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Indigenous and Traditional Practices for Climate Resilience in Cambodia

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Indigenous and Traditional Practices for Climate Resilience in Cambodia

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FOREWORD

Building knowledge on adaptation is a critical element of Cambodia's long-term response to the climate change. The Royal Government of Cambodia's Third Rectangular Strategy, the National Strategic Development Plan (NSDP) and the Cambodia Climate Change Strategic Plan (CCCSP) for 2014-2023 all call for more efforts to improve knowledge of climate change in order to develop more effective and sustainable responses.

A number of programs and projects implemented by the Department of Climate Change (DCC) of the General Secretariat of the National Council for Sustainable Development (GSSD), including the Strategic Program for Climate Resilience (SPCR) and Cambodia Climate Change Alliance (CCCA), are contributing to the expansion of the knowledge about adaptation and mitigation practices. These efforts have included learning from international approaches and techniques for adaptation. Of equal importance is to build a body of knowledge on national experiences with adaptation, including how indigenous and traditional practices can contribute to climate resilience.

This document contains a broad range of local climate change interventions. It features practices aimed at increasing resilience at community level, and identifies ways to leverage existing experience in dealing with climate variability and climate hazards in order to respond to future climate change impacts. These practices also demonstrate ways to promote the resilience and empowerment of vulnerable groups, including women, youth and children.

The DCC/GSSD recommends the study of these practices to government agencies, development partners and civil society organisations to consider how to integrate indigenous and traditional practices into adaptation programs and policies. Moreover, there are numerous local climate change adaptation and mitigation practices throughout the country which are yet to be captured, ranging from indigenous and traditional practices to efforts to promote inclusion and empower vulnerable groups, including women, youth and children. The DCC/GSSD will continue to lead efforts to promote the documentation and sharing of such practices in order to build a wider knowledge base on climate resilient pathways that are appropriate to the Cambodian context.

Phnom Penh, 22 March, 2019

Chair of National Council for Sustainable Development and Minister of Environment

Say Sam Al

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Secretary of State of Ministry of Environment
and SPCR Program Coordinator

H.E. Prof. Dr. SABO Ojano

ACRONYMS

ADB	Asian Development Bank
CARDI	Cambodian Agricultural Research and Development Institute
CBDRM	Community-Based Disaster Risk Management
CEDAC	Centre d'Étude et Development
DBST	Double Bituminous Surface Treatment
DPWT	Department of Public Works and Transportation
EFEO	École Française d'Extrême-Orient
FAO	Food and Agriculture Organisation of the United Nations
FWUC	Farmer Water User Community
GMS	Greater Mekong Sub-region
ha	hectare
ICEM	International Centre for Environmental Management
ITKP	Indigenous and Traditional Knowledge and Practices
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
kg	kilogram
km	kilometre
m	metre
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCRDP	Mainstreaming Climate Resilience into Development Planning
MIPAD	Mondulkiri Indigenous People Association for Development
mm	millimetre
MOE	Ministry of Environment
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRD	Ministry of Rural Development
NGO	Non-Government Organization
PDOWRAM	Provincial Departments of Water Resources and Meteorology
RSP	Rock Slope Protection
RWC	RainWater Cambodia
SPCR	Strategic Program of Climate Resilience
TA	Technical Assistance
UNEP	United Nations Environment Program

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar (currency)
WSP	Water and Sanitation Program
WUG	Water User Group

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EXECUTIVE SUMMARY

Introduction. The purpose of this publication is to share knowledge on indigenous and traditional adaptation practices being applied in Cambodia. Cambodia is highly vulnerability to climate change due its large population located in the Mekong Delta flood plains that will experience higher risk of severe and prolonged flooding and drier conditions, and its dependence on climate-vulnerable agriculture. Cambodia's upland communities are also vulnerable to increased risks of heavy rains, landslides and droughts. Adapting to changing climate conditions will mean exploring solutions to address climate change from diverse sources. Indigenous and traditional adaptation practices that have been applied in Cambodia for centuries have evolved with changing climate patterns, and offer potential options to respond to present and future climate change impacts.

Indigenous Practices and Adaptation. This publication applies the definition of "indigenous and traditional adaptation practice" adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO): "Local and indigenous knowledge systems refer to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For rural and indigenous peoples, local knowledge informs decision- making about fundamental aspects of day-to-day life."[1] Indigenous and traditional practices for climate resilience are a range of practices that a community might consider for adaptation or disaster risk reduction that are appropriate to its ecological and sociocultural environments and in conformity with its priorities, values and worldviews. Indigenous and traditional knowledge can inform climate observation, and demonstrate practical climate-resilient techniques that can be replicated in other areas with similar conditions. Indigenous and traditional knowledge and practices also demonstrate how cultivating an adaptation mindset is important to responding to long-term changes in climate patterns and the environment. Indigenous and traditional practices underline women's role in household and collective decision making; improving upon, valuing and expanding the use of these practices can hence promote women's empowerment.

Presentation of the practices. The practices in this publication were compiled from research conducted under ADB TA8179-CAM, as well as from submissions made in response to a call from the Department of Climate Change to non-government organisations (NGOs), civil society organizations, academics and the private sector in 2016. Practices were selected where they described 'structures, techniques and practices which have been used by local people for at least one generation to design or manage their buildings, natural resources or livelihoods, or to protect these from climate hazards including extreme events (floods, droughts, storms)' as well as meeting criteria for relevance, content and presentation (see Box 2). The practices cover each of Cambodia's four main regions (plains, coastal area, around Tonle Sap and mountain area) and are organized into three sectors that correspond to priority areas for Cambodia's Strategic Program for Climate Resilience: (i) agriculture, (ii) water resources management and (iii) settlements

[1] UNFCCC (2013). Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, the application of gender-sensitive approaches and tools. Technical paper, UNFCCC/TP/2013/11. http://unfccc.int/resource/docs/2013/tp/11.pdf

and transport. The information on each practice includes its sub-sector, climate hazards addressed, the main adaptation elements, description of the practices, the adaptation outcomes, the challenges to adoption as well as sources and key contacts.

Agriculture sector. Cambodia is a traditionally agrarian society. Growth in the agriculture sector is a major factor in the country's progress in reducing poverty by more than half over the last decade, and it continues to be a key pillar of the country's strategies for food security and economic growth. At the same time, these gains are far from secure given the high vulnerability of agriculture livelihoods to the negative impacts of climate change, including increases in floods, droughts, water scarcity at certain times of the year and higher temperatures. Indigenous knowledge and practices are an integral part of agriculture production in Cambodia. As adaptation transforms different facets of farming, it is important to capture, maintain, and replicate the traditional practices that have made livelihoods more climate-resilient in different parts of the country.

The indigenous and traditional practices in this publication cover the main facets of agriculture production including rice and other crop cultivation, fisheries, animal husbandry, agro-forestry, mangrove rehabilitation, and post-harvest processing. The adaptation elements identified include improving and diversifying livelihoods, adjusting seasonal crop calendars, changing production patterns, enhancing plant resilience to climate hazards and adopting technology for post-harvest processing. Practices also demonstrate measures for soil erosion prevention, coastal protection, and natural pasture land conservation.

Water resources management sector. Climate change will have an important impact on the Mekong River Basin, resulting in shifts in the timing, duration and intensity of rainfall patterns and seasons, and in the water cycle of major rivers and tributaries. Gains made in increasing safe access to water will be threatened, and agriculture and fishery livelihoods will be at risk. Cambodia will need more solutions to manage the availability and distribution of water throughout seasons, across regions and between users, in particular for women who spend more time ensuring household water supply.

Indigenous practices for water resource management provide examples of how communities have coped with seasonal variations in the past and put in place measures to better store and conserve water supply to meet their needs. The publication presents practices for water storage in ponds and reservoirs, rainwater harvesting, and irrigation canals from natural streams that allow households and communities to capture different sources of water. The adaptation element focuses on conserving and storing water when it is more plentiful, for use in drier periods. In addition, farmer water user communities (FWUCs) demonstrate the value of collective decision-making in managing scarce water resources.

Settlements and transport sector. Infrastructure investment represents a significant portion of government and international donor resources dedicated to reducing poverty and stimulating growth in developing countries such as Cambodia. One of the major climate change impacts facing Asian countries is vulnerability to increased flooding, causing damage to infrastructure and settlements and resulting in loss of life.[2] The materials and techniques used to build infrastructure in developing countries are often selected to allow for more rapid expansion rather than durability, and are consequently more at risk from climate change. Examining indigenous and traditional practices for infrastructure development is a key part of determining what methods to use to make investments more resilient to impacts of climate change without adding significant costs. The publication presents practices for settlements and land-use, home construction, flood protection, roads and bridges. The adaption elements cover safer settlement planning, structural measures to mitigate coastal erosion, flooding and saltwater intrusion, and climate-resilient construction techniques.

Conclusion. The potential for integrating the identified measures into policy frameworks and replication is facilitated by the fact that these measures tend to be low-cost, easily adopted, originate from community participation and consensus, and are practised by women and men. Next steps to developing policies and programs that value and promote indigenous practices to address climate change impacts include: more research to understand the reasons behind the practice, including comparisons with scientific knowledge available; evaluating how to make practices more efficient; combining with new technology to improve effectiveness; institutional support at national and sub-nation level for conserving, improving and replicating the measures; and dissemination of the measures through formal and informal education systems.

[2] Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change: Summary for Policy-Makers [Field, C.B., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 23.

1. INTRODUCTION

1.1 BACKGROUND

The purpose of this publication is to share knowledge on indigenous and traditional adaptation practices being applied in Cambodia. The Department of Climate Change of the General Secretariat of National Council for Sustainable Development, under the technical assistance Mainstreaming Climate Resilience into Development Planning (MCRDP), has compiled these examples from two sources.

Firstly, MCRDP specialists and government technical officers undertook field research to document existing adaptation practices in agriculture, water resources, urban development and transport sectors that have potential for scaling-up to enhance climate resilience of future investments in these sectors. The mandate of these specialists included identifying and describing indigenous and traditional pra ctices that demonstrate resilience and have potential to become part of Cambodia's knowledge base on adaptation.

Secondly, to supplement the findings from the technical assistance, the Department of Climate Change issued a call to NGOs, civil society organizations, academics and the private sector to share their research on indigenous and traditional practices. The call for submissions also encouraged applicants to include practices that specifically enhance livelihoods of women, children and/or youth, or reduce their vulnerability to climate change. The received submissions were reviewed based on criteria (Box 2) and edited for inclusion in this publication.

This publication has been divided into three sectors - agriculture, water resources, and settlements and transport - in order to categorize the range of examples documented. In reality, indigenous practices transverse sectors; for example, climate resilience measures for agriculture are closely related to those for water resources management. As a whole, the collection of practices shows that indigenous knowledge is a key influence on daily life in Cambodia and can provide practical solutions for climate resilience.

1.2 CLIMATE TRENDS IN CAMBODIA

Situated in the Lower Mekong Sub-basin, Cambodia has a tropical climate with two seasons: a monsoon-driven rainy season (May-October) and a dry season (November-April). The annual Mekong River flooding is a dominant feature of Cambodia's climate and geography, with 80-90% of annual precipitation occurring in this period. The floods leave rich sediments across the country's lowlands as they recede. The annual flooding also contributes to the rich biodiversity of the Tonle Sap Lake area that expands from 2,500 km^2 to more than 16,000 km^2, creating an enormous wetland area.[3] For centuries, Cambodians have sustained their livelihoods based on these unique geographic and climatic conditions.

Analyses of the changes in Cambodia's climate patterns have been made for the 1960-2003 period. Trends observed include:[4]

- Present average annual temperature is 25-27°C throughout most of the year, rising to the highest level of 26-40°C before the raining season. Mean annual temperatures have increased by 0.8°C since 1960, at a rate of about 0.18°C per decade.
- The rate of increase is most rapid in the drier seasons (December to May), increasing by 0.20-0.23°C per decade, and is slower in the wet seasons (June to November), increasing by 0.13-0.16°C per decade.
- Since 1960, the frequency of 'hot' days has increased significantly (with strongest increases noted in September to November), as has the frequency of 'hot' nights (with strongest increases noted in December to February).
- The frequency of 'cold' days has decreased significantly in September to February.
- Mean rainfall trends over Cambodia are unclear, with some areas experiencing increases and others decreases; these changes are not statistically significant. Inter-annual variations in climate result from the El Niño Southern Oscillation, which influences the nature of the monsoons in the region and generally brings warmer and drier-than -average winter conditions across Southeast Asia, while La Niña episodes bring cooler-than-average conditions.

