths (MOWRAM 2010); storms, like cyclone Ketsana in 2009 when 43 died (RGC 2010a), and the after-effects such as flash floods do tremendous damage.

Cambodia's limited adaptive capacity makes it highly vulnerable to global and regional climate change (Yusuf & Francisco 2009). Rural people whose livelihoods depend on agricultural activities, especially women and other vulnerable groups (the poor, people with disabilities, the elderly), will struggle to cope with the adverse effects of climate change and possibly suffer greater hardship as a result. Because it is not possible to predict precisely what the consequences of climate change will be, attention has focussed on strengthening adaptive capacity – especially among vulnerable population groups – to climate variability and extreme

natural events. Interventions that build resilience at local level are also critical to ensuring socioeconomic development that is inclusive.

3.2. Inclusive Growth, Climate Change Impacts, Vulnerability and Adaptation

3.2.1. Inclusive Growth in Cambodia

The world population is now approximately 7 billion. Demand for natural resources, ecosystem services and improved agricultural technology is constantly increasing to secure world food production and to meet growing consumer demand. The Millennium Ecosystem Assessment reports that reducing the pressure on ecosystems is vital for human wellbeing and livelihoods (Rashid *et al.* 2005). Multiple dialogues among global and national governments, local communities, civil societies, academia and private sector actors help bridge different perspectives for better use, management, protection and conservation of natural resources. Initiatives by multi-stakeholder partnerships that promote both equitable access to and adequate supplies of natural resources through transparent processes to achieve important social, economic and environmental goals are coherent with sustainable development.

The concepts and practices of “green thinking” – the new Green Revolution – have led to the evolution of integrated natural resources management, integrated water resources management (IWRM), community-based natural resource management (CBNRM), intensive agricultural practices and integrated crop management. These approaches are resulting in better fertiliser and pesticide use, improved irrigation systems, more coordinated resource governance, and climate change adaptation and resilience. At global level, numerous debates have raised awareness of pressing environment and development issues, including the landmark Rio Earth Summit in 1992, the Johannesburg 2002 World Summit and the recent Rio+20 United Nations Conference on Sustainable Development in 2012. Through various Rio Conventions, climate change, biodiversity protection and land degradation are now an integral part of international and national policy agendas, and people around the world are aware of the need for sustainable development.

For decades now human activities have exerted heavy pressure on natural resources and ecosystem services, making it progressively harder to protect the environment while ensuring the present generation’s well-being, not to speak of that of future generations. Just to have green thinking and green development is not enough for economic sustainability. Investments in basic services, including health, education and employment are also necessary to build resilience and mitigate adverse impacts of climate change and human activities on the environment. The shift to a green economy will not sufficiently ensure socioeconomic inclusiveness and sustainability.

Poverty reduction strategies in developing countries focus on growth. Economic growth alone, however, is unlikely to be equitable enough to mitigate climate change (World Bank 2010). Aware of the threat of potentially catastrophic weather-related hazards and climate extremes, the crucial challenge developing countries face is that of achieving their development aspirations and addressing climate change risks at the same time (World Growth 2007). For growth to be inclusive, it is essential that resources and the benefits of growth are distributed more fairly among all sections of society. This implies that key levers for achieving inclusive growth are pro-poor growth and policymaking that pursues a broad-based growth strategy. In short, inclusive growth stresses the importance of economic growth for poverty reduction, and, using growth diagnostics to identify remedies for easing binding constraints, suggests policy mixes to deliver the desired outcomes (Saad-Filho 2010). Further, for economic growth to

reduce inequalities and promote welfare and wellbeing for all, it should incorporate at its core the three Ps of sustainability – people, planet and profits – also referred to as the triple bottom line (Mulder 2008).

Before the introduction of community-based frameworks, the management and exploitation of Cambodia's natural resources (water, land, forests and fisheries) seemed to centre on productivity and economic benefits. Within the frameworks of sustainable development, good governance and inclusive growth, natural resource management has shifted focus from productivity to sustainability, integrating environmental and social considerations with the generation of economic benefits. Cambodia Millennium Development Goals (CMDG) set out national policies and strategies for delivering sustainable economic growth, development and poverty reduction (RGC 2003). Co-management of common property resources by the state and local communities, like community forestry for instance, indicates the effectiveness of decentralised local institutions in managing and protecting natural resources as well as reducing the effects of environmental and climate changes (Rachael 2010; UNDP 2011; Nang *et al.* 2011; OECD 2013). Government has established numerous local resource-user communities (CFi, CF, CPA and FWUC) to manage and protect the resource base against impractical activities such as the conversion of forestland for other land use or economic development, encroachment and clearance of forest by internal migrants for subsistence purposes, and to control illegal logging and fishing that put remaining resources at risk (RGC 2010b; MOE & UNDP 2011). The MOE recently reported that natural resource management and protection is more effective in the 120 community protected areas (CPA) than in areas not managed by CPA. CPA members have access to training, technical and financial support provided by government and NGOs to strengthen resource management capacity and ecosystem-based adaptation. As well as income from eco-tourism, CPA members have sustainable sources of timber and NTFP to secure their livelihoods (MOE 2013a).

The Rectangular Strategy for Growth, Empowerment, Equality and Efficiency sets out Cambodia's economic development policy framework, which aims to encourage growth, generate decent employment and improve public sector efficiency. Through its policy initiatives³, the government is committed to promoting sustainable economic development, and to ensuring the benefits of economic growth and development⁴ reach the poor and vulnerable. Despite various challenges, Cambodia's economy has made steady and robust progress in the last one and a half decades. Average annual growth stood at 9.5 percent from 1999 to 2009 and 10.3 percent from 2003 to 2008, reaching a high of 13.3 percent in 2005 (Sok 2011). Overall national poverty figures have gradually declined from 47 percent in 1993 to 34.7 percent in 2004, 30.1 percent in 2007 and 26.1 percent in 2010 (RGC 2010b; RGC 2011a).

3.2.2. Impacts of Climate Change

This section reviews existing studies on the interface between climate change impacts and livelihoods, and looks at the adaptation measures recommended so far in the existing literature. The key findings of previous research studies are first summarised, then identified gaps and needs for further study are discussed.

³ For example, the *National Poverty Reduction Strategy* (NPRS) 2003, National Strategic Development Plan (NSDP) 2009-13, Cambodia Millennium Development Goals (CMDG) 2003, and the National Social Protection Strategy for the Poor and Vulnerable (NSPSPV) 2011-15.

⁴ Benefits include productive and decent employment opportunities, health and education services, food security, social protection, community livelihood enhancement, and environmental conservation and protection.

3.2.2.1. Impacts of Climate Change on Livelihoods

The key natural resources Cambodian farmers depend on for their livelihoods are water, fisheries, forests and land (Veer *et al.* 2006; MOE 2009; Kapos *et al.* 2010; WFP 2012). Despite the country's abundant water and fertile soils, several constraints hamper farmers' livelihood improvement. Majority rely on rainwater for crop farming owing to the limited coverage and capacity of physical irrigation infrastructure, particularly dams and canals (main, secondary and tertiary). They still use traditional agricultural practices because improved technologies and extension services are in short supply (Microworld 2011; IFAD 2012). Although the country's main road network has been rehabilitated and new – especially provincial – roads constructed, limited rural feeder road networks restrict access to markets, forcing farmers in some areas to sell produce at below-market prices. Lack of rural banking services for agriculture and small or medium agribusiness is no longer a barrier to farmers and traders accessing credit.⁵ The number of microfinance institutions offering financial products and services to people in remote areas has expanded (CMA 2012), yet the fear of being unable to repay loans remains a constraint. In some areas, the problem of insecure land titles has also discouraged farmers from investing in their land and improved techniques.

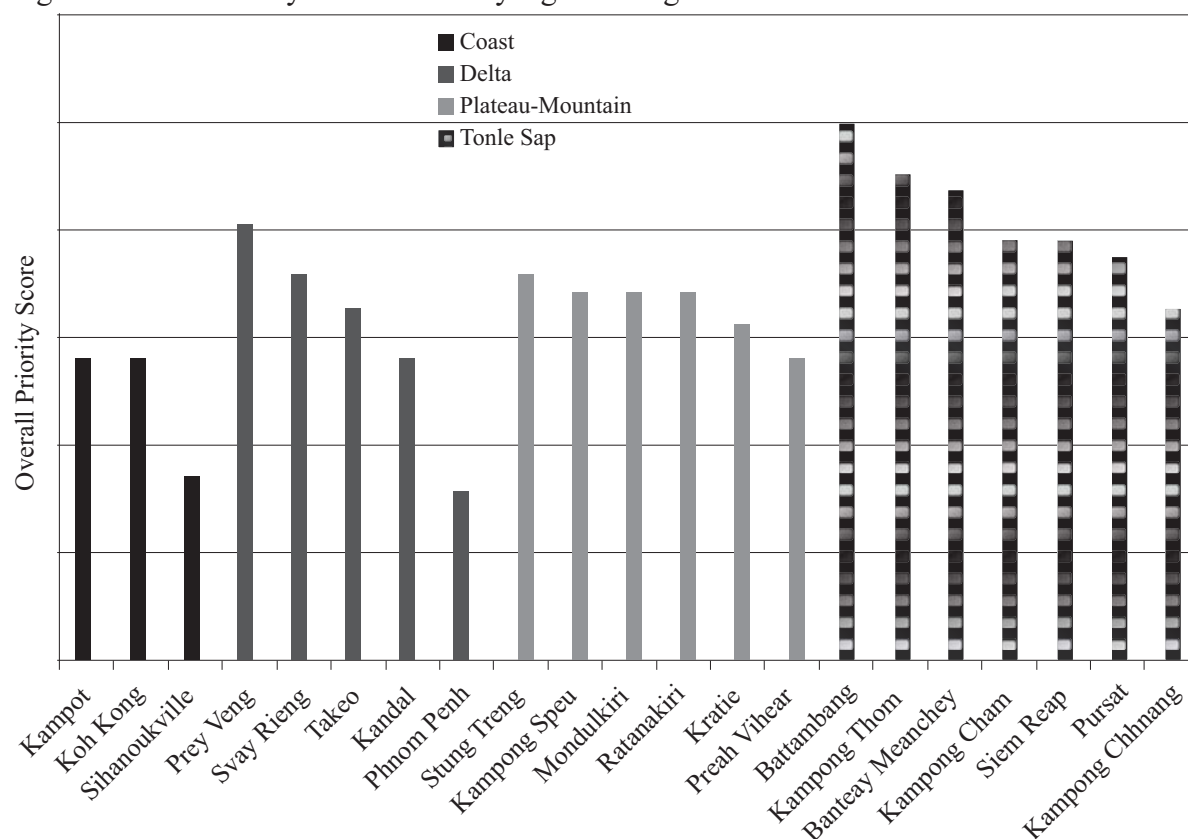
Consistent with national development strategies, government agencies have established various associations (saving groups, women's groups, rice banks and cow/buffalo banks) and resource-user groups (CFi, CPA, CF, and FWUC). Seen as fundamental social assets to support hard-to-reach groups, these bottom-up initiatives involve people dependent on natural resources in decisions about their use and management, and, in so doing, use local traditional and indigenous knowledge to conserve and protect the natural resource base.