Projections of future impacts of climate change in Cambodia are based on the information derived for Southeast Asia. These include:[5]

- Mean annual temperatures are projected to increase across Cambodia by 0.7-2.7°C by the 2060s, and 1.4-4.3°C by the 2090s.
- All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in the current climate, with hot days

[3] Global Facility for Disaster Reduction and Recovery. Vulnerability, Risk Reduction, and Adaptation to Climate Change - Climate Risk and Adaptation Country Profile: Cambodia. Washington: The World Bank Group: 2011.

[4] Ibid.

[5] Ibid.

increasing by 14-49% and hot nights increasing by 24-68% by 2060.

- All projections indicate decreases in the frequency of days and nights that are considered 'cold,' with these events becoming exceedingly rare.
- While no clear picture for precipitation changes yet exists due to large model uncertainties, projections indicate that Southeast Asia will experience more variability in precipitation in the future, in particular during El Niño years. Periods of drought followed by increases in rainfall appear to be likely during the monsoon season for Cambodia.
- Cambodia's high vulnerability to climate change is related in part to the high percentage of its population living in flood plains that are more at risk of severe or prolonged flooding or unusually dry conditions. While Cambodians have long been 'living with floods', the expected change in climate patterns will require new shifts beyond people's traditional coping mechanisms. Adapting to these conditions will mean exploring solutions to address climate change from diverse sources, including practices that have been applied in Cambodia for centuries and have evolved with changing climate patterns.

2. INDIGENOUS PRACTICES AND ADAPTATION

2.1 DEFINITIONS OF INDIGENOUS ADAPTATION PRACTICES

In this report, the concept of “indigenous and traditional knowledge and practices” refers to “Knowledge unique to a given culture or society, acquired through accumulation of years of experiences of local people, informal experiments and intimate understanding of the natural systems stressed by climate change and socio-economic development”.[6] Indigenous and traditional practices relate to every sphere of human activity such as settlement patterns, building techniques, plant cultivation, eco-systems conservation, food security, livelihoods, forestry, rituals, art, culture, leisure and recreation and many more. Traditional practices are not static but evolve by adaptive processes, and are handed down through generations by cultural transmission.[7] Box 1 highlights the definitions used by United Nations bodies and agencies.

[6] Srinivasan, Ancha. Integrating Indigenous Knowledge in Climate Change Adaptation Strategies of Asia and the Pacific: Issues and Options. (Presentation) Institute for Global Environmental Strategies. http://www.env.go.jp/en/earth/ap-net/documents/seminar/12th/34.IGES_Ancha_Srinivasan.pdf

[7] UNFCCC (2013). Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, the application of gender-sensitive approaches and tools. Technical paper, UNFCCC/TP/2013/11. http://unfccc.int/resource/docs/2013/tp/11.pdf

Box 1. Definitions of indigenous and traditional knowledge applied by United Nations bodies and agencies

Convention on Biological Diversity:

Traditional knowledge is the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language and agricultural practices, including the development of plant species and animal breeds. Sometimes it is referred to as an oral traditional for it is practiced, sung, danced, painted, carved, chanted and performed down through millennia. Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, forestry and environmental management in general.

UNESCO:

Local and indigenous knowledge systems refer to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For rural and indigenous peoples, local knowledge informs decision-making about fundamental aspects of day-to-day life. This knowledge is integral to a cultural complex that also encompasses language, systems of classification, resource use practices, social interactions, ritual and spirituality. These unique ways of knowing are important facets of the world's cultural diversity and provide a foundation for locally-appropriate sustainable development.

2.2 IMPORTANCE OF INDIGENOUS KNOWLEDGE FOR ADAPTATION

Recognition of the need to understand and document indigenous and traditional practices in response to climate change emerged as the Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC) triggered an increased focus on adaptation. The risk that changes proposed as adaptation actions could undermine the existing adaptive capacity of local communities rather than reinforce their resilience led to a call to better understanding of how indigenous knowledge has contributed to local resilience and documentation of best practices. In response to a growing interest in this field, UNFCCC commissioned a technical paper to provide an overview of the status of research and the international literature on indigenous and traditional practices and their relevance to climate change adaptation.[8] The UNFCC research noted the need for best practices and tools to understand and sustain the enabling environment for adaptive capacity, recognize the contributions of indigenous and traditional practices as a source of knowledge (alongside science) that could promote effective adaptation and understanding of the impacts of climate change.

According to UNFCCC, indigenous and traditional practices for climate resilience cover a range of practices that a community might consider for adaptation or

[8] UNFCCC (2013). Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, the application of gender-sensitive approaches and tools. Technical paper, UNFCCC/TP/2013/11. http://unfccc.int/resource/docs/2013/tp/11.pdf

disaster risk reduction that are appropriate to its ecological and sociocultural environments and in conformity with its priorities, values and worldviews.[9] Indigenous and traditional knowledge offer insights not only to specific techniques for climate resilience but also to approaches to long-term adaptation. Indigenous and traditional knowledge and practices (ITKP) are relevant to adaptation efforts in three ways – climate observation, climate-resilient techniques, and developing an adaptation 'mindset' to deal with long-term changes.

In terms of climate observation, indigenous knowledge is a useful source of information to use in developing climate change scenarios for specific locations. The use of indigenous and traditional observations and insights, whether documented or maintained through oral history, can supplement scientific evidence of past meteorological observations and provide more information on historical trends in a specific geographic location.[10] This information can be used to develop climate change projections that guide future adaptation efforts.

Secondly, indigenous and traditional knowledge and practices to cope with seasonal changes and annual climate variability have resulted in specific measures that can be adopted to deal with climate change. Indigenous communities depend on natural resources for their livelihoods and so must constantly adapt to climatic stresses and other changes in their environment. For example, in Cambodia and other Southeast Asian communities, mountain indigenous groups have developed shifting settlement and agriculture practices in order to use a combination of location, forest, and natural vegetation to protect their crops and homes from climate events. The practices applied by these indigenous communities such as using agro-forestry techniques to protect crops are still relevant and becoming more necessary as observed increases in extreme climate events associated with climate change threaten crop production in both mountain areas as well as in the flood plains.

In terms of developing an adaptation 'mindset', indigenous and traditional knowledge evolves over time, and develops from a way of thinking about changes in the environment. Transferring indigenous practices involves the community in cultivating a shared sensitivity to their environment, and developing solutions based on long-term transformations such as those resulting from climate change. For example, the tradition of 'living with floods' and other coping mechanisms have for centuries allowed many Cambodians to adapt to natural systems and sustain their livelihoods in the country's extensive, fertile flood plains.

The mindset developed is not to avoid or control flooding but to be aware of natural signs of likely climate scenarios and respond in ways that enhance benefits and mitigate negative impacts. This approach is an essential part of responding to future climate change impacts where the specific nature of the impacts is yet to be fully understood. This adaptation mind-set is also useful in understanding how and when to combine traditional practices and modern solutions to climate change problems in ways that do not undermine local knowledge.

9 Ibid.

10 Ibid.

Traditional practices will be under stress as climate change results in longer-term temperature increases and less-predictable precipitation patterns and cannot necessarily be adopted without further adaptation. However, new solutions can be developed by building on the knowledge and the collective adaptive process that are at the root of these traditional coping mechanisms. Local, indigenous and traditional knowledge and practices can widen the range of options that a community might consider for adaptation, that are appropriate to its ecological and sociocultural environments and in conformity with its priorities, values and worldviews.

Although originating in local conditions, indigenous practices offer solutions that can be adapted to dealing with climate change in similar contexts elsewhere. Transfer of practice depends on their feasibility in new conditions and on their providing socially accepted solutions to climate change problems at a new location with a different historical and cultural dynamics.

2.3 GENDER AND ADAPTATION

As in other countries, Cambodian women and men have different roles in society, production and household tasks. Consequently, women and men will not experience climate change impacts in the same way. Cambodia's high vulnerability to climate change is related to the dependence of its economy on agriculture – a sector that employs more than two-thirds of Cambodian women.[11] Women also spend more time than men collecting water, resulting in longer work days when water sources dry up. Evidence also shows that Cambodian women are more adversely affected by natural disasters – women are more likely to be at home in vulnerable flood plain zones when disasters strike, as men move to urban areas to find work. Being responsible for young children and the elderly, women are at greater risk during disasters. Despite women being the majority of residents in many rural communities when disasters strike, they are a small minority of those who benefit from trainings and other forums to develop disaster preparedness and response systems (due to their under-representation in local government and leadership roles).

In contrast to women's representation in official local bodies, many indigenous and traditional practices underline women's role in household and collective decision making. Improving upon, valuing and expanding the use of these practices can promote women's empowerment. For example, activities such as diversifying income sources by improving animal husbandry activities (traditionally managed by women) can generate revenues that remain in women's hands, increasing their status and control of resources. Installing and improving rainwater harvesting technologies near the household contributes to reducing women's workload.

Supporting women to maintain their traditional knowledge for conserving forests not only promotes climate resilience, but at the same time empowers women to actively participate in decision-making on the use of community resources.

Developing adaptation measures from indigenous practices goes beyond conserving traditional ways of doing things and must recognize that some traditional practices may in fact entrench gender inequality. But indigenous practices are

[11] ADB. Country Partnership Strategy 2014 – 2018: Gender Analysis. Phnom Penh: ADB, 2013.

by nature dynamic and evolving, and gender roles in applying practices are not static. Developing effective climate change adaptation measures from indigenous practices means analysing the gender dynamics and identifying specific measures to advance the active participation of women in activities that make communities and households safer and more climate-resilient.

2.4 SCALING-UP INDIGENOUS PRACTICES

Indigenous practices are naturally small-scale, originating from a specific set of social, agro-ecological, environmental, and cultural conditions. But such practices can be replicable across geographic regions where certain comparable conditions are in place. For example, local seed varieties or soil conservation techniques used in dry regions may become viable in other parts of the country as seasonal conditions change. Techniques that are proven to add production value in specific localities can be tested in agricultural trials to learn their replicability to other parts of the country. To experiment, replicate and scale up climate-resilient agriculture techniques involves strengthening private and public agriculture extension systems and farmer field schools. Policy and programmatic initiatives need to enhance MAFF's research and knowledge-sharing role at the national level with province, district and communal units facilitating farmers' access to traditional and/or modern technologies through cooperatives, private companies and other agencies. A series of maps on each of the four zones of Cambodia where these practices emerged and the climate conditions are included in section 3 of the report. Replication of these practices is most likely in areas with similar climate conditions and climate change scenarios.

Indigenous practices for forest management can provide examples of community-based natural resource management that can be expanded to other areas. Such practices are relevant for developing new programs and policies on sustainable forest management in upland areas as well as for maintaining natural habitats in other regions of the country. Maintaining watersheds and natural cooling effects from better management of forests and other natural eco-systems is essential to combatting the impacts of climate change on human health, water resources, and diverse livelihoods. Understanding, valuing and scaling up indigenous and traditional practices for forest and eco-system management are a fundamental element of climate-resilient development planning. Wider promotion of such practices requires enabling conditions such as new policy and program initiatives for sustainable natural resource management that promote collective community-based management.

The projected impacts of climate change on water resources in Cambodia are likely to result in scarcity of supply for agriculture and for other purposes in certain times of the year. As Cambodia invests in expanding access to rural and urban water supply systems, policy makers will be faced with the challenge of how to distribute less water to more people. Even small-scale systems to capture water in the wet season for use in the dry season – when replicated on a wider scale – can make a difference in water access.

Maps provided in section 3 and the Annex highlight the expected changes in temperature and precipitation that will have an impact on water resources. The application of rainwater harvesting and other traditional techniques for water resource management depends on local precipitation and hydrological conditions. But as climate conditions change, the relevance of such practices in different geographic regions will evolve. For example, the use of rooftop rainwater harvesting may not seem to be a priority for urban areas that have access to other forms of water supply. But as urban areas expand, and water becomes scarcer, this traditional practice will become more relevant to supplement the water supply of urban homes. Expanding these practices requires more research on the most effective methods to capture and store rainwater on different types of surfaces, and more incentives for individual homeowners and private developers to adopt such technology.