Government agencies at all levels, including at local community level, are the main human resources that help support and improve livelihoods and living conditions for farmers and their families. Policies at national and sub-national levels are crucial to realising a strong rural economy. Climate change adaptation and adaptive capacity are therefore promoted as essential for sustainable and equitable rural development and to support those most at risk from the effects of climate change to manage their resources and livelihoods.

In addition to natural and climate-related hazards, observed changes in natural systems and declining availability of (and access to) livelihood-supporting resources have intensified the vulnerability of local livelihoods, especially those of women and marginalised groups (the poor, female-headed households, people with disabilities). A recent study builds on field research into livelihood resilience and climate change adaptation in villages around the Tonle Sap Lake and synthesises livelihood analysis with hydrological and other environmental features to enable comparison of study villages with various livelihood backgrounds (Nuorteva *et al.* 2010). Extreme floods and droughts apart, it found that environmental changes including loss of soil fertility and water quality, decline in the availability of natural resources, and depleted fish catches are likely to intensify the challenges people are facing, particularly those whose livelihoods depend on natural resources.

⁵ Based on discussion with farmers in Kompong Thom, Kompong Chhnang and Pursat provinces, August 2012

Figure 2: Vulnerability of Provinces by Agro-ecological Zone



Source: MOE (2013b)

Figure 2 ranks the vulnerability of provinces by agro-ecological zone using the findings of various assessments: vulnerability mapping by the Economy and Environment Programme for Southeast Asia (Yusuf & Francisco 2009), the National Adaptation Programme of Action (NAPA) to Climate Change (MOE 2006), the Cambodian Human Development Report (MOE & UNDP 2011) and the Strategic Programme for Climate Resilience (RGC 2011b). All of these studies confirm that the provinces (Kompong Chhnang, Pursat, Battambang, Banteay Meanchey, Siem Reap, Kompong Thom and Kompong Cham) in the Tonle Sap agro-ecological zone, the source of vital livelihood resources – fertile soil for agriculture and fisheries for daily food – for marginalised groups, have the highest vulnerability scores.

The following discussion on threats of climate change to livelihoods focuses on three areas: (1) agriculture including agricultural practices, technologies and policies, irrigation, credit and markets; (2) co-management roles of CBNRM and resource-user groups (CF, CPA, CFi and FWUC) in protecting and managing resources to support community livelihoods and build adaptive capacity to climate change and development impacts; and (3) gender considerations.

a. Agriculture

Agriculture is the primary source of income for Cambodians, particularly for the rural poor. The frequent floods, windstorms and droughts during the last decade reduced rice yields and fish catches, resulting in widespread food insecurity and undernutrition in all affected rural and some urban communities (TWGAW 2007: 21). Between 2004 and 2009, over 70 percent of the country's rice production was lost to flood, about 20 percent was lost to drought, and approximately 10 percent was destroyed by pest infestation and disease (Heng & Pech 2009).

Flash floods often inundate areas around the Tonle Sap Lake and along the Mekong River and its tributaries. Besides destroying crops, floods also severely affect livestock, fisheries, infrastructure, settlements and welfare. Agricultural losses incurred by floods amount to USD100 million to USD170 million each year (RGC 2009). For example, in 2009 Typhoon Ketsana wreaked an estimated USD132 million worth of damage in 14 (of 24) provinces, where most of the affected districts are also the poorest.

Inadequate irrigation means that most farming is rain-fed, with majority of farmers cultivating rice in the wet season. Because global warming is expected to increase rainfall, wet season rice farmers are likely to be exposed to greater risk in the near future. Greenhouse gas emissions scenarios modelled by the Centre for Climate Research Studies predict that by 2025 annual rainfall in Cambodia could have increased by up to 6 percent of the baseline⁶, with the extent of change varying over time and location. Rainfall is likely to increase by 4 to 8 percent in the lowlands and by 0 to 4 percent in the plateau and coastal areas. Predicted changes in rainfall by 2050 are higher still – by 8 to 12 percent in the lowlands and by 2 to 6 percent in the plateau and coastal areas. In 2100, the change in rainfall would be lower than that predicted for 2050 and 2025 (IPCC 2000 cited in MOE 2002: 34-35). Similar modelling by the Commonwealth Scientific Industrial Research Organisation (CSIRO) forecasts that rainfall will continually increase from baseline until 2100 – between 5 and 15 percent by 2025, 5 and 23 percent by 2050, and 3 and 35 percent by 2100 (MOE 2002: 35).

The Mekong River Commission (MRC 2010b), based on modelling the effects of various Basin development scenarios, also forecasts that rainfall will increase during the wet season resulting in more flooding on the central plains. Floods and flash floods seriously damage the country's agriculture sector, rural infrastructure and human life and risk undermining economic growth and poverty eradication efforts.

Higher temperatures in the last few years have reportedly affected crops in many provinces. The MRC estimates that the average temperature has increased by 0.8°C between 1960 and 2005, with decadal increases of about 0.20 to 0.23°C in the dry season and 0.13 to 0.16°C in the wet season. It is projected that mean temperatures could rise between 0.3 and 0.6°C by 2025, 0.7 and 2.7°C by 2060, and 1.4 and 4.3°C by 2090 (MRC 2010b.). By 2100, the average temperature is projected to increase between 3 and 3.5 percent, and annual rainfall to increase between 3 and 35 percent from baseline. Coupled with the expected increase in the frequency and intensity of flooding, higher temperatures could seriously affect lowland farming, especially the major rice growing provinces around the Tonle Sap Lake and along the Mekong River (MOE 2002).

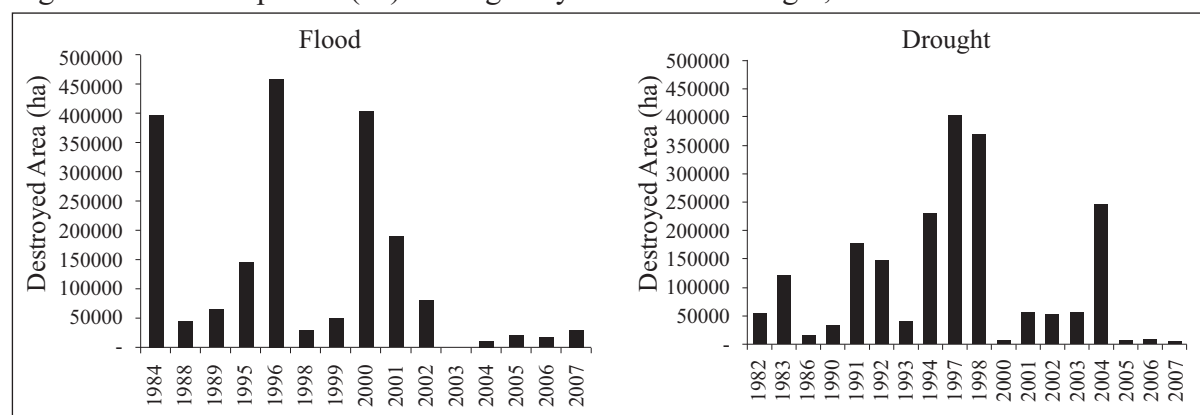
Drought and flood adversely affect Cambodia's rice yield almost every year (see Figure 3). The short dry spell that usually occurs in the middle of the wet season (July to August) often extends into prolonged drought, while flooding mostly hits agriculture and human systems at the end of the wet season (mid-October to mid-November). Although farmers are used to having to cope with either too much or too little water, they are now facing severe constraints caused by the intensity and frequency of extreme events, erratic and unreliable rainfall, and uncertain weather conditions.

The major 1997/8 drought caused farmers great hardship and pushed many into poverty. The prolonged drought in 1997 affected about 40,000 ha of crops. Following consecutive floods in 2000 and 2001, the drought in 2002 was one of the worst experienced in Cambodia

⁶ The baseline refers to the mid- to late 1990s (MOE 2002, 2013c)

as it severely affected two million people and incurred losses and damage of USD38 million (UNESCAP 2008). Extensive flooding in 2011 caused 250 deaths, affected 354,217 households and damaged 1297 houses. Crops in the provinces around the Tonle Sap Lake suffered heavy damage. Losses include damage to about 431,476 hectares of rice with 267,184 hectares of paddy destroyed, and around 21,929 hectares of other crops with yield on 17,264 hectares wiped out (RGC 2012). Drought in 2012 affected an estimated 80,000 ha of crops (Ty 2012).

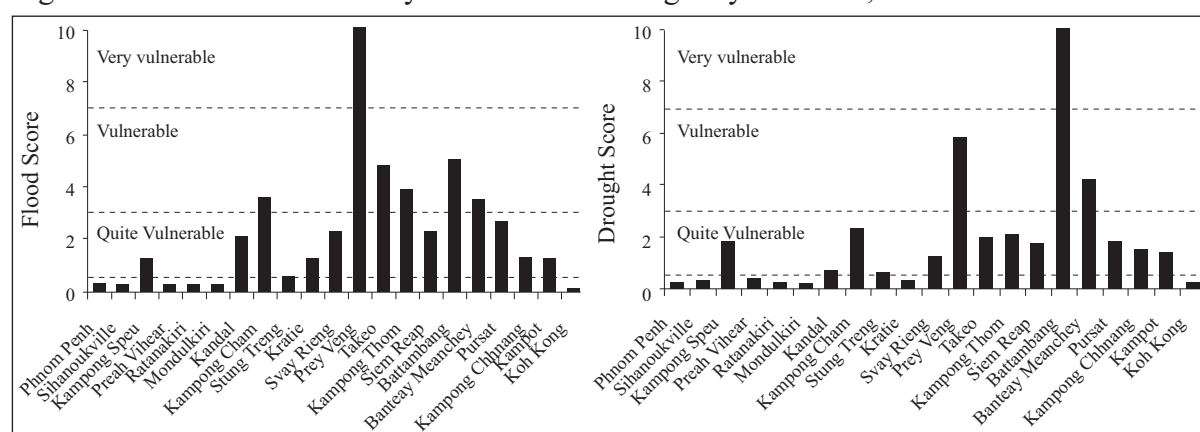
Figure 3: Total Crop Area (ha) Damaged by Flood and Drought, 1982-2007



Source: MAFF (2010)

Based on flood and drought records from 1982 to 2002, Figure 4 shows that provinces vulnerable to flooding are equally vulnerable to drought. The major rice producing provinces of Prey Veng, Takeo, Kompong Cham, Kompong Thom, Battambang, Banteay Meanchey and Siem Reap are affected by flood and drought almost every year.