The above-mentioned maps show how the practices identified will be subject to climate change impacts. The practices emerged in evolving climatic conditions that will continue to change. As climate change exacerbates extreme weather events, indigenous practices on their own will not overcome the adaptation deficit faced by communities, and improved techniques will be required. In this publication, some ways that improved techniques can be combined with the indigenous practice are provided. Learning from traditional practices, and combining this knowledge with scientific research and new technology, has the potential to generate new solutions to addressing the challenges of climate-resilient development that can be reflected in wider climate change policies and programs.

3. PRESENTATION OF THE PRACTICES

3.1 CRITERIA FOR INCLUSION OF PRACTICES IN THE PUBLICATION

The information compiled for this publication highlights how diverse communities across Cambodia are collectively preserving and applying traditional knowledge and practices essential to their daily life. The publication covers indigenous and traditional knowledge and practices as they have continued to evolve, and so practices are included where they have been used by local people for at least one generation. The primary and secondary criteria for inclusion are presented in Box 2. The primary criteria were defined based on accepted definitions developed under the United Nations Framework Convention on Climate Change (UNFCCC); additional criteria to ensure relevance, content presentation were also applied. Efforts were also made to ensure the three sectors (agriculture, water resources management, and settlements and transport) were covered and that the various geographic regions of Cambodia were represented in the collection. To expand the range of practices, some represent traditional techniques, such as sun-drying food products for conservation, that have been updated with new technology (solar drying greenhouses, p. 17) to further adapt to the changing climate as well as meet modern standards. In addition, practices originating from other countries have been included where such practices have been adopted in Cambodia for at least one generation.

The practices presented in this publication cover each of Cambodia's four main regions: plains, coastal area, around Tonle Sap and mountain area. The practices have been organized into three main sectors: (i) agriculture, (ii) water resources management and (iii) settlements and transport. The information presented on each practice includes its sub-sector, climate hazards it addresses, the adaptation elements, a description of the practices, the expected adaptation outcomes, the challenges to adoption of the practice as well as sources/references and key contacts.

Box 2. Criteria for inclusion of practices

A. Primary criteria

Structures, techniques and practices which have been used by local people for at least one generation to design or manage their buildings, natural resources or livelihoods, or to protect these from climate hazards including extreme events (floods, droughts, storms).

Measures that local people have started to develop themselves in response to observed changes in the climate such as increasing temperatures or changes in rainfall patterns.

B. Other criteria

Relevance

- ✓ Content is relevant to the publication's sectors (climate resilience in agriculture, water resources, settlements and transport)
- ✓ Relevance to climate change adaptation and/or disaster risk reduction issues is identified in the practice
- ✓ Appropriateness to solving community problems is made clear

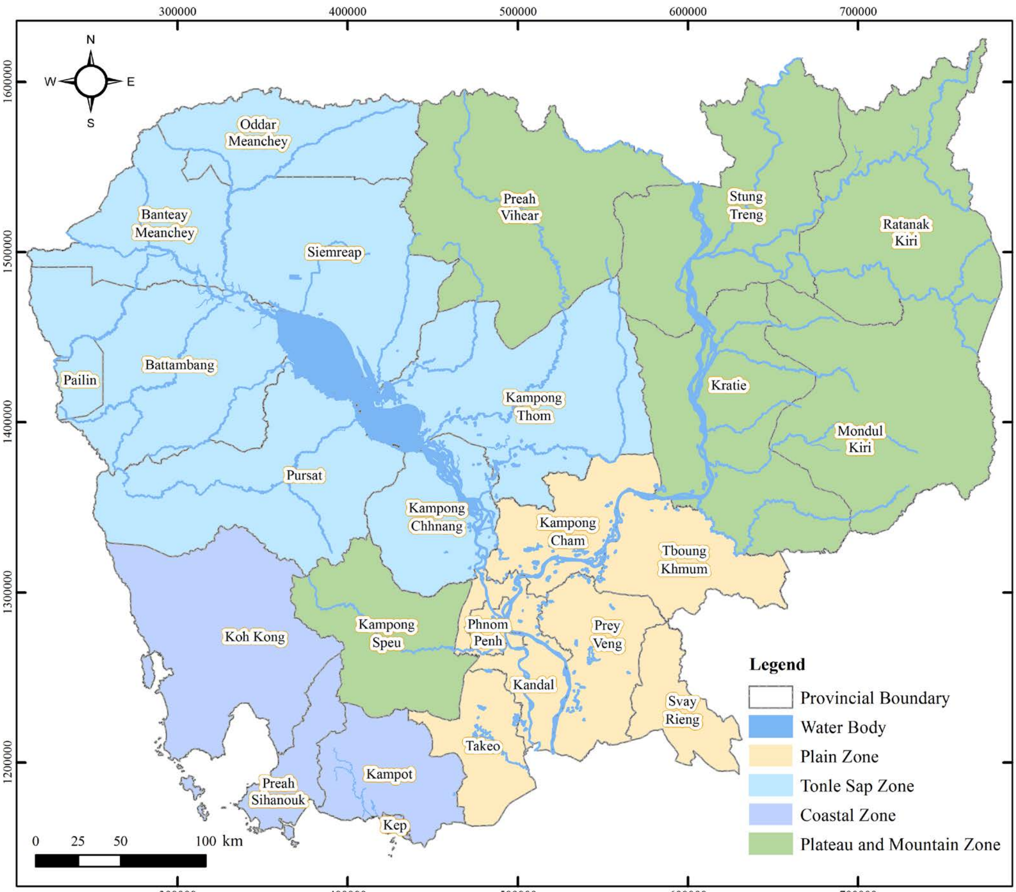
Content

- ✓ Practice is replicable where similar conditions exist
- ✓ Gender dimensions are addressed
- ✓ Evidence of local / community ownership provided
- ✓ Presentation
- ✓ Write-up is well written, clearly presented, with all the requested sections
- ✓ Practice is described in sufficient detail to fully understand it

3.2 CAMBODIA'S GEOGRAPHIC REGIONS

The practices presented in this publication cover each of Cambodia's four main regions (shown in Map 1) that are characterized by varied geography and distinct agro-ecological conditions. Some key characteristics of each of the regions and the expected changes in their climates are presented below.

Map 1 - Cambodia's geographic regions



Source: ICEM 2017

3.2.1 Plains

The plains cover 25,069 km^2 through which the Mekong River and its tributaries flow. This region is traditionally a significant rice-producing area, with the annual Mekong River flooding bringing water and nutrients important for a good crop. The plains area is the most densely populated part of Cambodia and includes many ethnic groups such as Khmer, Chinese, Vietnamese, Cham, as well as people coming from Thailand, Lao and other countries. Minority groups including Kuoy and Steang also live in Kompong Cham province. The capital city of Phnom Penh, as well as Kandal, Kampong Cham, Svay Riend, Prey Veng and Takeo provinces are located in this area.

By 2050, dry- and wet-season temperatures in the plains are projected to increase by +2.4oC and +2.9oC from their current baselines (31.4oC and 30.2oC, respectively). Precipitation in the wet season is expected to increase significantly - by +10.5% from its present baseline of 1028.7mm. Precipitation in the dry season is expected to decrease by -2.36%.[12]

3.2.2 Coastal area

Cambodia's coastal area covers 17,237 km2. The area includes Sihanoukville, Kampot and Koh Kong provinces, and Kep city. All lie along Cambodia's southwestern coast, which is 440 km long. Sihanoukville is the mid-point of the coastal area, 232 km from Phnom Penh. About 80% of the population of the coastal area is Khmer, although Cham, Vietnamese, Chinese, Thai and ethnic minorities such Sa Och also live here. The topography of Cambodia's coastal area is mountainous, plateau, plain, coast, seaside and gulf. There are 60 islands in Cambodia's coastal waters. They include 23 in Koh Kong province, two in Kampot province, 22 in Sihanoukville and 13 in Kep city.

By 2050, dry- and wet-season temperatures in the coastal area are projected to increase by +2.2oC and +2.8oC from their current baselines (29.8oC and 28.9oC, respectively). Precipitation in the wet season is expected to increase by +9.13% from its present baseline of 1082.5mm, while precipitation in the dry season is expected to decrease by -2.95% from the baseline of 257mm.[13]

[12] ICEM. 2017. Cambodia Climate Change Toolbox. URL: http://icem.com.au/CambodiaCC/.

[13] Ibid.

3.2.3 Around Tonle Sap

This area covers 67,668 km^2. The Tonle Sap is the largest freshwater lake in Southeast Asia and one of the richest inland fishing grounds in the world. It functions as a natural flood water reservoir for the Mekong system as a whole by regulating the floods downstream from Phnom Penh during the wet season, and makes an important supplement to the dry-season flow to the lowlands. The Tonle Sap is rich in fish and other forms of biodiversity. Fishing and rice production are the main livelihoods of the populations living in this area.

The area surrounding Tonle Sap is inhabited by different ethnic groups, including Khmer, Chinese, Vietnamese and Cham. There are a number of minority hill tribes such as Sa Och, Steang and Samre, who inhabit the mountainous area. The area includes Kampong Thom, Siem Reap, Banteay Meanchey, Battambang, Pursat, Kampong Chhnang and Oddar Meanchey provinces and Pailin city.

By 2050, dry- and wet-season temperatures around Tonle Sap are projected to increase by +2.4oC and +3.0 oC from their current baselines (31.2oC and 29.5oC, respectively). Precipitation in the wet season is expected to increase by +9.4% from its present baseline of 1191.2mm, while precipitation in the dry season is expected to decrease by -0.04%.[14]

3.2.4 Plateau and mountains

This area covers 68,061 km2 in north-east of Cambodia. Many ethnic groups inhabit the mountainous and plateau region. Cambodia's uplands are forested areas with low density. Along with Khmer, Chinese, Vietnamese, Laotian, and Thai, there are 18 minority ethnic groups in the region: Pnong, Steang, Kraol, Ro Oung, Tumpun, Tmuon, Bruv, Smil, Kuoy, Ar Norng, Charay, Kreung, Roder, Kha, Sa Och, Kachok, Kavet and Lun. Of these minority groups, the Pnong are the largest, comprising about 45% of the minority population. The population largely practices subsistence agro-forestry activities for their livelihoods, including swidden crop production.[15] Most of Cambodia's protected forests are in this area. The area includes Kampong Speu, Kratie, Stung Treng, Preah Vihear, Rattanakiri, and Mondulkiri provinces.

Temperature increased in this zone are projected to be greater compared to other three zones. By 2050, dry- and wet-season temperatures are projected to increase by +2.8oC and +3.5oC from their current baselines (30.6oC and 29.2oC, respectively). Precipitation in the wet season is expected to increase by +10.5% from its present baseline of 1,354 mm, while precipitation in the dry season is expected to increase by +0.15% from its current baseline of 264.3mm.[16]

The specific climate change hazards for which the documented practices are a potential response are noted in the report. These hazards are based on the

[14] Ibid.