Figure 4: Level of Vulnerability to Flood and Drought by Province, 1982 to 2002



Source: (MOE 2005)

b. Natural Resources

Land Cover/Forestry Resources

As well as regulating the environment, the carbon cycle⁷ and the climate, forests are crucial for sustaining local livelihoods, for example, through employment on plantations and in forest-based industries (wood and NTFP processing), collecting food, medicinal plants and utility

⁷ The combined processes, including photosynthesis, decomposition and respiration, by which carbon as a component of various compounds cycles between its major reservoirs the atmosphere, oceans, and living organisms (see also: <http://www.thefreedictionary.com/carbon+cycle>, accessed 16 November 2012)

items, and generating local income from NTFP and carbon markets⁸—A trading system through which countries may buy or sell units of greenhouse-gas emissions in an effort to meet their national limits on emissions, either under the Kyoto Protocol or under other agreements, such as that among member states of the European Union (MAFF 2009). Climate change will likely disrupt future forest productivity and biodiversity and hasten forest degradation including the loss of wet and dry forest ecosystems (MOE 2002; MRC 2009). The Intergovernmental Panel on Climate Change (IPCC) reports that forest expansion and forest migration will be curtailed and biodiversity threatened by landuse/cover change and population pressure (Cruz *et al.* 2007: 471). Converting forest areas to other land use such as for urban purposes, agriculture and other development means there will be fewer trees to absorb carbon dioxide and release oxygen. The consequent increase in greenhouse gases and carbon dioxide emissions warm the atmosphere, causing increasingly intense weather variability and climate change. Analysts predict that if nothing is done to address this problem, the global economic cost of climate change resulting from deforestation could reach USD1 trillion a year by 2100 (Eliasch Review 2008). Strong and urgent action to tackle forest loss is the key to developing a comprehensive approach to address climate change impacts in the agriculture sector.

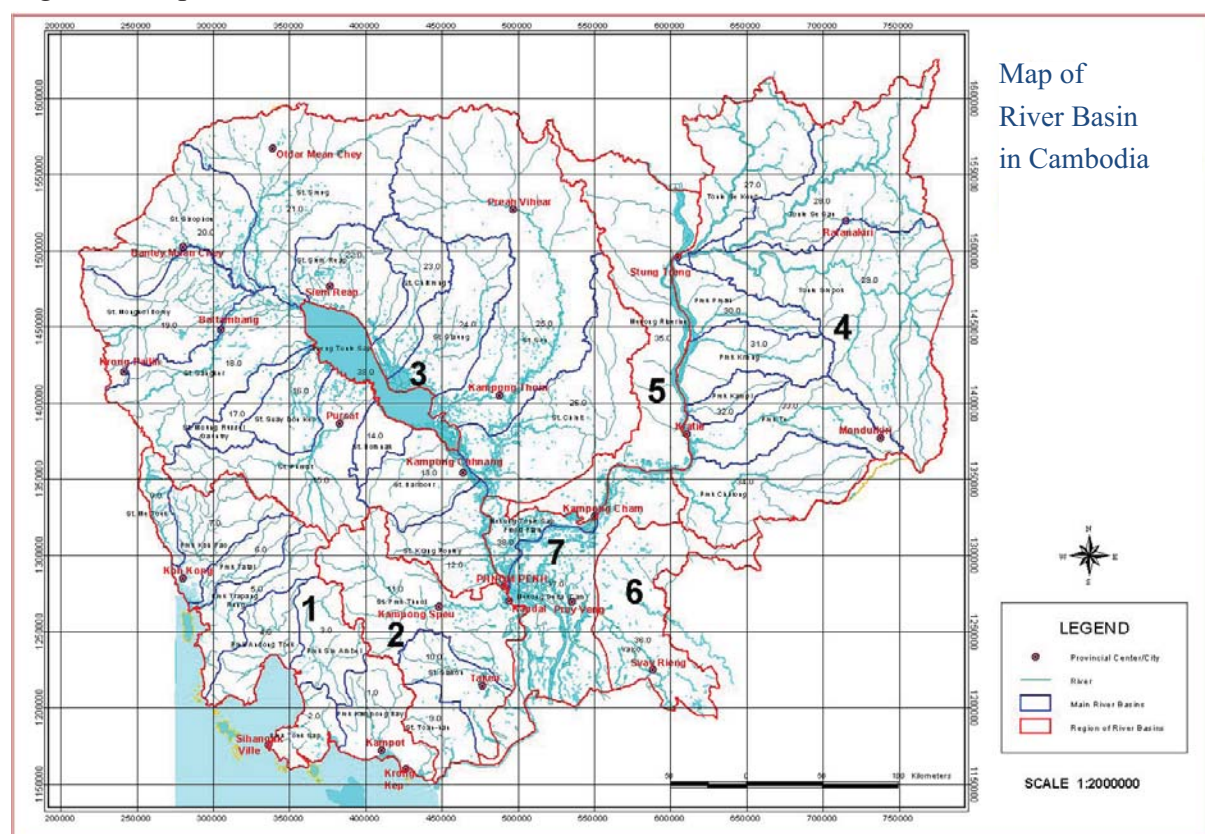
The depletion of forest resources due to lack of forestry management and landuse planning could have disastrous consequences for the environment and local livelihoods, for forest-dependent communities in general and indigenous people in particular (FAO 2012). Between 1990 and 2005, the global forest area decreased substantially by an average of 13 million hectares a year (FAO 2006 cited in Vong & Dutschke 2009: 3). Likewise, Cambodia's forest area has declined noticeably: forest cover in 2010 had decreased 16 percent since 1965, with an annual deforestation rate of about 0.52 percent in 2002-10 (MAFF 2012). The conversion of forest to non-forest land use is associated with large immediate reductions in forest carbon stock (FAO 2012) and economic hardship for local people who rely on NTFP for their livelihoods. A recent CDRI report points out that the anticipated increased production of agro-industrial crops (rubber, cassava, sweet potatoes and soybeans) over the next few years will inevitably lead to the expansion of cultivated areas (Ros *et al.* 2011). The study suggests that to avoid possible negative direct (short-term), indirect and cumulative (long-term) impacts of development/investment projects, technical impact assessments that take a triple bottom line approach – economic, environmental, and social – to sustainability should be developed and carefully implemented. In the context of global change and sustainable development, effective forestry management plays a vital role in climate change mitigation and adaptation (Nabuurs *et al.* 2007).

Water Resources

Cambodia's land area falls within several distinct topographical regions, which define the country's hydrologic system (Figure 5). Watersheds, catchments and sub-catchments in the southwest direct water eastwards to the Tonle Sap and westwards to the coastal region; the Mekong, Tonle Sap and Tonle Basac Rivers and the Tonle Sap Lake and Basin collect water from the mountains and plateaus to the north and northeast. The Tonle Sap is the largest freshwater lake in Southeast Asia. It covers an area of about 2500-3000 km² in the dry season and swells to cover around 10,000-16,000 km² in the wet season. About 25 to 30 percent of the Lake's water comes from the Tonle Sap drainage basin, which covers an area of approximately 70,000 km² (Matsui 2006), and the other 70 to 75 percent originates from the Mekong River Basin (RB).

⁸ See also http://www.windfallcentre.ca/index.php?st=1&s=Home&p=COP-15_Glossary&t=ip, (accessed 22 November 2012).

Figure 5: Map of Cambodia's River Basins



Source: MoWRAM (2012)

Note: 1. Coastal RB, 2. Tonle Basac RB, 3. Tonle Sap RB, 4. Northeast RB, 5. Upper Mekong RB, 6. Southeast RB, and 7. Lower Mekong Delta RB.

The Mekong River, its numerous tributaries and the Tonle Sap Lake-River system dominate the country's hydrology. The Tonle Sap Lake supports and maintains rich biodiversity and high productivity (fish, aquatic plants, wildlife), which serve as fundamental resources for local community livelihoods and the country. Cambodia has a coastline of about 450 km. Marine fishing is also a main source of local livelihoods, especially for coastal communities.

Various institutions have assessed the current and potential impacts of climate change under different scenarios on the Tonle Sap Lake-River and coastal ecosystems. The Ministry of Environment (MOE 2002) reports that because of global warming, low-lying areas of Koh Kong province will be permanently inundated by rises in sea level. Analysis of Basin development scenarios⁹ by the MRC (2010c) indicates that the Tonle Sap's flood levels (minimum and maximum) and flooding duration will change. Several CDRI studies confirm that farmers commonly face water shortage in the dry season and water excess in the wet season, and note that water use conflicts among water-user groups in upstream and downstream irrigation schemes often break out in the dry season (Chem & Someth 2011; Nang *et al.* 2011; Ros *et al.* 2011). This in part is also due to lack of good governance, poor integration of water management and adaptation strategies, and their weak enforcement (Nang *et al.* 2011).

⁹ Scenarios include hydropower development by construction of storage reservoirs (a cascade of dams in the Upper Basin in China, dams on upstream tributaries), construction of run-of-the-river dams on the mainstream, implementation of flood protection measures on the Cambodian and Vietnamese floodplains, development of irrigated agriculture, and increases in domestic and industrial water use driven by population growth.

Despite strong efforts by the government to manage and protect biodiversity, the combined effects of human-induced (conversion of forest for agriculture, agro-industry and hydropower development) and natural climate changes (flash floods, increased run-off and stronger winds, drought) cause the erosion of fertile topsoil from uplands to lowlands. Erosion exposes sub-soil, rock and sand and results in high sedimentation, increased water run-off, decreased water quality and reduced agricultural productivity in key watersheds (MAFF 2012; Nan *et al.* 2010). Fragmented irrigation planning and management means that water shortages in the dry season are a major problem every year (Chem & Someth 2011). Further, the European Environment Agency (2010) and the MRC (2013) report that large dams which store much water in upstream areas disconnect hydrological processes by changing the quantity (too much or too little) and quality of water and by obstructing fish migration and sediment movement.

Freshwater and Marine Fisheries Resources

The Tonle Sap Basin is the largest freshwater fishery in the country and in Southeast Asia. Marine and freshwater fisheries are vital to Cambodian livelihoods. The combined effects of over-fishing, human-induced (roads, dams, irrigation schemes) and natural climate changes (precipitation), hydrological change (flow, quality and quantity of water) and disruption to the fertility cycle in the Mekong River and Tonle Sap Lake will likely destroy fish habitats, deplete fish stocks and lead to fish species collapse (CNMC 2007; Ros *et al.* 2011; MOWRAM *et al.* 2013). Preliminary analysis of the impacts of a rise in sea level on Cambodia's coastal zone by the MOE (2002) identifies low-lying areas of Koh Kong province (one of four coastal provinces) as the most vulnerable. A one metre rise in sea level will permanently submerge about 0.4 percent of the total area of Koh Kong province, seriously damaging mangroves, forest, aquaculture, grassland and human settlements. Changes in the hydrology of the Tonle Sap Lake-River pulse system would have significant effects. For example, decline in the overall flooded area would alter the Lake's dry and flooded conditions that support rich biodiversity and regulate natural nutrient exchange, reduce overall ecosystem productivity, and reduce fish production/catches (MRC 2010c). Similarly, exploitation of coastal and marine fisheries will be beyond their regenerative capacity. If this situation is allowed to continue unregulated, marine species will become depleted and coastal fishing communities will face greater hardship (Ros *et al.* 2011).

3.2.2.2. Climate Change, Gender and Women's Empowerment

Gender is defined as "the social roles and relations between women and men. This includes the different responsibilities of women and men in a given culture or location. Unlike the sex of men or women, which is biologically determined, the gender roles of women and men are socially constructed and such roles can change over time and vary according to geographic location and social context"(UNEP 2006:18).

Historically, women have been actively involved in agriculture, particularly rice cultivation, and in the management and development of irrigation systems (Kumar *et al.* 2000). Under the Khmer Rouge regime (1975-79), women had the same tasks as men. They were forced to work on the fields and to build canals, reservoirs and even a gigantic irrigation system; virtually all the work was done by hand¹⁰ (Bergström 2012). Like the men, they worked long days under severe living conditions such as insufficient food, water, sanitation and shelter, no health or social care, and no freedom of expression. Large numbers of women and men died from starvation, over work, illness or beating (Yimsut 2013). During the post conflict period, due to the absence of male household members, women had to perform all agricultural tasks

¹⁰ See also <http://www.kambodja.name/page10/page18/index.html> (accessed 5 February 2013)

(Bergström 2012). In the 1990s, under the “Food for Work” or “Work for Food” programmes aimed at rehabilitating and constructing irrigation systems, rural men and women exchanged labour for rice (workers would get 0.5 kg of rice for every 1m x 1m x 0.2-0.5m of canal they dug).¹¹ Women farmers have repeatedly proved their critical contribution to agriculture. They have shown that they work as hard if not harder than men work and are as good farmers as the men are. Moreover, they save and invest well. Their small livestock keeping and home/market gardening is critical to household nutrition security. Given the resources and opportunities, women can be a powerful force for positive change. Yet they and therefore their communities to some extent are disadvantaged by gender barriers that effectively deny women access to resources such as agricultural training, improved inputs, information, and so on.

Future climate change and weather variability are likely to affect water and food security (Field *et al.* 2007). Recognising the need for greater stakeholder participation to improve irrigation systems, rice productivity and livelihoods as well as to cope with climate change, the government has been implementing IWRM and PIMD policies since the early-2000s. These frameworks encourage women’s greater involvement and participation in water management. Farmer water user communities (FWUC), where local men and women play various roles, are delegated primary responsibility and authority to manage, repair and improve existing irrigation systems, and to promote and guide the development of new ones (Nang *et al.* 2011).

The challenges posed by food insecurity, including limited availability of and access to food, higher food prices and lower purchasing power have crucial implications for rural communities, the poor and food-insecure, in the frontline of drought, flood and other climate-related risks. Women, who make up majority of the poor, are more vulnerable to food security risks and the effects of climate change than men are mainly because their livelihoods are more dependent on resources threatened by climate change (World Bank 2011; Taylor 2011). A case study on Prey Veng province, an area naturally prone to annual flooding, reports that flooding both damages women’s farming and assets and increases their workload. Because they have to spend more time collecting food (far from the village) for their family and caring for children who cannot get to school, they have less time for farming and earning daily income and are often pushed into debt in order to cope (CARE 2002).¹² Similarly, another study found that widows and orphans struggle to cope with the impacts of climate change (WEN 2010). For instance, they have to cope with higher levels of ill health: already weakened by undernutrition, they are particularly susceptible to infectious disease.

Mainstreaming gender issues in national poverty reduction strategies is essential for achieving sustainable development. Government and development partners have increasingly incorporated gender considerations into policy (UNIFEM *et al.* 2004). In its third five-year strategic plan (2009-2013) for Gender Equality and the Empowerment of Women in Cambodia (Nearby Rattanak III), the Ministry of Women’s Affairs (MOWA) committed to ensuring gender responsive national policies, legislation and reforms that support women’s empowerment and capacity development, address gender barriers hindering women’s leadership and economic participation, and enable women to access and share the benefits of development. Furthermore, the full and equal participation of women will help drive positive change i.e., climate change adaptation, development and poverty reduction (MOWA 2011b).

¹¹ Personal communication with former staff of the Catholic International Cooperation for Development and Solidarity (CIDSE).

¹² CARE has been providing relief and development assistance in Cambodia since 1973.

Women are the backbone of the country's economy and society, and this is acknowledged in the Rectangular Strategy Phase II (MOWA 2011a). Allowing women the opportunity to participate equally in the decisions and processes that shape their livelihoods will help minimise unequal power relations and access to and control over resources, and drive equitable benefit sharing in socioeconomic development, the workplace and the community. The equal participation of women and men is vital to help ensure sustainable economic growth, social wellbeing and poverty reduction.

3.2.3. Climate Change Adaptation

3.2.3.1. Practical Adaptation Measures

Public and private actors in both developed and developing countries carry out adaptation measures through policies, investments in infrastructure and technology, and behavioural change (Schneider *et al.* 2007). Adaptation measures are classified as reactive, i.e., in response to current climate variability and observed impacts, or anticipatory, i.e., undertaken before impacts are observed to reduce exposure to future risks (Koh & Buller 2010). Given the uncertainty surrounding climate change, the implementation of anticipatory measures is especially challenging, as they require in-depth information and knowledge about climate change.

Resilience to climate change can be advanced by developing new technologies and adaptation methods, and by disseminating knowledge through education and public information campaigns to bring about behavioural change (OECD 2009). Having received low priority in the past, these activities are now gaining importance as the need to involve more communities, sectors and regions in practical adaptation actions is realised.

In its policy guidance, the Organisation for Economic Cooperation and Development (OECD 2009) recommends changes in farming practices, drought-tolerant crops or varieties that yield more with fewer inputs, flood protection and dam development, income diversification, water management and land-use planning as resiliency measures that reduce vulnerability to climate hazards. The extent to which people can cope with future environmental changes, whether caused by climate change (natural), land use change or water resources development (human-induced), is largely defined by livelihood resilience and adaptive capacity (Nuorteva *et al.* 2010),.

3.2.3.2. Water and Agriculture

Climate change is expected to affect the economic and social dimensions of sustainable development. At the same time, today's development agendas and actions will influence adaptive capacity and livelihood resilience: "In other words, climate change threatens development objectives and is in turn affected by development choices" (OECD 2009:15). Mitigating the impacts of climate stresses on human and natural systems, therefore, is critical. The 2008 Cambodia climate change screening (assessment and identification of climate change risks and adaptation options) by the Danish International Development Agency (DANIDA 2008) and the Cambodia Climate Change Office found that vulnerability to climate change is high due to poverty, poor governance, food insecurity and marginalisation. Further, it reports that the capacity and capability to adapt and avoid impacts of climate variability is limited. Water shortages, food insecurity and greater risks to human health and life resultant of climate change will affect vulnerable and marginalised groups (women-headed households, the poor, and people with disabilities).

The first assessment of the country's vulnerability to climate change to identify adaptation and mitigation measures was conducted in 1999-2001 under Cambodia's Initial National Communication, and the second assessment was done in 2003-04. These evaluations were used to identify key adaptation strategies for agriculture, which include the improvement and development of high-yielding crop varieties, crop management and agricultural practices, adaptive capacity to climate extremes, weather/climate variability forecasting and early warning alarm/alert systems, irrigation infrastructure in lowland areas, and food crop diversification (Heng & Pech 2009). Implementation of some of these strategies requires huge investments, particularly irrigation infrastructure development. Good governance and effective water resources management can help water-user groups reduce the impact of water shortages caused by climate change, while effective irrigation development and management will help secure water for agriculture and improve protection against natural disasters.

Government has renewed efforts to rehabilitate existing and construct new irrigation infrastructure including pumping stations, canals (main, secondary and tertiary), flood protection barriers, and water gates. Further, there are plans to expand the irrigated area by 25,000 ha every year (MOWRAM 2009). Adaptation to climate change requires the provision of legal frameworks to cope with climate change impacts; development of technology for improved land and water resource management; encouragement to change the attitude of water-user groups towards efficient water use; exploration of new water sources; improvement of operational and institutional performance; protection and restoration of watersheds, streamside and lakeside buffers; restoration of water channels; integration of coastal zone management; construction of seawalls and dykes; and the protection and replanting of trees (Tin 2010). Agriculture and climate change studies by CDRI suggest that in addition to learning from past disasters, early warning systems, crop calendar, reliable weather/climate variability forecasting and agricultural information and agricultural extension services should be handed over to farmers on time so that they are able to prepare and respond more quickly to the changing climate (Ros *et al.* 2011; Koy & Em 2012).

3.2.3.3. *Natural Resources Management*

Adaptive capacity largely depends on the extent to which individuals and communities can cope with future environmental changes, whether caused by climate change or other factors such as land use change and water resources development. The integration of adaptation strategies into national programmes and policies can help vulnerable rural communities mitigate and adjust to climate-related changes and disaster risks, but diverse strategies will be required depending on the level of economic development, surrounding communities, strength of community institutions, locally available natural resources and seasonal weather patterns (Leary *et al.* 2008).

Cambodia's fisheries play an important role in the national economy, contributing 6.8 percent to GDP (at constant prices 2000) in 2010 (NIS 2011). Fish is the main source of animal protein (40 to 60 percent) in rural diets. Marine and inland fisheries resources and livelihoods dependent on them face critical challenges caused by natural system and anthropogenic changes. Multi-sectoral support (technical, financial) from all stakeholders along with strong law enforcement measures is needed to both protect fisheries resources and strengthen rural livelihoods. Catchment management, coastline protection, climate change awareness raising, information on vulnerability, adaptation and resilience and so on are increasingly demanded by local communities and local authorities to minimise the stresses and shocks impinging on their lives and livelihoods. Likewise, livelihood diversification, for example, into ecotourism,

vegetable cropping and micro-business, must be considered to reduce (or manage) the pressure on rapidly depleting fishing grounds (So *et al.* 2011). Increasing adaptive capacity to cope with the challenges of short-term climate variability and long-term climate changes is an urgent priority, especially in fishery resources management and development of the fisheries sector. Effective institutions will be needed at all levels, but especially at local and community level, to plan and implement adaptation actions that strengthen resilience to climate change and support poor, fishery resource-dependent households, women and other vulnerable groups that typically have limited capacity, assets and resources to cope with climate change challenges.