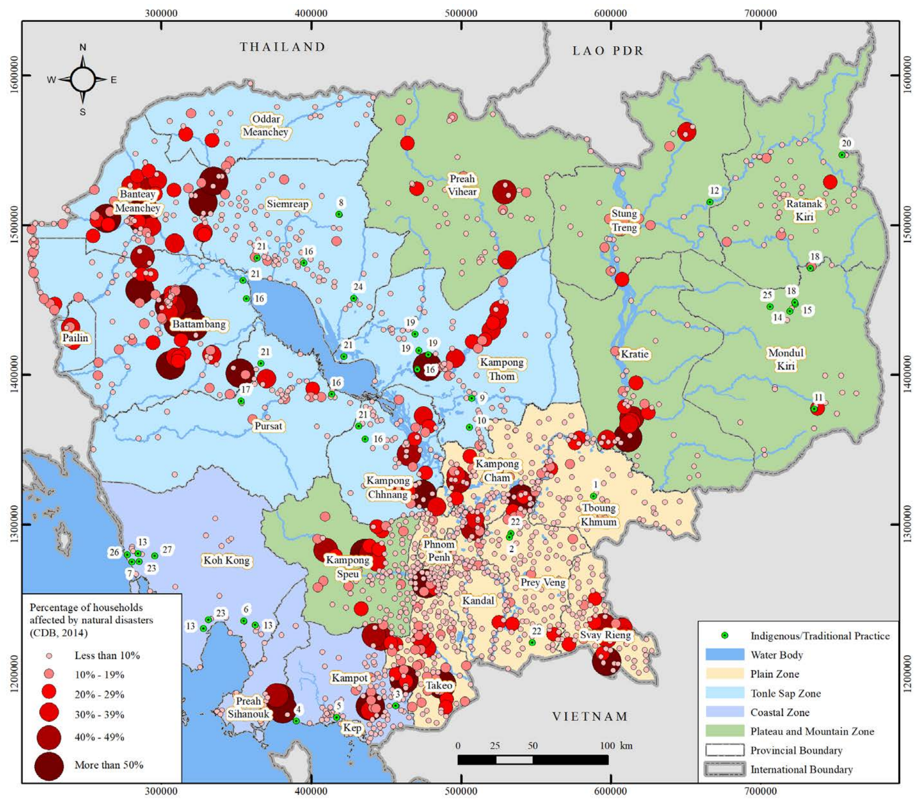
[15] Swidden is a rotational form of agriculture that applies natural vegetative processes as a means of replenishing soil fertility and controlling invasive weeds (ADB. Upland Agriculture in Cambodia - Regional Technical Assistance 5771 Poverty Reduction & Environmental Management in Remote Greater Mekong Subregion (GMS) Watersheds Project, 2003.)

[16] ICEM. 2017. Cambodia Climate Change Toolbox. URL: http://icem.com.au/CambodiaCC/.

climate conditions in which the practice emerged according to their location in one of the four main ecological zones.

Map 2 presents the location of each practice in relation to percentage of households estimated to be at risk to climate related disasters. Map 3 shows the location of the practice according to expected increases in dry season temperature by 2050. More information on exposure of each practice to climate change projections for wet and dry season temperature and changes in precipitation are presented in Annex 1.

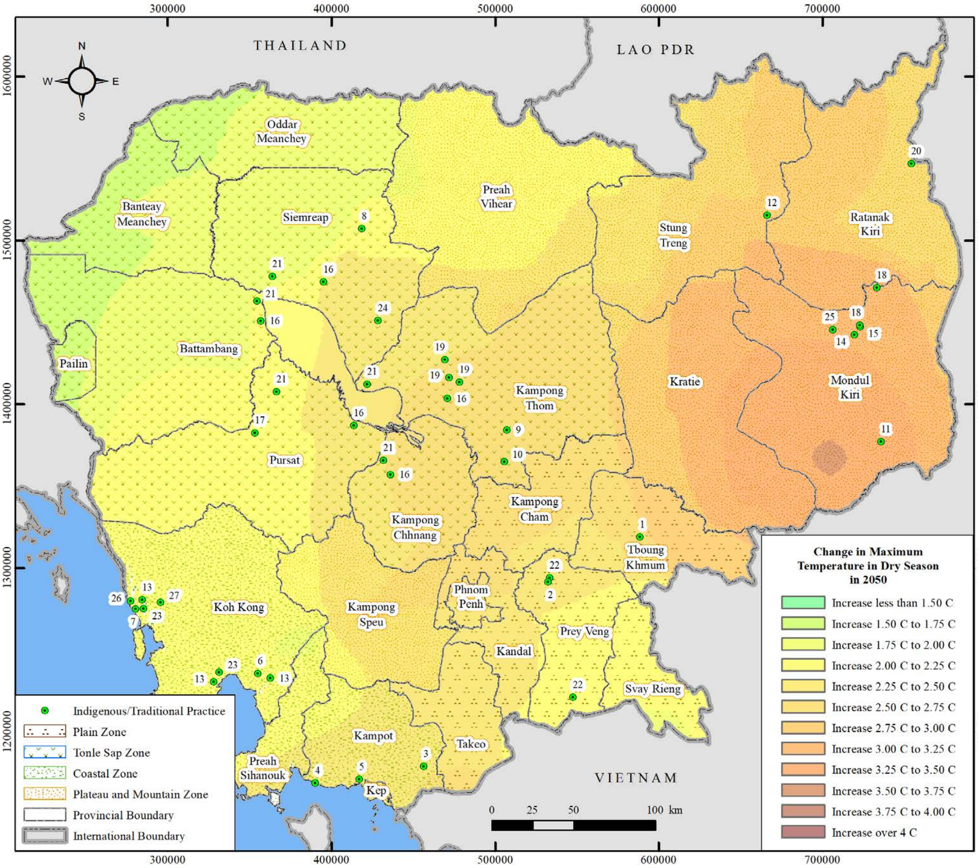
Map 2 – Location of documented practices in relation to risk of disasters



Code	Indigenous and Traditional Practices
1	Growing forage to enhance animal husbandry
2	Adopting shorter-season rice varieties
3	Multi-crop farming systems using biomass waste
4	Preserving food products through solar drying
5	Regeneration of mangroves in fishery communities
6	Cultivating local rice varieties
7	Raising green mussels in coastal communities
8	Improved poultry-raising techniques
9	Seed and grain storage
10	Integrated rice-fish systems
11	Upland agroforestry for agriculture
12	Livelihood diversification along the 3S Rivers
13	Coastal water storage reservoirs
14	Mountain water storage reservoirs
15	Surface water reservoirs and canal systems
16	Rainwater harvesting around Tonle Sap
17	Rainwater harvesting in Pursat Province
18	A simple roof rainwater collection system in Mondulkiri
19	Farmer Water User Communities (FWUCs)
20	Utilization of upland spring water for dry-season rice farming
21	Traditional weather forecasting system
22	Living with floods in lowland areas
23	Seawater protection dykes in Koh Kong Province
24	Khmer ancient bridge masonry
25	Settlements near bamboo forest and thatch meadows
26	Macadam base roads
27	Rock slope protection (RSP) for erosion control

Source: National Committee for Democratic Development, 2015, Commune Database - 2014.

Map 3 – Location of practices in relation to change in dry season temperature



Code	Indigenous and Traditional Practices
1	Growing forage to enhance animal husbandry
2	Adopting shorter-season rice varieties
3	Multi-crop farming systems using biomass waste
4	Preserving food products through solar drying
5	Regeneration of mangroves in fishery communities
6	Cultivating local rice varieties
7	Raising green mussels in coastal communities
8	Improved poultry-raising techniques
9	Seed and grain storage
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15	Surface water reservoirs and canal systems
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21	Traditional weather forecasting system
22	Living with floods in lowland areas
23	Seawater protection dykes in Koh Kong Province
24	Khmer ancient bridge masonry
25	Settlements near bamboo forest and thatch meadows
26	Macadam base roads
27	Rock slope protection (RSP) for erosion control

Source: www.mekongarcc.net

4. AGRICULTURE

4.1 OVERVIEW

Cambodia is a traditionally agrarian society. Agriculture contributes 37% of gross domestic product and employs two-thirds of the population[17]. Growth in the agriculture sector is a major factor in the country's progress in reducing poverty by more than half over the last decade, and continues to be a key pillar of the country's strategies for food security and economic growth.[18]

As with other parts of the world, indigenous knowledge and practices are an integral part of agriculture production in Cambodia. The majority of Cambodian farmers live in lowlands along the Mekong River, its tributaries and around the Tonle Sap Lake. Traditionally, these farmers have cultivated a single wet-season rice crop as their main agriculture activity. The Mekong River's annual flooding deposits rich sediment on its flood plains, leaving fertile agricultural land behind when river levels fall. Paddy rice farming is supplemented with fishing in this freshwater system that is among the world's greatest in terms of fish biodiversity.

Cambodia's upland areas account for a smaller portion of total agriculture production but have a rich history of evolving agriculture practices. According to statistics from the International Rice Research Institute (IRRI), there is about 50 000 ha of upland rice in Cambodia (2-4% of total rice area). Agriculture in Cambodia's upland is mainly rain-fed swidden rice production.[19]

Swidden agriculture for rice production has been the main source of livelihood in the highlands for centuries. As the government has promoted sedentary paddy production, many upland farmers have adopted dual systems of having both paddy rice and upland swidden cultivation. Over time, rice production has been supplemented with growing perennials, animal raising, non-timber forest products, legumes, root crops, cucurbits and non-food crops using a mix of traditional and more modern techniques.[20]

In efforts to reduce poverty and enhance food security for its growing population, the Royal Government of Cambodia has implemented various strategies to modernize and promote commercialization in the agriculture sector. Strategies have included greater diversification, dissemination of improved technologies, rehabilitating and expanding irrigation systems, as well as better access to modern inputs and mechanized services. These efforts have resulted in higher wages in the agriculture sector and have successfully contributed to poverty reduction.[21]

The improvements in efficiency and commercialization of Cambodia's agriculture

[17] FAO. Country fact sheet on food and agriculture policy trends. Rome: FAO, April 2014.

[18] World Bank Group. Cambodian Agriculture in Transition: Opportunities and Risks. Economic and Sector Work, Report No. 96308-KH. Washington, D.C.: World Bank Group, 2015.

[19] ADB. Upland Agriculture in Cambodia - Regional Technical Assistance 5771 Poverty Reduction & Environmental Management in Remote Greater Mekong Subregion (GMS) Watersheds Project, 2003.

[20] Ibid.

[21] World Bank Group. Cambodian Agriculture in Transition: Opportunities and Risks. Economic and Sector Work, Report No. 96308-KH. Washington, D.C.: World Bank Group, 2015.

sector have had clear benefits for farmers. At the same time, the gains are far from secure given the high vulnerability of agriculture livelihoods to the negative impacts of climate change. Southeast Asia's water resources are already under stress due to rapid population increase and industrial growth, and climate change is expected to intensify this problem.[22] Higher temperatures will also influence agriculture productivity. The dry conditions experienced in 2015 and 2016 demonstrated the urgent need to make Cambodia's agricultural sector more climate-resilient. Projecting to the future, a study of climate change impacts on agriculture in the Lower Mekong Basin projected a 3.6% decline in rice yields in Kampong Thom Province and 3.0% in Mondulkiri Province by 2050, due mainly to increased temperatures.[23]

Adaptation will potentially transform different facets of farming, from land use and water management to commodity choices and cropping patterns. As Cambodia continues to modernize and improve agriculture sector performance, it is important to capture, maintain, and replicate the traditional practices that have made livelihoods more climate-resilient in different parts of the country. For example, agricultural researchers and extension agents can help farmers identify new varieties that may be better adapted to changing climatic conditions, and facilitate farmers to compare these new varieties with those they already produce. In some cases, farmers may participate in crossing select seeds from plant varieties that demonstrate the qualities they seek to propagate to develop new varieties with the characteristics they desire.

It is by drawing from the full range of available techniques – both traditional practices as well as new technologies – that farmers will be best able to respond to changing climate patterns.

[22] ADB. 2011. Economic Impacts of Climate Change in South East Asia. Manila.

[23] USAID. USAID Mekong ARCC Climate Change Impact and Adaptation Study: Main Report (ICEM and DAI), 2014.

4.2 PLAINS

4.2.1 Growing forage to enhance animal husbandry

Sub-sector	Climate Hazards	Adaptation Elements
Animal husbandry	Temperature increase, drought, flooding	Livelihood diversification Soil erosion prevention Natural pasture land conservation

Description of the Practice

Increasingly high temperatures, drought and flooding reduce the amount of natural grass available in pasture areas for farmers who raise livestock. Flooding results in longer periods of pasture inundation, preventing animals from feeding. When animals have less feed they remain thin and are more susceptible to diseases. Growing animal forage on their farmland allows farmers to have more control over the quantity of food available for their animals during periods of flood and drought.

Farmers in Punleak Village, Chong Cheach Commune, Dombe District, Tboung Khmum P rovince traditional rely on animal husbandry to supplement their farm incomes. The traditional practice is to allow animals to graze in grasslands that surround the communities. As grasslands become less covered in vegetation due to drier conditions and overexploitation from animal husbandry, these farmers are adapting by growing forage with the support of the provincial and district department of agriculture, forestry and fisheries, and local authorities.

Families raising animals allocate part of their land for forage. They cultivate high-quality grasses that grow well in local conditions, require less water and provide dense vegetation in relatively small surfaces (STAYLOs184, King Grass, Elephant Grass, Symong Grass, Molato, and Paspalum). Some families grow the grass along their fence or in other suitable place in order to conserve land space.

Depending on the amount of land available, the farmers harvest the grass for feed and mix it with straw so it will last longer. Others allow the animals to feed from the grass plantation in the field.


Examples of forage plantation

Adaptation Outcomes	
Sensitivity/ Exposure	Cultivating forage allows farmers to choose grass varieties that are more resilient to local conditions and less sensitive to climate hazards. Planting animal forage in fields compared to vegetation in open pasture land allows farmers to take measures in response to climate variation such as watering the plants during dry conditions or harvesting and storing before flood events. Having a ready source of feed animals contributes to healthier animals that are less sensitive to extreme heat and cold, or disease resulting from prolonged wet conditions. Avoids the need to take animals for grazing far from the home during flood season, reducing vulnerability to disaster risks for the herder and the animals.
Adaptive capacity	Grasses planted as forage are higher quality feed and contribute to a better animal growth. Farmers earn more income from having a better-fed animal and also from selling extra forage to other farmers.
Eco-system integrity	Certain types of forage planted along farm fields reduces soil erosion. Forage substitutes for grazing on natural pasture lands and can reduce pasture over-exploitation and land degradation.
Additional benefits	Children, who are often responsible to take the animals to pasture, are more likely to attend school when the forage is available near the home.
Criteria for Adoption	
Relevance	Addresses needs of rural farming communities who are dependent on animal husbandry that is facing land degradation in natural pastures.
Social acceptability	The change in animal feeding technique was accepted in the case study area. The community realized the benefit to maintaining the traditional livelihood practice of animal husbandry in face of the growing environmental pressures on pasture lands.
Gender dimensions	In many communities, women are responsible for collecting vegetation to feed animals. Growing forage can be a time-saving measure for women.

Economic Viability	Costs are allocation of land and initial investment in forage plants. Affordable varieties of forage plant are available to meet varying household budgets. Forage can be grown along fences, around the home and fields to conserve land. Well maintained grass plants can be used over a number of seasons. Farmers will realize a return from having healthier livestock assets.
Replication potential	Applicable to rural farming communities in agro-ecological zones suitable for animal husbandry.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on grass variety selection, and cultivation suitable to local conditions as well as on improved animal feeding techniques. Improving input supply chain for access to affordable, quality forage plants.
Sustainability	Creates a renewable agriculture input and contributes to sustainable land management.

Challenges in Adoption

- Forage requires some land allocation and periodic land rotation, reducing the area available for other types of cultivation.
- Forage is fairly simple to grow but still requires knowledge transfer to farmers for whom the practice is new to be sure they understand how to maintain it.
- Flooding or drought can also damage forage. Land to be selected has to be less flood prone and have some access to water.

References/Sources	Key Contact
Discussions with farmers' families in the communities and local authorities of Punleak Village, Chong Cheach Commune, Domebe District, Tboung Khmum Province, and with the Provincial Department of Agriculture, Forestry and Fisheries in Tboung Khmum Province.	Mr. Sroin Chanthea Heng Samrin Tboung Khmum University Tel: 012 479 562 Email: chanthearsroin2010@yahoo.com

4.2.2 Adopting rice varieties to changing agro-ecological conditions

Sub-sector	Climate Hazards	Adaptation Elements
Rice cultivation	Temperature increase, drought, flooding, shifting climate patterns	Adjusting seasonal crop calendar

Description of the Practice

Growing wet-season rice is an important indigenous livelihood activity in Cambodia's plains. Traditional practices have been improved in order to adapt to climate change while maintaining this long-practiced livelihood activity.

Traditional practice:

Khmer farmers have been growing rain-fed rice for at least 2,000 years and irrigated rice production technologies were introduced 1,500 years ago. Research shows that rice-growing technologies were brought into Cambodia from people travelling along the trade routes from India.[24]

Given the ancient experience with rice, Cambodia's rice land areas fit into different ecosystems. For hundreds of years, natural selection pressures such as drought, submergence, flooding, nutrient stresses, and biotic stresses have contributed significantly to the evolution of various rice varietal types for different agro-ecological environments.

Variations in cultural management practices (e.g., harvesting by cutting the panicles vs harvesting by hand stripping individual grains, direct seeding vs transplanting, mixed cropping vs pure stand) and differential preferences of farmers for grain characteristics also contributed to the genetic diversity of rice varieties.[25]

This traditional process where Cambodian farmers adopt rice varieties in relation to changing agro-ecological conditions is continuing today and is an important technique for adaptation to climate change. Dependence on rain-fed agriculture is a risky practice in the context of climate change as rice is easily damaged by a late start to the rainy season or lower levels of rainfall. With the impacts of climate change and other hydrological factors affecting the Mekong River and its tributaries, farmers are increasingly facing damage to wet-season rice fields and harvest. In order to continue to adapt their traditional practice of wet-season rice, villagers are adopting rice varieties that require a shorter period of cultivation in order to harvesting before flooding becomes a risk.

Farmers in Trea village, Kagnchom commune, Pearang district, Prey Veng province, have been trying these rice varieties under the Build-Farm-Adapt initiative supported by the Cambodia Climate Change Alliance. Prey Veng

[24] Nesbitt, H.J., ed. 1997. Rice production in Cambodia. Manila (Philippines): International Rice Re search Institute.

[25] Ibid.

Province is one of the provinces most vulnerable to climate change, particularly flood and drought. Severe flooding has become a most serious climate threat for rice farmers in Trea village, Kagnchom commune, where cultivation takes 5-6 months. In some years, the rice production was completely lost due to floods and drought.

Farmers have started using shorter-period varieties, which allows them to harvest their rice within 3 months. Two varieties are most common: 1) Sen Pidor variety is a local variety developed by Cambodian Agricultural Research and Development Institute (CARDI), and 2) IR504 a variety which is imported from Vietnam.

For these varieties, farmers can start their crop in early June and harvest in early September. This pattern avoids the need to plant as early as April/May when prolonged dry conditions may occur and prevents losses in October and November when extreme flooding is more likely to occur. The adaptation practice of using shorter-season rice varieties has reduced rice losses due to flooding up to 100%.

Fields with shorter-season rice in Prey Veng Province

Adaptation Outcomes	
Sensitivity/ Exposure	A shorter period of rice cultivation allows farmers to adapt to shifting climate patterns and avoid losses due to increased occurrence of extreme climate events associated with climate change. A later planting time avoids periods of prolonged dry conditions and an earlier harvest prevents losses during the period when intense flooding is most likely to occur. These varieties can grow in all seasons, allowing adjusting the cropping calendar based on observed and projected changing climate patterns.
Adaptive capacity	Enhances community resilience and food security by enabling farmers to cultivate a key food crop.
Eco-system integrity	Combining training on integrated pest management with the use of local varieties such as San Pidor can reduce the use of fertilizers and pesticides that can harm the local environment.

Additional benefits	These rice varieties generate a good yield at 3-4 tones/ ha. The rice produced from these varieties is popular and draws a higher price.
Criteria for Adoption	
Relevance	Addresses needs of rural farming communities that are dependent on rice cultivation for their food security.
Social acceptability	As Cambodian farmers recognize the need to change their seasonal crop calendar due to shifting seasonal climate patterns and more intense flooding, the use of shorter-season varieties is becoming more acceptable. In particular, the use of local shorter-season varieties where farmers can save and store seeds is preferred.
Gender dimensions	Women have less access to resources and a lower labour mobility than men. As a result, women are more dependent on subsistence crops and disproportionally affected by their loss to disasters. Shorter-season rice cultivation enhances women's capacity to assure family food security and allows more time in the production calendar for alternative sources of income generation.
Economic Viability	Costs are land and agriculture inputs. Some shorter-season rice varieties such as IR504 are more costly, but have higher yields and farmers are able to increase their output by avoiding losses.
Replication potential	Applicable to most rural farming communities in Cambodia as the majority of farmers grow wet-season rice and have knowledge of rice farming techniques that are transferable to using these varieties.
Institutional needs	Expanding this practice depends on greater availability of shorter-season varieties and ensuring they are suitable for sustainable production over large areas through more study of environmental factors. For Sen Pidor, the government needs to collaborate with CARDI to ensure supply and develop more channels to make the variety more available on the market. Although farmers can rely on their traditional knowledge when using these varieties, more technical support to ensure they are maximizing their yields over the shorter-season is essential to promoting wider use of this technique.
Sustainability	Sen Pidor variety is local and farmers can use traditional techniques to save and store seeds for the next planting season.

Challenges in Adoption

- As an imported product, the price of the rice variety IR504 is higher and more variable than local varieties.
- More studies about the impact of IR504 variety on the environment and on the continued availability of local varieties is needed.
- As Sen Pidor is a new local variety being introduced by CARDI, the availability is limited and the annual supply is not secure.

Source	Key Contact
Discussions with farmers in Trea village, Kagnchom commune, Pearang district, Prey Veng province	Mr. Pin Tara University of Heng Samrin Thbongkhmum (UHST) Tel: 012 797 879 / 015 797 879 Email: pintara30@gmail.com pintara@uhst.edu.kh Website: www.uhst.edu.kh National Road No. 73, Nikum Leu Village, Srolub Commune, Thbong Khmum District, Thbong Khmum Province, Cambodia.

4.3 COASTAL

4.3.1 Multi-crop farming systems using biomass waste

Sub-sector	Climate Hazards	Adaptation Elements
Plant production Biomass	Temperature increase, drought, flooding	Enhancing plant resilience to climate hazards Adjusting seasonal crop calendar Livelihood diversification

Description of the Practice

Biomass is a substance developed from waste that can be used for either energy or for fertilization. The reuse of residues from agriculture, animals and the household for fertilization or fuel has been a long-time practice for farms in Cambodia and other countries. Recent efforts to improve household biomass production techniques have promoted its use as a fuel substitute for wood or wood-based charcoal to reduce deforestation. In parallel, improved biomass production and application are also an adaption measure to improve crop nutrition in ways that can make farming more climate-resilient.

Biomass fertilizer is a highly effective resource for enriching soil and improving plant production. Biomass fertilizer helps to retain nutrients and moisture during dry season and can help to protect crops from too much water in the wet season. By using biomass as a low-cost and readily available resource for plant cultivation, farm families can switch from traditional single rice crop cultivation to year-round multi-crop systems, integrating beans and vegetables. This transition makes farmers more climate-resilient by diversifying their cropping patterns and sources of income. Farmers that cultivate more than one single-season crop are less vulnerable when floods and drought events affect the main cropping season.

In Toukmease Khang Leak Commune, Banteay Mease District, Kampot Province, farmers have introduced biomass from animal waste for crop nutrition. This additional source of fertilizer makes it possible to cultivate a bigger range of crops and diversify their cropping systems. MAFF is providing technical knowledge on multi-crop systems, while a local NGO Centre d'Etude et de Development (CEDAC) is providing information on how to produce the biomass. A total of 23 families are piloting the biomass. Women are about 75% of people joining groups to learn about setting up and maintaining biomass, in particular to grow vegetables.

Prior to introducing the biomass for crop nutrition, at the start of the dry season, the farmers in these villages did not have enough water for agriculture due to insufficient rain. More than 60% of their rice fields dried up in drought years. In the wet season, the same villages had too much rain that spoiled their vegetables.

To adapt to these conditions, the famers changed their practice to a multi-crop system using biomass. For example, one farm family used biomass to cultivate 1 ha of vegetables on their 3 ha of land, planting cucumbers and long beans. They spent around 1,099,900 Riel (USD 275) on seeds and other costs, and earn about 3,582,000 Riel (USD 900) in income from selling the vegetables. Farmers in this pilot use the seasonal calendar to forecast the weather and select the most appropriate land and timing for their crops. Some vegetables can grow at different times of year, giving farmers more options for production. Farmers are developing the practice of following the prices in the market to select the crops that will bring the best return.