Deforestation and degradation can be delayed or reduced through complete protection of forests, sustainable forest management policies and practices, or generating economic returns from NTFP and forest use not involving tree removal (e.g., eco-tourism). Tin (2010) draws attention to practical adaptive measures to maintain forest ecology, including the creation and maintenance of natural migration (biodiversity) corridors, reforestation of denuded forestland, selection of appropriate plant species for rangeland, introduction of drought-tolerant species, and improvement of soil and landuse management and planning. Forests contribute directly to livelihood improvement, national economic development, biodiversity conservation and greenhouse gas sinks¹³. Cambodia's forest ecosystems store an estimated 2.96 giga tonnes of carbon (Kapos *et al.* 2010). Protecting forest from all harvesting typically results in maintained or increased forest carbon stocks, but also reduces land encroachment and wood harvesting to meet other societal needs. Global mitigation assessments conclude that in the short-term, thoughtfully reduced deforestation and forest degradation is the forest mitigation option with the largest and most immediate carbon stock impact per ha and per year because large carbon stocks (about 350-900 tonnes CO₂ per ha) are not emitted when deforestation is prevented (Nabuurs *et al.* 2007).

The Cambodian government has demarcated 23 areas, approximately 18 percent of the country's total land area, for special protection (MOE 2002). Community protected areas (CPA) and community forests (CF) have been established to increase forest cover and to ensure the long-term security of livelihoods in communities that depend on forest products. CPAs and CFs where local communities have significant management authority and custodianship have been recognised as effective mechanisms for sustainable forest management and protection (*ibid.*). Community-based forestry management gives rights to local people to conserve the forest and to earn more income from forest resources, thus contributing to poverty alleviation and climate change adaptation. In 2009, there were 401 CFs in Cambodia covering an area of 380,587 ha, or about two percent of the total land area. If the target of establishing CFs on 11 percent of the land area is achieved, they would cover more than 2 million hectares, contributing to local livelihoods and moderating climate change (Vong & Dutschke 2009).

The National Forest Programme (2010) for the Permanent Forest Estate regulated by the Forestry Administration, the Protected Areas Law developed by the MOE, and the Management of Flooded Forests and Mangroves regulated by the Fisheries Administration are the main national forest management strategies (UN-REDD 2010). The newly implemented Reduced Emissions from Deforestation and Degradation (REDD+) programme could be a significant financial source for achieving sustainable forest management and the successful implementation of forestry strategies to support both local livelihoods and biodiversity conservation. REDD+

¹³ According to UNFCCC (2012) the term sink is referred as "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis" (see also http://unfccc.int/essential_background/glossary/items/3666.php, accessed 20 November 2012)

will reduce carbon emissions and increase carbon stock, which would help Cambodia achieve its CMDG target of maintaining 60 percent forest cover by 2015.

3.2.3.4. Gender Considerations

Gender equality and climate change resilience are inextricably linked. Women especially should be targeted in multi-stakeholder participative learning and decision-making on mitigation activities and adaptive capacity development (Wamukonya *et al.* 2002). Using participatory approaches, many developing countries already facing the depressing effects of climate change have identified new adaptation measures for women and other vulnerable groups. These include (i) adopting climate-friendly farming practices that foster better land and water use management and techniques including soil conservation and soil fertility enrichment and restoration, soil carbon¹⁴ enrichment, high-carbon cropping¹⁵ and climate-friendly livestock production systems; (ii) improving local health and nutrition status; and (iii) reducing livelihood risks through diversification and resilience building (Solar 2010; Sell 2012). Similarly, livelihood diversification and training programmes that include rainwater harvesting and moisture retention, reforestation, and so on would help address gender needs in climate-change and water-scarcity adaptation processes (Buechler 2009). In addition, promoting the participation of men and women in community-based fish sanctuaries protection and promotion, effective fish habit conservation, and post-harvest processing and market access improvement should be considered to ensure sustainable use of fisheries resources (Maneth & Jones 2011). A gender communication and social network should be created and climate change adaptation and disaster risk reduction strategies developed and disseminated to enable women and vulnerable groups to respond to climatic hazards (Buechler 2009; Solar 2010).

Most rural women in Cambodia are involved in subsistence rice farming, where water is one of the main inputs and water control is the most important management practice that determines the effectiveness of other inputs, and ultimately the size and quality of yields. Within the frameworks of IWRM and PIMD, water resources are co-managed by government and FWUCs. Despite considerable rehabilitation and development of irrigation systems and physical infrastructure, flooding and drought still pose serious constraints and challenges to women and vulnerable groups in some areas, undermining the potential benefits of improved infrastructure. Population groups that rely heavily on only one livelihood source, often the poorest households dependent on fishing or paddy farming, are likely to be affected most by climate change because of their low adaptive capacity. Given that women have a major role in earning income and primary responsibility for providing food for the family, increasing women's access to resources and opportunities would make a powerful contribution to food and nutrition security and poverty reduction (Quisumbing *et al.* 2004).

CDRI reports that higher temperatures, prolonged drought and water shortages in the dry season cause crop losses and livestock (cattle and buffalo) illness and death (Ros *et al.* 2011; Koy & Em 2012). For example, 1675 heads of livestock perished in the 2011 flood (CNDM 2011 cited in Tes 2012). Lack of hygiene, polluted water and mosquito out-breaks result in diarrhoeal illness, infectious and parasitic diseases, malaria, dengue and other vector borne diseases (Ölund Wingqvist 2009; Futtrup Borg 2011; SCW 2012). Already weakened by undernutrition and contaminated water, women, children and other vulnerable groups tend to

¹⁴ "Soil carbon is one of the most neglected yet most important factors in soil fertility, disease control, water efficiency and farm productivity"(see also <http://www.amazingcarbon.com/Leu%20-%20Organics%20and%20soil%20carbon.pdf>, accessed 26 June 2013)

¹⁵ Use crops or plants to increase soil carbon

be more susceptible to illness, especially acute respiratory infections and vaccine preventable diseases such as measles.

Poor rural households typically depend on subsistence farming (rice, beans, corn, potatoes), small livestock raising (chickens, ducks, pigs), home-gardening, wild food foraging (roots, vegetables, frogs, crabs, snails), aquaculture and fishing in nearby rivers/streams as their main sources of daily food. They do not have money to buy fruit and vegetables, fish and meat from the market. Prolonged drought and flood damages agricultural produce, livestock, animal fodder, and other natural resources important to daily livelihoods.

During floods, women and girls have to spend more time finding food, as they must go further from home, and looking after children who cannot get to school. They cannot run even a small home business nor do farming in non-flooded areas because most of their time is spent taking care of children and ill family members, and providing food for the family. Some households (male and female-headed) fall into debt through having to take out loans to buy food, medicine and agricultural inputs (fertiliser, seeds, pesticide).

In response to climate stresses, hazards and extremes, rural men and women have adopted various farming practices, from smallholder inter/mixed-cropping and crop-livestock systems to intensive agricultural practices and crop diversification, agroforestry, water-use efficiency and irrigation management – responses that fall within the IWRM, PIMD and CBA frameworks (MRC 2011b; Ros *et al.* 2011). Some farmers grow new drought-tolerant or flood-resilient crops and have changed the crop calendar, while others run a small business, collect NTFP or catch fish. Taking out a cash loan or finding paid work in a city or provincial town are the main options selected by men to cope with natural disasters, while getting paid work in the village or local area is the main measure chosen by women and female headed-households (Koy & Em 2012).

3.3. Observed Climate Change Impacts and Adaptation Actions

To help analyse potential climate change impacts and adaptive capacity and to identify limitations and gaps within different sectors, Table 1 summarises observed climate change impacts and existing adaptive capacity and measures.

Table 1: Climate Change Impacts and Adaptation Actions

Agriculture	Forestry	Water	Fisheries
<i>Climate change impacts</i>			
<ul style="list-style-type: none"> - High frequency of severe floods and intense droughts - Large-scale insect outbreaks due to loss of biodiversity - Mass erosion of fertile topsoil from uplands to lowlands causes water pollution and sediment hazards - Large decreases in soil fertility, deterioration of soil properties - Devastating loss of yield, especially where land management cannot compensate for lost soil materials - Disrupted fertility cycle and decline in farm incomes. 	<ul style="list-style-type: none"> - Disrupted forest productivity and biodiversity - Increases in runoff leading to devastating flash floods - Curtailed forest expansion and forest migration - Immediate reductions in forest carbon stock - Disconnected forest areas i.e. lack of green corridors impacts on wildlife and biodiversity - Threat to biodiversity - Increases in greenhouse gases and carbon dioxide emissions. 	<ul style="list-style-type: none"> - Sea level rise submerges wetlands and swamps - Saltwater intrusion - Drop in water table affects freshwater fisheries - Changes in rainfall amount and distribution - Changes in hydrological regimes and water levels - Irregular rainfall (frequency, duration) - Inundation of low-lying areas - Water scarcity and water use conflicts - Increases in water borne-diseases - Water quality for human and animal consumption. 	<ul style="list-style-type: none"> - Lower water supply (quantity) for fisheries - Water pollution and contamination - Accelerated eutrophication - Reduced flood pulse, duration and level - Reduce reverse flows and inflow of nutrients associated with fine sediments - Reduce ecologically and commercially important fish species - Fish stock depletion - Loss of fish habitats e.g., deep pools, spawning grounds, sanctuaries - Barriers restrict fish breeding and migration and sediment movement - Sedimentation hazards.

<i>Recommended and on-going adaptation actions</i>			
<ul style="list-style-type: none"> - High-yielding, flood-resilient, heat- and drought-resistant crop varieties - Resource efficient crop management and agricultural practices - Build men and women farmers' adaptive capacity to cope with climate extremes - Food crop diversification - Weather and climate variability forecasting and information dissemination - Agriculture information sharing - Training and agricultural extension services - On-farm demonstration of climate-smart seed/ crop varieties and farming techniques - Land and water management - High-carbon cropping or soil carbon enrichment and restoration 	<ul style="list-style-type: none"> - Maintain at least 60% forest cover by 2015 as targeted in CMDG7 - Improve forest governance and management - Implement sustainable forest management policies - National Forest Programme and REDD+ initiative to maintain and increase forest carbon stocks - Creation of community-based natural resource-user groups (CFs and CPAs) - Creation of natural "green" migration/ biodiversity corridors - Reforestation of denuded forest areas - Introduction of drought-tolerant species - Improved land use management and planning - Integrate gender-sensitive planning and programmes in forest management, CFs, CPAs and REDD+ projects. 	<ul style="list-style-type: none"> - Integrate climate change adaptation into coastal zone development and management plan - Improve water governance and strengthen water management institutions - Develop irrigation infrastructure and flood protection in lowland areas - Set up weather/climate variability forecasting information sharing and early warning alarm/alert systems - Strengthen community-based water resource management (FWUC) - Introduce climate-smart farming practices that ensure proper land and water use management - Improve water resource management and soil moisture retention techniques - Explore new water sources (ground water) - Restore (dredge) water channels - Integrate gender-sensitive planning and programmes in water governance. 	<ul style="list-style-type: none"> - Fisheries management and sector reform - More fisheries management communities (CFi) to manage and protect local fishery resources - Livelihood diversification into ecotourism, market gardening, and micro-business, to reduce pressure on rapidly depleting fish stocks - Adaptive capacity development to cope with short and long-term challenges - Designated fish habitat conservation grounds - Mainstream climate change adaptation initiatives to strengthen resilience at all levels - Gender-sensitive planning and programmes in fisheries management and CFi.
<i>Observed constraints to recommended and on-going adaptation actions</i>			
<ul style="list-style-type: none"> - Lack of access to weather forecasts agricultural training and extension services - Limited irrigation infrastructure and smart agriculture technologies - Barriers to financial services (loans and credit) in rural areas - Geographical conditions could also make local farmers and communities slow to change attitude and practice towards climate-smart agricultural practices and technologies. 	<ul style="list-style-type: none"> - Illegal land encroachment, logging and forest clearance undermine sustainable forest management - Lack knowledge and understanding of carbon markets, carbon pricing and budgeting - Limited resources (human, expertise and finance) for strengthening co-management roles - Complexities of good governance in natural resource management - Low representation of women in forestry management committees (CFs and CPAs). 	<ul style="list-style-type: none"> - Inadequate irrigation coverage and capacity - Weak local ownership - Lack of good governance - Limited human and financial resources constrain local communities' ability to manage and protect water resources from climate impacts - Limited climate-change adaptation/ resilience building processes and mechanisms to increase women's participation - Low representation of women in water management committee (FWUCs). 	<ul style="list-style-type: none"> - Limited human and financial resources to improve government officials and local communities' capacity to manage and protect fisheries - Limited systematic mechanism for integrating irrigation development, fisheries management and climate change adaptation strategies - Limited enforcement mechanisms and actions to stop fish habitat destruction - Low representation of women in fishery management committees (CFi).
<i>Challenges, remedies and gender considerations</i>			
<ul style="list-style-type: none"> - Climate change is complex and cannot be addressed in isolation from natural resource management, agricultural development, livelihood improvement of women and men, energy poverty, and water food security. - Good governance of natural resources is the key for integrating social, economic and environmental dimensions into cohesive policies and actions that ensure economic growth and wellbeing. - Transfer of co-management role and responsibilities to local communities dependent on natural resources should be hastened so that needs and adaptive measures can be collectively prioritised to minimise emerging challenges caused by climate change extremes. - Integration of social, economic and environmental dimensions into cohesive natural resources management, climate change adaptation, and sustainable agriculture development policies and actions would help ensure inclusive economic growth. - Changes in natural systems and declining availability of and access to main livelihood-supporting resources have intensified the vulnerability of local livelihoods, especially of women and marginalised groups. - Gender equality issues should be mainstreamed in policy planning and actions to ensure women have equal access to essential resources and services including agricultural extension services, awareness raising and information on climate change adaptation and resilience. - Women and vulnerable groups in rural areas are in the frontline of exposure to climate extremes (drought, flood and windstorm) and other climate-related risks since their daily subsistence mainly depends on natural resources. - Challenges posed by climate change, especially to food security, are directly relevant to women, who play a vital role in the provision and production of food, child welfare and nutrition and income generation for their families. - Women's access to resources remains limited despite their active role in agriculture and natural resources management and even within community-based initiatives. A mix of mitigation and adaptation strategies is required to build sustainable livelihoods and local communities' resilience to climate change. - Women must be encouraged and their specific needs provided for in the innovation and selection of appropriate agricultural technologies and income diversification opportunities. 			

3.4. Limitations and Gaps Assessment

This section focuses on three major themes that emerge on analysis of the limitations and gaps identified in the literature review on CBNRM and CBA frameworks: agricultural technology and extension services, community-based natural resource management, and women's role in natural resources management.

3.4.1. *Agricultural Technology and Extension Services*

Various climate change adaptation policy options and measures are reported in the literature including the improvement and development of high-yielding flood-resilient and drought-resistant crop varieties, sustainable crop, water and land management practices, food crop diversification and capacity building of farmers. In tandem with these initiatives, a weather and climate variability forecast system has been set up at national and sub national levels and information is disseminated through web-based announcements (circulars), direct communication (cell phone) and regular radio and television broadcasts. Agricultural extension services and training through on-farm demonstration of recommended seeds and crop varieties are in place, though access to such services remains limited. Efforts are also being made to introduce improved land and water management and soil fertility enrichment and restoration techniques. However, progress in implementing adaptive measures is slow and changes in capacity are gradual.

Climate-smart agricultural practices and technologies help improve land and water use management and generate multiple benefits such as developing the resilience and adaptive capacity of farming systems and improving agricultural productivity, income generation and environmental protection (FAO 2010). The expansion of irrigation networks and modern irrigation and agricultural technologies are essential to improve water supply and crop yield, and protect against flood, drought and other unexpected natural hazards. With new technologies, farmers will be able to intensify production, grow alternative crops and increase yield without expanding the cultivated area. This would both reduce land encroachment and conversion of natural forest (deforestation) while protecting the environment and ecosystem services, and contribute to livelihood resilience and climate change adaptation and mitigation (Bellassen 2010 cited in UNDP 2011). Farmers can learn new technologies and techniques through agricultural extension services delivered by state agencies and private sector and civil society organisations. In-depth discussion on smart agriculture, however, is almost absent in the literature on Cambodia's agriculture sector.

Majority of Cambodian farmers remain highly dependent on rainfall distribution, which determines the size and success of the harvest. To ensure water security for agriculture and to protect against climate-related risks (flood and drought), the government has restored existing irrigation systems and built new infrastructure – pumping stations, water gates, dams and canals. By 2008, 31.63 percent (827,373 ha) of the total rice cultivated area (2,615,741 ha) was irrigated (MOWRAM 2009). Despite government commitment to establishing water resources management along the principles of IWRM (MOWRAM 2007), some irrigation schemes were designed based on sparse hydrological and other relevant information and with limited local participation.¹⁶ These shortcomings have led to inequitable water allocation, water scarcity and conflict among water-users, lack of ownership, unclear stakeholder responsibilities, poor maintenance and ineffective irrigation management (Chem & Someth 2011; Nang *et al.* 2011).

¹⁶ Reasons include short timeframe for project implementation, and undertaking projects during cultivation or harvesting.

A clear message from experience is that irrigation system planning, design and construction, and integrated adaptation and irrigation management strategies should be informed by comprehensive scientific assessment of climate change impacts on water resources.

Farmers will accept and benefit from extension services if their views are heard and local traditional/indigenous knowledge is integrated into development planning. Agricultural extension and rural information services provide the knowledge and skills people need to improve their livelihoods and play a critical role in driving sustainable and equitable economic growth. Yet the under-resourcing (shortage of funds, equipment and qualified extension workers) of agricultural research means that training and extension development, agricultural extension programmes and services provision¹⁷ do not meet the needs of local farmers, particularly women farmers (CDC 2002; MAFF & MOWRAM 2010; MOE & UNDP 2011; Rushdy 2009). On the other hand, farmers' perceptions of climate-related hazards and their attitudes and behaviour towards smart agriculture present a picture of slow and gradual change. Participatory mechanisms that promote vertical and horizontal linkages, technology transfer, knowledge sharing and feedback must be in place to ensure close communication among and between farmers and agricultural extension services delivery agencies at village, commune, district, provincial and national levels.

3.4.2. Community-based Natural Resource Management

Good governance is the core tool for integrating social, economic and environmental dimensions into cohesive policies and actions that ensure economic growth and wellbeing. The Rectangular Strategy, which aims at improving public sector effectiveness, developing agriculture, promoting economic growth, ensuring social equity, enhancing good governance and protecting natural and cultural resources, reflects the government's vision of realising the CMDGs towards sustainable development and poverty reduction. Yet ensuring smooth implementation of good governance principles in natural resource management remains problematic.

To bring equitable social, economic and environmental benefits to all segments of the population, particularly local communities, the government has continuously improved sectoral development strategies. Maintaining forest cover at 60 percent of the total land area through 2015 is targeted in CMDG7. Consistent with the principles of good governance and sustainable forest management policies such as the National Forest Programme and Cambodia REDD+, the government has committed to a forest management strategy aimed at maintaining or increasing forest carbon stocks. Measures involve establishing more community-based natural resource-user groups, increasing the number of rangers and community patrol teams to control illegal logging, creating and protecting natural migration (biodiversity) corridors and reforesting denuded forestland.

With technical and financial support from international development partners, a number of community forestry groups have joined the Cambodia REDD+ programme. Recent assessment of REDD+ found its progress hindered by long-term challenges¹⁸ due to staff's (NGOs, public and private sector institutions) limited knowledge and capacity on the formulation of REDD+ benefit-sharing policies and mechanisms, and lack of basic understanding of carbon markets,

¹⁷ Particularly land and water management, seedling husbandry, fertiliser application, cropping calendar, diversification and multiple cropping systems, livestock husbandry, crop rotation patterns and planting methods, credit, marketing and entrepreneurial skills.

¹⁸ The issue of REDD+ and carbon credit was discussed at the COOL (Comparing Options and Analysing Obstacles in Local Context) dissemination workshop on Outcomes and Updates on Climate Change Mitigation Initiatives, organised by MOE at Sunway Hotel, 28, Phnom Penh, February 2012.

carbon pricing and budgeting (Stevenson 2012). Moreover, land encroachment, forest clearance and illegal logging may undermine the future success of community forestry. If it is to benefit the rural poor, REDD+ will have to be hyper-progressive and decisive (Ribot and Larson 2011).

Water issues in Cambodia are highly significant in terms of river discharge, nutrient supply, flooded recession areas, fish habitats and soil fertility for both wet and dry seasons. Concerted efforts have been made to implement effective fishery (marine and freshwater) management and fishery policy reforms and improve landuse management and planning while protecting habitats and reducing illegal forest clearance, land encroachment and impractical forest land conversion.

Climate change in Cambodia is likely to intensify many water demand and supply problems, mainly access to water for irrigation and agriculture, hydropower, domestic and industrial use. Economic and population growth leads to increased demand for electricity, which is expected to build at an average annual rate of 6-7 percent (MRC 2010a). Mainstream hydropower projects will compromise ecological integrity. The cumulative impacts of hydropower dams will have long-lasting effects on river hydrology, sediment movement, nutrient transport, and biodiversity. Community livelihoods and food security will be affected by water shortages for agriculture, irrigation, fisheries, riverbank gardens and floodplain farming.