Adaptation Outcomes	
Sensitivity/ Exposure	The multi-crop system using biomass fertilizer diversifies farmers' cropping pattern and income sources, making them less vulnerable to climate events that damage a single crop. Plants receive more nutrients and are protected in the early growing stages. As a result, crops are stronger, more resilient to climate conditions, and require less water.
Adaptive capacity	Enhances farmers' access to inputs for climate-resilient agriculture production. Diversifies farmers' income and food security sources, thereby increasing their resilience to disaster risks.
Eco-system integrity	Using biomass improves soil quality and lessens the need for chemical fertilizers. It prevents invasive plants from growing, thereby reducing the need for harmful herbicides.
Additional benefits	Growing vegetables diversifies family's diet and provides more nutrition for children.
Criteria for Adoption	
Relevance	Addresses the need for rural communities to diversify their livelihoods in response to changing climate patterns.
Social acceptability	As Cambodian farmers recognize the need to change their seasonal crop calendar due to shifting seasonal climate patterns and more intense flooding, multi-cropping is becoming more acceptable. Based on the case study experience, farmers are ready to accept biomass production after observing the benefits from demonstrations.

Gender dimensions	Producing biomass fertilizer may add to women's labour. This potential negative impact may be offset by the increased access to a source of soil nutrient for growing vegetable gardens that enhance income and family food security, and by the decreased expenditures on chemical fertilizers.
Economic Viability	Materials and equipment for biomass production vary based on the complexity of the system but start at a low-cost investment of close to USD 1,000. Farmers who invest in biomass materials and equipment in the case study area earned a return on their investment from vegetable production. Using biomass farmers reduces their expenditure on fertilizer.
Replication potential	Applicable to farming communities in agro-ecological zones suitable to multi-crop production, including vegetable production.
Institutional needs	Implementation requires MAFF to extend its program to transfer technical knowledge on multi-crop systems. It also requires support from MAFF extension workers or from other rural service providers to transfer techniques on biomass production.
Sustainability	Biomass is a renewable resource from agricultural waste, so once the system is installed farmers can continue to use in on ongoing basis to diversify their crop production.

Challenges in Adoption

- Farmers need to select the right types of cropping pattern to avoid losses given that the crops are still vulnerable to adverse climate conditions.
- While biomass is a traditional farm by-product, using the right combination of residues is important for healthy crop growth. Technical support from MAFF and other agencies is needed to transfer the skills to farmers to apply the techniques correctly.

References/Sources	Key Contact
The discussion was conducted with the sample families in the Prey Thom Commune, with Banteay Meas Agriculture Office District, with CEDAC organization based permanently in Kampot Province.	Mr. Kem Nith Royal University of Agriculture Dongkor District, Phnom Penh, Cambodia P.O.Box 2696. Tel: +855 69 504 294,+855 23 219 829 Email: knith@rua.edu.kh, rua@camnet.com.kh Website: www.rua.edu.kh

4.3.2 Preserving food products through solar drying

Sub-sector	Climate Hazards	Adaptation elements
Fisheries Post-harvest processing Food preservation	Temperature increase, drought, flooding, shifting seasonal patterns	Livelihood diversification Technology for post-harvest processing to adjust to changing seasonal patterns

Description of the Practice

Preserving agricultural and fish products through drying is a traditional technique that is widely practiced in Cambodia. Traditionally, open-sun drying has been an easy-to-use and low-cost technique for conserving food products for consumption or sale. With this technique, farmers and fishers can maximize their production in periods of optimal climate and conserve products for later consumption or sale when the climate may be less favorable. This allows producers to reduce the risk of losing production to extreme weather events.

Despite its advantages, traditional open-sun drying has drawbacks. Increases in heavy rain and storms have led to difficulties in leaving products in open areas. Increases in temperature are also creating conditions less conducive to open-sun drying, which is more suited to moderate temperatures. Also, food dried in open areas is often exposed to dust, and pests and other contaminants, creating hygiene risks.

Solar drying is a modern technique to improve upon the traditional practice of preserving fish and other products through drying. Using a solar dryer enhances this traditional technique by allowing producers to adapt to changing climate conditions while also increasing processing efficiency and sanitary conditions.

The technique of drying fish and agricultural products with solar greenhouse dryers is being practiced in Chan Hoan Village, a fishing village located in Kampot province. The fishers in this village rely on agriculture and fishing for their income, and have traditionally dried fish and shrimp for sale in Kampot Town. A NGO named ASSIST has been helping the village to improve the practice of drying agricultural produce and fish products.

In 2013, one of the women residents, Ms. Chey Sopha, introduced a solar greenhouse dryer in her neighborhood. Ms. Sopha is currently providing a service to 10 other families to dry shrimp, fish and other products. The pilot solar greenhouse dryer improves performance of drying and the quality of the product by drying more quickly and in more hygienic conditions than conventional open-sun drying. By improving the process and preventing post-harvest loss, this initiative helps the community to reduce costs, generate more earnings, and eventually grow as businesses.

Adaptation Outcomes	
Sensitivity/ Exposure	Drying fish and crop products allows access to food sources for sale or consumption over longer periods in the year, reducing the need to fish or cultivate during periods when extreme climate events are more likely to occur. Solar drying allows for a more rapid post-harvest processing and reduces risks of losing aquatic or crop products during disasters.
Adaptive capacity	Enhances farmers' access to post-harvest processing facilities and diversifies their income sources. Farming and fishing households with diversified livelihood sources are more resilient as they can recover more easily if one source of livelihood is lost or damaged in a disaster.
Eco-system integrity	Both open drying and solar drying use the sun as a source of energy and avoid using wood or non-renewable sources to process food.
Additional benefits	Using solar dryers reduces processing time and limits post-harvest losses. Updating the technique has improved the hygiene, quality and marketability of the dried products, providing the local industry greater opportunities for export.
Criteria for Adoption	
Relevance	Addresses the need for rural communities to diversify their livelihood sources in response to changing climate patterns and to apply modern food-processing techniques to reach more markets.
Social acceptability	Based on the case study experience, farmers consider solar drying an acceptable modernization of traditional food drying techniques.

Gender dimensions	Women are primarily responsible for post-harvest food processing. The drying techniques provide women with a means to secure their family's food for longer periods and potentially earn income from the sale of processed products. Using the solar dryer reduces labour time and provides a potential source of income.
Economic Viability	The initial investment in the solar dryer is high, with the equipment and supplies needed to get started costing around USD 10,000. The estimated return on investment is 3-4 years if the solar dryer owner dries their own products and charges a small fee to dry the products of others in their community.
Replication potential	Food processing by open solar drying is replicable in communities that have a high number of days of sunshine and dry weather during at least part of the year. Drying using solar dryer equipment is replicable in most areas but requires access to finance to invest in the equipment and supplies.
Institutional needs	The example is of a solar greenhouse dryer provided as part of a funded project implemented by ASSIST. Successful implementation of the model solar dryer is intended to encourage the installation of solar greenhouse dryers by small or micro enterprises that offer the service in their community. Scaling up the practice requires the development of a business plan guide to assist men and women interested in this business on how to calculate the return on their investment. It also requires promotion through micro-loan programs that can assist women entrepreneurs with the capital for the initial investment. To extend these benefits to other communities, Chan Hoan Fishery Community could act as an ambassador to demonstrate to other communities that the solar drier is efficient both environmentally and economically.
Sustainability	The use of this technique draws on renewable energy to process local products. It provides a steady and reliable source of income that producers can gradually invest in growing a micro-small food processing enterprise.

Challenges in Adoption

- Initial financial investment is the main limitation, with the purchase of the solar dryer and other materials reaching close to USD 10,000. The adoption would be limited to those with access to loans of this size. Through the sale of products and renting of the dryer, the return on investment would take approximately three years.
- Solar dryers are rare in Cambodia, with only four other solar dryers found in the whole country.

References/Sources	Key Contact
ASSIST ASIA Organization; interviews in Chan Hoan Village, Kampot Province.	Asia Society for Social Improvement and Sustainable Transformation (ASSIST) Tel: +855 (0) 10 690 498 Email: mathieu@assistasia.org info@assistasia.org Website: www.assistasia.org

4.3.3 Regeneration of mangroves in fishery communities

Sub-sector	Climate Hazards	Adaptation Elements
Forestry Mangrove Rehabilitation	Temperature increase, flooding, sea level rise	Coastal protection Livelihood diversification

Description of the Practice

Regenerating mangrove forest is an adaptation measure that can also drive a local economic development strategy. Mangrove regeneration has a double effect on the economy: 1) it increases marine life to sustain fishing as a source of income, and 2) it creates more natural beauty that increases tourism potential of a locality, offering a secondary source of income.

As the residents of the coastal fishing village Trapeang Sangkae Commune in Kampot Province (population 734) observed the more intense seasonal flooding and loss of marine life they became increasingly aware of the need to protect and rehabilitate their mangrove area. Marine stocks were down due to the lack of mangrove habitat and families', 75% of whom depended on fishing, saw their main source of income threatened. The community decided to form a mangrove rehabilitation group with support from different local and international organizations. This measure contributes to climate resilience by protecting the coastal community from flood and storm, and creates favorable conditions for sustaining the growth of fish and shrimp stocks. As a result of the community mobilization for planting and conservation, the mangrove area is expanding - in the past, there were only 31 hectares of mangrove forest, but now 21 hectares have been added and 10 more hectares are planned.

While mangrove reforestation is labour-intensive, mobilizing the community (in particular women and youth) can result in more rapid reforestation and community ownership over protecting the replanted mangroves. The expansion of the mangrove area improves the coastal scenery in ways that are favorable to tourism, including eco-tourism. With some tourism development, coastal communities are less dependent on fishing to make ends meet.

The mangrove forest combined with the villages' physical setting and access to a river is conducive to eco-tourism, including boat and kayak tours to see the mangroves and marine life. Women and youth are particularly active in finding tourism-related jobs and business opportunities. An added innovation has been to offer tourist the chance to buy a mangrove tree to plant, thereby contributing to improving the environment and climate resilience.


Walking path for eco-tourism along mangrove forests in Trapeang Sangkae Commune, Kampot Province

Adaptation Outcomes	
Sensitivity/ Exposure	Mangrove forests break waves, trap sediments and reduce coastal erosion. As a result, they protect coastal areas from hazards such as sea surges and storm damage that will become more frequent and intense due to climate change. Mangrove forests are sensitive to sea level rise associated with climate change. Rehabilitation to reinforce sections of mangrove forest and reducing human stresses on mangrove growth contribute to climate resilience.
Adaptive capacity	Mangroves provide habitats for a large number of mollusks, crustaceans, birds, insects, monkeys, and reptiles. They are a nursery for economically important fish life such as shrimp. Eco-friendly tourism reduces over-fishing by providing an alternative source of income.
Eco-system integrity	Mangroves provide habitats for a large number of mollusks, crustaceans, birds, insects, monkeys, and reptiles. They are a nursery for economically important fish life such as shrimp. Eco-friendly tourism reduces over-fishing by providing an alternative source of income.
Additional benefits	Eco-tourism is now a main driver of the local economy in Trapeang Sangkae community. Increased income has meant that children and youth are able to obtain formal education and vocational training.

Criteria for Adoption	
Relevance	Mangrove regeneration improves the environment, regenerates fish stocks, and creates conditions conducive to eco-tourism.

Social acceptability	Mangroves are recognized by the community as an important element in the eco-system that benefits their community and livelihoods. Developing a community-based organization to manage mangrove rehabilitation contributes to social acceptance.
Gender dimensions	Both men and women are able to create livelihood opportunities that contribute to family income. Women in particular have identified small enterprise development opportunities such as food-processing to serve tourists.
Economic Viability	Initial investment in mangrove trees includes the cost of trees, labour, and potentially equipment for preparing/ restoring sites. Costs also include set up and training of community organizations. Mangrove forests provide ongoing eco-systems services. Economic benefits include increased incomes from fishing, reduced losses from disasters, and other eco-system services. One study estimates that mangrove restoration could generate USD 160 million in eco-systems service in Cambodia with the support of green growth strategies (USAID, 2016).
Replication potential	Mangrove forests can be established along erosion-prone coastlines and riverbanks and in areas which experience significant damage from typhoons, tidal surges, cyclones, and geomorphic erosion in order to contribute to coastal protection. Restoring existing mangrove sites that have the suitable biological conditions offer the best potential for mangrove growth. Establishing buffer zones bordering the seaward and landward margins of protected mangrove areas provides a transition between human settlements with intensively used lands and waters and the protected area.
Institutional needs	Scaling up this practice across coastal communities in Cambodia requires: • A clear policy for community-based mangrove rehabilitation and protection, including developing community user groups for managing mangrove forests. • Developing nation-wide training programs and community mobilization campaigns with collaboration from MAFF, MOE, National Council for Sustainable Development, Ministry of Tourism, NGOs and international agencies.
Sustainability	Community buy-in and involvement in decision-making and implementation of mangrove development action plans are essential to the sustainability of restoration efforts.

Challenges in Adoption
• Illegal fishing in the mangrove areas is a concern, requiring patrolling and other control measures • Much of the coastal land is private, meaning that cooperation with the private sector is important for similar initiatives.

References/Sources	Key Contact
• Interviews with villagers in Trapeang Sangkae by Ms. Sim Sydalis (2016). • USAID (United States Agency for International Development). 2016. Valuing Eco-system Services in the Lower Mekong Basin: Country Report for Cambodia. USAID Mekong Adaptation and Resilience to Climate Change. • McLeod, Elizabeth and Salm, Rodney V. (2006). Managing Mangroves for Resilience to Climate Change. IUCN, Gland, Switzerland. 64pp.	Mr. Phou Teng Children and Women Development Center in Cambodia #44, St. Mittapheap, Kampong Bay Khang Tbong village, Sangkat Kampong Bay, Krong Kampot, Kampot province. Tel: 012 643 136 Email: info@cwdcc.org Website: www.cwdcc.org

4.3.4 Cultivating local rice varieties

Sub-sector	Climate Hazards	Adaptation Elements
Rice cultivation	Temperature increase, drought, flooding, shifting climate patterns	Disaster-resilient crop varieties

Description of the Practice

Farmers have introduced new and improved crop varieties over centuries in response to environmental stress conditions. The introduction of new or improved varieties is a practice aimed at enhancing plant productivity, quality, health and nutritional value, and building crop resilience to diseases, pest organisms and environmental stresses. There are many thousands of existing varieties of all of the important crops, with wide variation in their abilities to adapt to climatic conditions. Coastal communities in Cambodia that have cultivated rice for centuries are observing changes in the local agro-ecological conditions due to climate change. The changes include more intense rains, longer periods of drought, higher temperatures, and more saline conditions in soil and water due to sea level rise. Developing and selecting crop varieties that are suited to the changing growing conditions is a key technique for farmers to adapt to climate change.

Chi Kho Leu commune is located in Sre Ambel district, Koh Kong Province. It is home to about 1,073 households with a total population of 5,025 people, living in four villages. About 90% of the population are engaged in farming as a primary source of incomes and livelihoods. Rice (the major crop) is cultivated once a year. The total rice farming area in Chi Kho Leu is about 1,330 ha, with the average landholding per households of about 0.5 ha. The commune has no irrigation system, meaning that rice farming is completely dependent on rainfall. Farmers plant rice by direct seeding using the broadcasting method.

Farmer planting local variety

In recent years, farmers have observed a pattern of more intense rains in the wet season, followed by periods of drought. In some years, higher temperatures and drought have caused water sources in Chi Kho Leu to dry out completely. Since 2011, some farmers began to change their local rice variety for wet-season rice in order to adapt to changing climate conditions.

Farmers brought a local variety known as Sar Tuk Pray to Chi Kho Leu from Koh

Kong Town. It is suitable for cultivating in variable conditions due to its greater resilience to drought and flooding. About 10-20% of farming population in Chi Kho Leu now use this variety.

Farmers plant this variety in June at the start of the wet season. The rice grown with this variety does not need much labour, and it is ready to cultivate after four months (November). Farmers report that for a land area of 2.5 ha, the variety generally yields 6,000-7,000 tons of rice, and performs better than others in face of seawater intrusion into the rice fields.

Discussion with farmers and Chi Kho Leu commune officials about local rice varieties

Agricultural researchers and extension agents can help farmers identify new varieties that may be better adapted to changing climatic conditions, and facilitate farmers to compare these new varieties with those they already produce. In some cases, farmers may participate in crossing select seeds from plant varieties that demonstrate the qualities they seek to propagate to develop new varieties with the characteristics they desire.

Adaptation Outcomes	
Sensitivity/ Exposure	More-resilient crop varieties allow farmers to avoid losses due to increased occurrence of extreme climate events such as drought, floods and salt water intrusion associated with climate change. These varieties are suited to agro-ecological conditions in Cambodia, and planting and harvesting time can be adjusted based on observed and projected changing climate patterns.
Adaptive capacity	Enhances community resilience and food security by enabling farmers to cultivate a key food crop.
Eco-system integrity	Combining training on integrated pest management along with use of local varieties can reduce the use of fertilizers and pesticides that can be harmful to the local environment. Directing seeding techniques uses less water.
Additional benefits	People like the taste of the rice grown from this variety. The seeds are affordable and can be made readily available from season to season - local people have distributed this variety from household to household and from village to village.

Criteria for Adoption	
Relevance	Addresses needs of rural farming communities that are dependent on rice cultivation for their food security.
Social tacceptability	As Cambodian farmers experience increasing crop losses from drought and flooding, they seek to adapt planting varieties to changing conditions. In particular, the use of local varieties where farmers can save and store seeds is preferred.
Gender dimensions	Women have less access to resources and a lower labour mobility than men. As a result, women are more dependent on subsistence crops and disproportionally affected by their loss to disasters. Local varieties enhance women's capacity to assure family food security and allow more time in the production calendar for alternative sources of income generation. Direct seeding methods using local varieties reduces labour and represents time-saving for women.
Economic Viability	Costs are land and agriculture inputs. By avoiding losses, farmers are able to increase their output.
Replication potential	Applicable to most rural farming communities in Cambodia as the majority of farmers grow wet-season rice and have knowledge of rice farming techniques that are transferable to using these varieties.
Institutional needs	Agricultural researchers and extension agents can help farmers identify new varieties that are better adapted to changing climatic conditions, and facilitate farmers to compare these new varieties with those they already produce. In some cases, farmers may participate in crossing select seeds from plant varieties that demonstrate the qualities they seek to propagate to develop new varieties with the characteristics they desire.
Sustainability	With local varieties, farmers can use traditional techniques to save and store seeds for the next planting season.

Challenges in Adoption

- Currently, the variety is produced only for household consumption; it is a less known variety and so has not been promoted for sale on the market. More promotion of the good taste of this variety could make it viable for sale.

References/Sources	Key Contact
• Discussions with farmers and commune authority of Chi Kho Leu, 28 April 2016	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

4.3.5 Raising green mussels in coastal communities

Sub-sector	Climate Hazards	Adaptation Elements
Fisheries	Temperature increase, flooding, sea level rise	Livelihood diversification Changing fishing patterns to adjust to changes in marine life

Description of the Practice

Climate change has affected both fishing and farming activities in coastal Cambodia. During the wet season, the more frequent heavy rain and strong storms are reducing the number days available for offshore fishing. As a result, fishers are earning less income.

Farming is also affected. Sea level rise has resulted in saltwater intrusion into the land areas, damaging crops and agriculture. Consequently, farming activities such as cultivating rice and other crops have lower yields, and farming is not considered a good investment for villagers.

To adapt their livelihoods in face of these conditions and still maintain their traditional fishing lifestyle, local villagers have been developing techniques to better cultivate and harvest different sea products. One option developed by fishers in some coastal villages has been to raise green mussels as an alternative to fishing and farming.

Peam Krasop is a coastal commune in Koh Kong Province, comprising three villages. Fishing is the primary source of income and food for the majority of population (70-80%), although they supplement fishing with farming, animal raising, small trade and working as labourers. Fishing activities in this village have been affected by various factors including more storms and depleted stocks, and farming has become more difficult due to higher levels of salinity in fields due to seawater intrusion. Various environmental and market factors have also led to the collapse of shrimp farming that had been a profitable source of income for many years.

Farmers have adopted green mussel (Perna viridis) farming as a sustainable income alternative after the collapse of shrimp farming. About 80% of households in the commune raise green mussels in the mangrove area, surrounded by saltwater creeks which have a high potential for sustaining mussels. This activity accounts for almost 80% of their income. Each household uses about 0.5-1 ha of the creeks in the mangrove areas. As part of raising mussels, fishers buy small trees (about 3-5 m in height) and plant them in the open sea where they occupy and have a control over the space that is deeper than 10 m.

Fishermen plant the trees throughout the areas with a spacing of about 5 m between pillars. Fishermen have realized that by growing green mussel in deeper areas, the cultivars can be protected from high temperatures and freshwater intrusion.

Some local producers have been trying to find places with 10-15 m depth to raise green mussels, in order to reduce risk associated with any environmental variability. It takes 12 months to raise the mussels, with yields around 10-15 tons/ha. The harvest time is after Khmer New Year (April).

Adaptation Outcomes	
Sensitivity/ Exposure	Fishing activities have been reduced from the threat of storms and lower stocks due to numerous factors including climate change impacts. By growing green mussel in deeper areas, the cultivars can be protected from high temperatures and freshwater intrusion, and are consequently more resilient to climate change.
Adaptive capacity	Enhances community resilience and food security by enabling farmers to produce an alternative source of food and income.
Eco-system integrity	Mussel cultivation reduces dependence on over-exploiting other types of fish and seafood, and allowing these species to regenerate.
Additional benefits	Provides families with a supplemental source of income to fishing and farming.
Criteria for Adoption	
Relevance	Address the needs of villagers in coastal areas to diversify their livelihood activities.
Social acceptability	Green mussels are a familiar product for villagers living near mangrove areas that offers an income-generating activity to substitute for fishing.

Gender dimensions	Women can engage in cultivating and selling green mussels as a supplemental source of income. The activity is labour-intensive and can add to work time for women. Ensuring that women have ready access to markets to earn a good return on their labour can mitigate this potential negative impact.
Economic Viability	Establishing mussel cultivation is relatively affordable at under USD 10,000 per year. Estimated annual income from green mussel raising for fishermen with one hectare of mussel pillars is about USD 6,000-8,000 a year (in 2016, the price of green mussels was about USD 0.5 per kilogram).
Replication potential	The practice is an option in coastal villages. It is particularly relevant in areas where other types of production such as shrimp farming are no longer viable.
Institutional needs	Scaling up requires support to farmers/fishers to learn the technique as well as establish suitable cultivation areas. Require regulation of coastal land use to zone specific areas suitable for mussel farming and avoid over-exploitation.
Sustainability	The product has a stable market. Traders collect the mussels from villages in Peam Krasop and sell them to the main market for green mussel in Thailand, where the product is in demand.

Challenges in Adoption

- The practice has also been affected by variable climate conditions. Increased rainfall leads to greater freshwater and reduced salinity in the creek waters, which can kill the mussels. In addition, in the last few years, green mussels started to die in November when there is no rain for reasons not yet known but which some fishers report may be linked to longer monsoon rains and higher temperatures. More research is needed to ensure that green mussel farming will remain a viable activity as climate change continues to affect growing conditions.
- It is a labour-intensive exercise which requires active management by fishermen in order to keep yields high.
- Some ownership issues exist over the rights to use the creek. Most of fishermen do not have ownership rights over the areas where they are growing mussels. The current practice is based on an understanding between villagers and local authorities. The increased population and development in the area is likely to increase competition for creek areas. Consequently, the local and provincial government would need to work with local community to address this issue.

References/Sources	Key Contact
• Discussion with Peam Krasop community in Koh Kong Province.	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

4.4 AROUND TONLE SAP

4.4.1 Improved poultry-raising techniques

Sub-sector	Climate Hazards	Adaptation elements
Poultry-raising	Temperature increase, drought, flooding, shifting seasonal patterns	Livelihood diversification

Description of the Practice

Mixed farming is a traditional agricultural system in which a farmer combines different types of production, such as cash crops and livestock. The types of farming practices combined vary according to the agro-ecological conditions, water access, and local knowledge and cultures. The aim is to increase income through different sources and to complement land and labour demands across the year. Such systems evolve over time in response to various factors including climate.