The Tonle Sap Lake absorbs around 20 percent of the Mekong River's floodwater. It acts as a crucial natural flood regulator for the river and contributes significantly to hydrological and ecological stability in the delta (MRC 2006). The Tonle Sap ecosystem provides a large flooded area for agriculture and seasonal breeding and nursery grounds for fish. Freshwater fisheries resources and livelihoods dependent on them face various challenges. Lack of financial resources and low capacity hinder fishers in the Tonle Sap area from improving their livelihoods despite the government's bold fishery reforms that released 731,433 hectares (553,552 hectares in 2001 and 177,881 hectares in 2012) of former private fishing lots for community fisheries (So *et al.* forthcoming). Local people's resilience is relatively weak and likely to remain so without concerted effort and integration of water, food (natural resources and agriculture), energy, climate change adaptation and local knowledge into decision and policy-making. The stark warning that under the Lower Mekong Basin 20-Year Plan Scenario, where the construction of 11 mainstream dams and 30 tributary dams and irrigation and water supply projects is planned, about 50 percent of white fish production could decline is more than a significant concern (Pech *et al.* 2008). Besides being an indicator of the Basin's ecological health, millions of people rely on the diversity of fish species as their main source of income, livelihood and protein.

Coastal fishing communities have similar experiences of fish species decline, smaller catches and fewer large fish. Economic development activities in coastal areas (hydropower, port development, special economic zone, tourism) and population growth exert increasing pressure on marine and coastal fisheries. Since catches started to decline, more fishers have turned to using modern fishing methods and prohibited (destructive) equipment.

Water governance arrangements and institutional performances have improved significantly along with irrigation infrastructure and flood protection development. Strengthened farmer water-user committees (FWUCs) ensure better water allocation and moisture retention techniques, and the adoption of climate-smart farming practices fosters sound land and water management. However, the integration of irrigation development and fisheries management, and effective enforcement mechanisms to protect fish habitats against illegal felling of flooded forest remain limited. The combined impacts of climate change, economic development and natural resource management are not yet fully understood. Further, local people's resilience is relatively weak and likely to remain so given the limited integration of water and food security (natural resources and agriculture), energy, climate change adaptation and local knowledge into decision and policy-making. These factors constrain and limit climate change adaptation efforts.

The co-management by the state and resource-user groups of Cambodia's forest, fishery and water resources has improved, but local communities' capacity to respond or adapt to climate change impacts is still deficient. Using traditional/indigenous knowledge, local people have mostly developed their own ways of fighting back or surviving extreme weather events and natural disasters (cyclone, flood and drought). Disaster preparedness and climate adaptation strategies require financial, technical and human resources and legal frameworks. However, available support is nowhere near enough to meet actual needs: financial support for climate change mitigation and adaptation frameworks, strategy development and individual and institutional capacity development is urgently needed (AIT & UNEP 2010). As the National Adaptation Programme of Action to Climate Change (NAPA) reports, the country lacks economic and institutional capacity to deal with unpredictable natural system changes (MOE 2006).

3.4.3. Improving Women's Role in Natural Resource Management

Various key policies respond to the demand for disaster preparedness and climate-related risk reduction by promoting CBNRM and encouraging community (CFi, CF, CPA and FWUC) participation from men and women. The need to increase women's role in society, from farming at local level to policy-making at local, sub-national and national (or international) levels, is set out in Cambodia's gender policy.

Water resources are essential for agriculture. Cambodia's water sector policy underlines the need for multi-stakeholder (men and women) participation to improve rice production, irrigation systems and livelihoods. In terms of irrigation management and development, FWUCs are responsible for irrigation scheme operation and water allocation. Women are encouraged to take decision-making roles in the management structure, but their low participation leaves men to dominate FWUC committees. Traditional, cultural and socioeconomic barriers coupled with general low education and skills can often deny women the chance to express their views in their own way. Women's empowerment, i.e. the strengthening of women's political voice, is crucial to increasing women's effective participation (Quisumbing *et al.* 2004). Having a position on local community committees, however, does not necessarily mean that women can

meaningfully articulate or protect women's needs, choices and benefits. This indicates the gaps between leadership and ownership among men and women in local communities.

Despite women's critical role in agriculture and natural resources management, their access to resources – even within community-based initiatives – is limited (MOWA 2008 cited in MOE & UNDP 2011). Women's fuller participation is needed in all development sectors, yet changing attitudes and behaviour towards gender equality and women's rights is a long-term process that requires long-term effort (RGC 2010c). Women's participation in CBNRM and local administration (commune, villages) has markedly increased, but women are still underrepresented in senior leadership positions. Various barriers such as no experience and lack of time due to household and childcare responsibilities relegate women to subordinate roles. Women's greater participation, therefore, should be supported and their specific needs provided for in the selection of appropriate technologies and income diversification opportunities. Applying a "gender lens" in all aspects of policy formulation and development planning, particularly in the water and agriculture sectors, would help ensure that benefits reach women and men equally. Moreover, since women farmers mostly rely on rainfall for their rice and crop farming, expanding irrigation networks, providing agricultural extension services and training, and securing access to adequate irrigation water and climate-smart seeds and crop varieties is essential for improving women's livelihoods.

Conclusion, Policy Considerations and Future Directions for Action

Climate change is complex and cannot be addressed in isolation from natural resource management, good governance, and livelihood and food security (DANIDA 2008). Economic growth is necessary for livelihood improvement and poverty reduction, but the benefits must be equitably shared otherwise unbalanced development and widening inequality will result (Yohe *et al.* 2007). Through experience the poor have developed great practical knowledge that has helped them survive the threats linked to climate change and weather variability. However, present coping strategies will not suffice when their livelihood systems are threatened by unpredictable more frequent climate hazards and increasing weather uncertainties, or if their legitimate rights to access natural resources are impeded by unsustainable economic development activities. Women and the marginalised are particularly vulnerable because they are more dependent on natural resource-based livelihoods and often lack the capacity, power, assets and resources necessary to recover from climate change impacts. Hence, greater participation from women and vulnerable groups in the development and implementation of climate change adaptation actions and strategies is actively encouraged.

Bottom-up approaches have the potential to develop adaptation strategies and build resilience because local communities that live with and use natural resources are the core factor in determining suitable measures to respond to climate change impacts. However, since local communities' capacity to respond or adapt to climate change impacts is still insufficient, co-management by the state and resource-user groups of Cambodia's forests, fisheries and water resources is vital and must be strengthened. Adaptive capacity building and awareness raising must be thoughtfully taken into account and promoted since it will help build community ownership that underpins the success of adaptation initiatives and community resilience. Effective adaptation actions must be taken at all levels (local, sub-national and national) to reduce vulnerability to natural system changes, whether natural or anthropogenic, and targeted to meet the needs of different vulnerable groups. Towards this end, a comprehensive assessment of community vulnerability and adaptive capacity to climate change should be carefully undertaken by relevant institutions to design appropriate adaptation initiatives that can be integrated into livelihood and natural resource management programmes.

Natural climate variability and its impacts will alter the conditions of local livelihoods for decades to come. Climate extremes hinder efforts to reduce inequalities between and within urban and rural areas, between regions and social groups, between the rich and the poor, and between women and men (MOP 2010). Sustainable agricultural development and natural-resource management, while protecting and mitigating adverse consequences of climate change, are key to improving livelihoods. Integrating environmental protection and ecological health into decision-making and planning for agricultural, industrial and economic development is essential for sustainable economic growth, social progress and poverty reduction while ensuring that the benefits of growth and development are shared countrywide.

It is clear that the general impacts of climate change will be intense and long lasting, yet the specific nature of climate change impacts at local level, i.e. time and location, remains uncertain. Designing appropriate climate change adaptation strategies, therefore, will be very challenging. To some extent, innovation and experimentation – the capacity to learn from

mistakes and experience – will be required. Policy, interventions, institutions and financial support will need to be flexible to adopt new knowledge and technologies and cope with climate challenges. Tight coordination between central and local levels will be essential. Importantly, local knowledge and local institutions, as the main interface between livelihood systems and natural systems, must be integrated into the formulation of climate change adaptation policies and strategies and the implementation of development activities.

For economic growth, human activities have exerted heavy pressure on natural resources and ecosystem services, making it progressively harder to protect the environment. Economic growth alone, however, is unlikely to be equitable enough to mitigate climate change. Given the threat of potentially catastrophic weather-related hazards and climate extremes, the crucial challenge developing countries will face is that of achieving their development aspirations and addressing climate change risks at the same time.

Following is a summary of considerations for policy and policy actions arising from this study:

Policy Considerations and Future Directions for Action

National Level (Policy Makers, Development Partners, Academics)

- Improve cross-sectoral coordination for coherent policy interventions, research and information sharing, incentive mechanisms and financial supports that foster the uptake of new strategies and technologies to cope with the uncertainties of climate change.
- Integrate adaptation initiatives into agriculture and irrigation system development and natural resource management to reduce vulnerability and secure agricultural productivity and sustainability of land, forests, water and fisheries that support daily livelihoods.
- Strengthen community-based natural resource management (CBNRM) and adaptation (CBA) while minimising unfair governance practices, inequalities and lack of livelihood diversification opportunities that weaken resilience.
- Improve women's access to economic opportunities, credit, financial support, research and professional training, and agricultural extension and services that respond to their needs.
- Address challenges to the formulation and implementation of gender-related policies in natural resources management, particularly climate change adaptation and water security for agriculture.
- Promote gender equity, women's livelihoods, and women's political representation.
- Create conditions conducive to women's greater participation in adaptation initiatives, which is critical to building local community resilience and eradicating poverty.
- Apply a "gender lens" to all aspects of policy formulation and development planning, particularly in the agriculture sector, to ensure that benefits reach both men and women.

Sub-national Level (Practitioners, NGOs, CSOs, Private Sector)

- Build capacity to manage the environment, reduce disaster risks, and adapt to climate variability and unexpected climate changes in the short and medium term.
- Strengthen coordination between and within state departments, community organisations, private sector agencies, CSOs and research/academic institutions to improve CBNRM and CBA.
- Heighten law enforcement to eliminate illegal activities that threaten natural resources and the environment.
- Monitor economic development activities to ensure they follow state policies aiming at sustainable natural resources use and local livelihood and national economic improvement.
- Invest in smart-agriculture development and climate resilient livelihoods, and explore new opportunities, practices and technologies that help farmers cope with climate change impacts.
- Upgrade agricultural extension services and weather and climate variability forecasting and information sharing.
- Support gender mainstreaming and women's greater participation in decision-making and implementation processes for climate change adaptation.

Community Level (Local Authorities, CBNRMs, NGOs, CSOs, Private Sector)

- Improve coordination between provincial departments, NGOs and private sector agencies to build the capacity of resource-user communities and foster their greater involvement in decision-making on natural resource management and climate change adaptation.
- Minimise unsustainable agricultural practices and encourage the adoption of climate-smart agricultural techniques and technologies and livelihood diversification to ensure livelihood resilience.
- Develop community capacity to manage natural resources and adapt to climate change impacts.
- Strengthen community ownership, legitimacy, co-management roles and responsibilities, and local participation (men and women) to ensure the success of CBNRM.
- Establish mechanisms to raise awareness and provide training to men and women in resource-user communities and other vulnerable social groups to enable their participation in and improve the effectiveness of CBNRM and CBA.

Knowledge Gaps and Future Directions for Research

- Water governance, irrigation management and development, fisheries and forest management, agricultural extension services and technology transfer are crucial to securing sustainable agriculture and land, forest, water and fisheries resources that support daily livelihoods. Yet few studies focus on strengthening the capacity of farmers and resource-user communities or designing mechanisms and policies for agricultural development that builds local adaptation and resilience to climate risks. This underscores the need to assess the impacts of climate change on food security and livelihoods and identify opportunities for developing CBNRM and CBA, including measures and options to bolster community livelihoods and capacities to cope with climate hazards. Such study should examine the status of key livelihood-supporting resources and their trends, and ways in which the CBNRM model could contribute to or consolidate community adaptive capacity. Findings can contribute to policy and climate change adaptation and vulnerability reduction measures for integration into land and water management practices that ensure sustainable agricultural development, food security and livelihood improvement.
- People have learned to adapt to seasonal variations in water and related resources in their locality, but their capacity to adapt to rapid environmental changes is weak. The poorest are most at risk because of their homogenous livelihood structures, limited livelihood opportunities, and unjust governance practices. Cambodia is composed of four agro-ecological zones – Tonle Sap plain, Mekong plain, Mountains/Plateau, and Coastal area – that represent heterogeneous agricultural activities, populations and livelihood systems (MOE & UNDP 2011). This necessitates research into the challenges affecting agriculture and livelihood-supporting natural resources to identify better ways for people facing different local conditions to adapt to climate change. Study should focus on agricultural technologies and practices, adaptive capacities and adaptation strategies within each zone to determine the effects of climate change, the areas and communities most at risk from climate hazards, and location-specific adaptation strategies. Findings would help shape climate adaptation strategies to better support households and communities and build resilience in those areas.
- Government has committed to using the REDD+ mechanism to protect forests and to improve the livelihoods of communities living in or near forest areas. More recently, the MOE reported that Cambodia plans to expand carbon credit in protected areas and community-protected areas to two million hectares.¹⁹ This highlights the need for research on the potential involvement of the state in CBNRM (organisation, structure, roles and responsibilities) and on carbon credit and REDD+ related policies/mechanisms so that initiatives benefit local communities and the state through livelihood and food security improvement as well as global carbon emission reduction and mitigation. Such study will help identify technical measures to ensure that REDD+ initiatives (and economic

¹⁹ http://www.cen.com.kh/localnews/details_more/136?token=ZTY4ZTcyMGI5NjQ1NTA3YjRmODgzMGNmOGYzYzI2 (accessed 13 March 2013)

development activities) provide short and long-term revenues for the state and local communities as well as practical mechanisms that encourage local communities to protect and conserve the resources they rely on.

- Various studies have reported farmer water-user communities' success and effectiveness in water and irrigation management, but have failed to consider the constraints hindering women's participation in water governance, especially in the context of climate change. Gender mainstreaming in agriculture and water management is critical to ensure that women have equal access to services, especially agricultural extension services, awareness raising and information on climate change adaptation and resilience. Further study on women's roles and gender issues in water and irrigation management in the context of climate change adaptation is vital to identify the critical issues women face and the responses that can best support them. Women's significant roles on community committees and in local administration as well as issues of gender mainstreaming, gender disparities and constraints affecting women's access to resources should be examined. Findings will support the integration of gender-sensitive approaches into water and irrigation management strategies that will help minimise the issues affecting women farmers.

The findings of this review raise additional questions for future research to answer:

- What are the gaps in agricultural technologies and practices for climate change adaptation?
- How can the CBNRM model be developed to maintain or improve its contribution to climate change adaptation and food security?
- What are women's roles in implementing IWRM and PIMD in the context of climate change?
- What is the adaptation capacity of rural people facing different conditions in the main agro-ecological zones –Tonle Sap Lowlands, Mountain/Plateau, Lower Mekong Plains, and Coastal Area?

Glossary of Common Climate Change Terms

Climate change has become a well known concept, but other standard environmental terminology and vocabulary are less familiar. This glossary is provided as a general reference to help the non-specialist better understand the discussion on climate change, not as an authority. Revised in May 2013, it includes terms, definitions and explanations of concepts and processes collected from various sources²⁰ and presented here in good faith.

Adaptation

The measures or adjustment taken in response to climate change, to reduce the adverse impacts or to take advantage of opportunities offered by such changes.

Afforestation

Planting of new forests on lands that historically have not contained forests.

Anthropogenic change

Natural system changes resulting from or produced by human activities.

Biomass fuels or bio fuels

Fuel produced from dry organic matter or combustible oils produced by plants. These fuels are considered renewable as long as the vegetation producing them is maintained or replanted, such as firewood, alcohol fermented from sugar, and combustible oils extracted from soy beans. Their use in place of fossil fuels cuts greenhouse gas emissions because the plants that are the fuel sources capture carbon dioxide from the atmosphere.

Capacity building

The process of developing the technical skills and institutional capability to address effectively the causes and results of climate change.

Carbon market

A trading system through which countries may buy or sell units of greenhouse-gas emissions in an effort to meet their national limits on emissions, either under the Kyoto Protocol or under other agreements, such as that among member states of the European Union.

Carbon cycle

The combined processes, including photosynthesis, decomposition, and respiration, by which carbon in various forms (e.g. as carbon dioxide) is stored and exchanged between its major reservoirs the atmosphere, oceans, land and living organisms.

Clean Development Mechanism

A market mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so which can be counted towards meeting mandatory limits on their own emissions.

Cities for Climate Protection

The Cities for Climate Protection (CCP) campaign assists cities to adopt policies and implement quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban liveability and sustainability. More than 800 local governments participate

²⁰ Including Climate Change Glossary.com (2008-2010), Earth Journalism Network (n.d), Environmental Protection Agency of the US (2012), PricewaterhouseCoopers (2008), IPCC (2012) and UNFCCC (2012)

in the CCP, integrating climate change mitigation into their decision-making processes. The International Council for Local Environmental Initiatives (ICLEI) runs this highly successful and widely recognised initiative.

Climate change

As defined by the United Nations Framework Convention on Climate Change (UNFCCC), a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability over a comparable period.

Climate-smart agriculture

A pathway towards development and food security built on three pillars: increasing productivity and incomes, enhancing resilience of livelihoods and ecosystem and reducing and removing greenhouse gas emissions from the atmosphere.

Deforestation

Conversion of forested land to non-forest use.

Evaporation

Process where liquid water is converted to water vapour (vaporisation) and removed from the evaporating surface (vapour removal). Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soils and wet vegetation. *See also transpiration.*

Evapotranspiration

Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. Apart from the water availability in the topsoil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface. This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

Governance

The way government is understood has changed in response to social, economic, and technological changes over recent decades. There is a corresponding shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognising the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of non-governmental actors, and of civil society.

Greenhouse gases

The atmospheric gases responsible for causing global warming and climate change. The major greenhouse gases are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). Less prevalent – but very powerful – greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆).

Intergovernmental Panel on Climate Change (IPCC)

Established in 1988 by the World Meteorological Organisation and the UN Environment Programme, the IPCC surveys worldwide scientific and technical literature and publishes assessment reports that are widely recognised as the most credible existing sources of information on climate change. The IPCC also works on methodologies and responds to specific requests from the Convention's subsidiary bodies. The IPCC is independent of the Convention.

Kyoto Protocol

An international agreement standing on its own, and requiring separate ratification by governments, but linked to the UNFCCC, the Kyoto Protocol, among other things, sets binding targets for the reduction of greenhouse-gas emissions by industrialised countries.

Land use

The total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation).

Land use change

A change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land-use change may have an impact on evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have an impact on climate, locally or globally.

Mitigation

Human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other “sinks” to remove greater amounts of carbon dioxide from the atmosphere.

National Adaptation Programmes of Action to Climate Change (NAPA)

Documents prepared by least developed countries identifying urgent and immediate needs for adapting to climate change.

Policies and measures

A frequently used phrase – sometimes abbreviated as PAMs – referring to the steps taken or to be taken by countries to reduce greenhouse-gas emissions under the UNFCCC and the Kyoto Protocol. Some possible policies and measures are listed in the Protocol and could offer opportunities for intergovernmental cooperation.

Radiative forcing

A measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, and is an index of the importance of the factor as a potential climate change mechanism. It is expressed in watts per square meter (W/m²).

Reforestation

Replanting of forests on lands that have previously contained forests but that have been converted to some other use.

Rio Conventions

Three environmental conventions, two of which were adopted at the 1992 “Earth Summit” in Rio de Janeiro: the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention on Biodiversity (UNCBD), while the third, the United Nations Convention to Combat Desertification (UNCCD), was adopted in 1994. The issues addressed by the three treaties are related – in particular, climate change can have adverse effects on desertification and biodiversity – and through a Joint Liaison Group, the secretariats of the three conventions take steps to coordinate activities to achieve common progress.

Rio+20

The United Nations Conference on Sustainable Development, held in Rio de Janeiro, Brazil, on June 4-6, 2012.

Sinks

Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis.

Soil carbon

Soil carbon is one of the most neglected yet most important factors in soil fertility, disease control, water efficiency and farm productivity.

Spill-over effects

Also known as rebound or take-back effects, spill-over effects are reverberations in developing countries caused by actions taken by developed countries to cut greenhouse-gas emissions. For example, emissions reductions in developed countries could lower demand for oil and thus international oil prices, leading to more use of oil and greater emissions in developing nations, partially off-setting the original cuts. Current estimates are that full-scale implementation of the Kyoto Protocol may cause 5 to 20 percent of emissions reductions in industrialised countries to “leak” into developing countries.

Sustainable development

Development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs.

Technology transfer

Exchange of expertise, experience and equipment for mitigating and adapting to climate change among different stakeholders

Transpiration

Vaporisation of liquid water contained in plant tissues and the vapours removal to the atmosphere. Crops predominately lose their water through stomata. These are small openings on the plant leaf through which gases and water vapour pass. The water, together with some nutrients, is taken up by the roots and transported through the plant. *See also Evapotranspiration*

Vulnerability

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

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