A project from a local NGO and the district department of agriculture introduced a new technique for more resilient poultry-raising. The aim is for poultry-raising to become less vulnerable to climate factors and to provide a higher portion of household income to compensate for the losses in other areas of production.

Koulen commune (Svay Leu District, Siem Reap Province) is located in a forest protected area on Koulen Mountain. The communities in the commune have traditionally practiced mixed farming, with women undertaking poultry-raising as one of the household livelihood components. The farmers in this community began to experience problems in their agricultural production and conventional poultry-raising due to less rainfall, higher temperatures and drought. In particular, the high temperatures at the end of the dry season followed by the intense rains in the start of the wet season became a high risk for the spread of disease among chickens raised in open areas.

Under this technique, local chickens are grown and fed in cages and pens instead of roaming freely around the yard. The cages for keeping chickens are 2x3 m. A pen of 10x10 m is also constructed for chickens to walk and feed during the day. The pens and cages are placed in an area near the home, such as the backyard, and are situated near trees or other shade. The pens and cages are made from small pieces of wood from the community forest. Chickens grow faster in cages and are ready for sale after only 3-4 months, depending on the care given. The women raising chickens are provided with technical advice on care such as vaccinating and giving the right amount of food and water. Women also learn the importance of good forest and tree conservation to provide shade for the chicken pens.

 

Adaptation Outcomes	
Sensitivity/ Exposure	The mixed farming practice is adaptive to climate change because the diversification of crops and livestock gives farmers a greater number of options when facing uncertain weather conditions associated with the increased climate variability. Mixed farming can also provide a more stable production because if one crop or variety fails, others may compensate. Chicken farming has become a good alternative source of income for villagers to supplement rice and taro which are highly vulnerable to dry conditions.
Adaptive capacity	Livestock is a 'walking bank' of assets that can be sold during periods of need, such as if crops fail due to drought or flooding. Farmers earn more income from having healthier and better-fed animals using this technique.
Eco-system integrity	Keeping animals in pens reduces risks of disease spread and prevents contamination of water sources.
Additional benefits	Households have increased their total income, with chicken sales adding USD 225-300 to annual income.
Criteria for Adoption	
Relevance	Addresses needs of rural farming communities to diversify livelihood sources and reduce risk of food insecurity from losing a single crop commodity to disasters.
Social acceptability	The women in the community were familiar with poultry-raising. The new technique of using pens was accepted due to its positive impact on poultry and time-saving for feeding and caring for animals.

Gender dimensions	Mixed farming is also linked to gender roles in household's productive activities. Women represent the majority of agriculture workers in Cambodia and have tasks in some stage of production of every household crop. Certain activities, in particular those carried out near the home such as gardening and poultry-raising, are almost entirely under women's responsibility. Promoting improvements in production and marketing of the mixed farming components under women's responsibility promotes women's economic empowerment.
Economic Viability	Costs are purchases of chickens for breeding, allocation of land for pens and the materials for the pens. The average start-up cost is estimated at USD 100. In the case study area, incomes from chicken became the third most important source of income for villagers after rice and cashew nut farming. Women sell the chickens 3-4 times per year to traders, earning up to USD 300 per year.
Replication potential	Applicable to rural farming communities in agro-ecological zones suitable for animal husbandry.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on improved poultry-raising techniques. Support to women in learning more on market dynamics would also increase the livelihood diversification benefits of this measure.
Sustainability	Once learned, the technique can be continued by women and men as a sustainable livelihood option.

Challenges in Adoption

- This technique requires some extraction of small trees from the community forest. A study on sustainable levels of extraction of these small trees is needed to mitigate the risk of over-exploitation.
- This practice needs support from agriculture specialists and local authorities to ensure villagers understand the importance of keeping the chickens in pens, using proper feed, and other techniques to reduce disease risk.

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4.4.2 Seed and grain storage

Sub-sector	Climate Hazards	Adaptation Elements
Cereal cultivation Crop storage	Temperature increase, drought, flooding, shifting climate patterns	Adjusting seasonal crop calendar

Description of the Practice

Seed security is key to the attainment of household food security among resource-poor farmers in developing countries. The basic objective of good storage is to create environmental conditions that protect the product and maintain its quality and its quantity, thus reducing financial and production losses.

Farmers throughout Cambodia are well aware of the risks of climate events, such as storms, floods and drought which can destroy or damage their crops. As a result, they have a long tradition of storing the paddy rice throughout the year in order to address the potential crop failure in the next farming season. In the absence of modern agricultural insurance schemes to protect from losses, many farmers have traditional ways of protecting their livelihoods in the event of extreme climate events.

Farmers have a practice of storing rice seed in order to start the recession rice farming immediately after a crisis. One example is the FWUC in Thnoat Chum, Baray District, Kampong Thom Province that practices food storage between farming seasons to avoid the food shortage if their rice farming failed. Farmers would set aside a percentage of paddy rice crop (up to 20%) rather than sell it. They would then store this rice until they are certain that the new crop has developed well. Thus if the crop in the ground is damaged by flood or drought, they retain a seed source to replace the damaged crop. Only when they are certain of the new harvest do they sell the old crop.

Villagers store the paddy rice in a storage unit which holds about 1-2 tons. The size of the unit is about 3x2x1.5 m. Traditionally it is made of clay, but farmers now use other materials such as metal containers if they can afford it. The storage system is located under the house or sometimes inside the house. In October 2009, the storm Ketsana destroyed the rice field completely. Paddy rice in the storage unit saved from the previous year helped farmers to replant and have rice to feed their family at the end of the season. In November, water started receding, and after water receded, farmers immediately began to cultivate recession rice. While part of the stored rice was used for food, some of it was used for seeding in the next farming season. This measure meant that farmers quickly restored their livelihoods.

Traditional rice seed storage

Adaptation Outcomes	
Sensitivity/ Exposure	Grain storage has been established in order to prepare for droughts and hunger and malnutrition. Grain storage provides an adaptation strategy for climate change by ensuring feed is available for livestock and seed stock is available in the event of poor harvests due to drought.
Adaptive capacity	Part of the stored rice can be used for food and the remainder for seeding in the next farming season. This allows farmers to quickly restore their livelihoods after experiencing disaster losses. In fact, the establishment of safe storage for seeds and reserves of food and agricultural inputs have long been used as indicators of adaptive capacity in the agriculture sector.[26]
Eco-system integrity	Grain storage has no negative environmental effects and can encourage the propagation and use of local varieties suited to local conditions with less chemical inputs and water than imported seeds.
Additional benefits	Efficient harvesting can reduce post-harvest losses and preserve food quantity, quality and the nutritional value of the product. Innovations for addressing climate change include technologies for reducing the waste from agricultural produce.

Criteria for Adoption	
Relevance	Addresses needs of rural farming communities to diversify livelihood sources and reduce risk of food insecurity from losing a single crop commodity to disasters.
Social acceptability	Social acceptability is high as farmers can select grain storage options most suited to their conditions.
Gender dimensions	Women often face more constraints to accessing inputs supplies that are far from the home. Grain storage increases family food security and provides women farmers with ready access to seed without having to travel to markets.
Economic Viability	The costs depend on the type of storage system selected. Farmers can earn a return on investment in the storage equipment by saving their produce and selling in the off-season when prices are higher.
Replication potential	Storage facilities can be replicated at household and/or community level in any farming community in Cambodia. They can be adapted to the local conditions and available resources.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on grass variety selection, and cultivation suitable to local conditions as well as on improved animal feeding techniques. Improving input supply chain for access to affordable, quality forage plants.
Sustainability	Creates a renewable agriculture input and contributes to sustainable land management.

[26] http://www.climatetechwiki.org/content/seed-and-grain-storage

Challenges in Adoption
• Effective storage requires controlling temperature, moisture, light, pests and hygiene. • Insects and rats can damage the rice storage and the storage facilities. • Rice storage can help farmers facing natural disaster for a short period of time, but not for food shortages lasting longer than three months. • The cleaning and drying of grain for storage are essential measures. However, difficulties in reducing excess moisture and foreign matter are frequently encountered. • Failure to adequately clean and dry grain can lead to pest infestations. Over-drying of grains can also negatively impact seed quality. Losses of seeds from insects, rodents, birds and moisture can be high in traditional bulk storage systems. Controlling or preventing pest infestation may require chemical sprays, but some markets will not accept seeds and grains treated with these chemicals.

References/Sources	Key Contact
• Business and Industry Advisory Committee to the Organisation for Economic Cooperation and Development. 2009. Agriculture and climate change, Issues for consideration. November 2009, Paris, France • FAO (Food and Agriculture Organisation of the United Nations). 2010. “Climate-Smart” Agriculture – Policies, Practices and Financing for Food Security, Adaptation and Mitigation, FAO, Rome. • Climate Tech Wiki http://www.climatetechwiki.org/content/seed-and-grain-storage	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

4.4.3 Integrated rice-fish systems

Sub-sector	Climate Hazards	Adaptation Elements
Rice cultivation Fisheries Aquaculture	Temperature increase, drought, flooding, shifting climate patterns	Adjusting seasonal crop calendar

Description of the Practice

A rice-fish system is an integrated rice field or rice field/pond complex where fish are grown concurrently or alternately with rice. Fish may be deliberately stocked (fish culture), or may enter fields naturally from surrounding water ways when flooding occurs (rice field fisheries), or a combination of both. Fish yields can range widely from of 1.5 to 174 kg/ha/season, depending on the type of rice fish system, the species present, and the management employed.

The most common indigenous fish found in Asian rice fields include:

- White fish (small plant- or plankton-eating species) such as Danios (Rasbora), Barbs (Puntius), Snakeskin Gourami (Trichogaster), and Half beaks (Xenentodon).
- Black fish (often carnivorous air-breathers that can survive low or no oxygen levels) such as Snakehead (Channa), Catfish (Clarias), Climbing Perch (Anabas), Spiny eels (Mastacembelus), and Sheatfish (Ompok).
- Introduced exotic fish species such as Common Carp (Cyprinus), Tilapia (Oreochromis), and Silver carp (Hypophthalmichthys).
- Other wild aquatic species such as crabs, shrimp, snails, and insects may also be harvested.

Wild fish can be encouraged to enter rice fields by keeping entrances to fields open and bunds low. They can be also attracted by placing branches in the field which provide shelter for the fish or by placing buffalo or cow skins to attract catfish and eels. Wild fish may be harvested from rice fields by netting, hooking, trapping, harpooning, throwing nets, or by draining the field. As water levels fall, fish may be channelled into adjacent trap pond areas where they can be held alive until required. Black fish from trap ponds are often marketed live in local markets.

If water sources are secure and the risk of flooding is low, farmers may invest in fish stock for their paddies or adjacent pond areas. Fish can be stocked at rates of 0.25 - 1 fish/m2. An example stocking rate (per ha) for Cambodia is 2,500 for common carp, 1,250 for silver barb and 1,250 for tilapia. Predatory fish, particularly Snakehead, should be absent from the system when fish seed is introduced. If available and economically viable, feed supplements such as duckweed, termites, earthworms, and rice bran can be supplied. Similar harvesting methods as for rice field fisheries can be used. Harvests usually include a percentage of wild fish that have entered the system themselves.


Raising fish in rice systems

Adaptation Outcomes	
Sensitivity/ Exposure	Combining fish and rice allows farmers to diversity their livelihoods and to have a greater number of options when facing uncertain weather conditions associated with the increased climate variability. Rice-fish systems can also give a more stable production because if one crop or variety fails, others may compensate. Fishing has become a good alternative source of income for villagers to supplement rice, which is highly vulnerable to dry conditions.
Adaptive capacity	The implementation of rice-fish systems needs to ensure that wild fish are harvested sustainably. Farmers need to learn techniques for raising fish that do not introduce harmful chemicals or antibiotics into the waters that may also reach wild fish. Having fish present may help dissuade farmers from using pesticides that are harmful to animals and human health.
Eco-system integrity	Grain storage has no negative environmental effects and can encourage the propagation and use of local varieties suited to local conditions with less chemical inputs and water than imported seeds.
Additional benefits	Rice-fish systems allow for production of fish and other aquatic animals, as well as rice, from the same rice field area and generally without causing reductions in rice yields. This source of animal protein can be important for household nutrition and farm income.

Criteria for Adoption	
Relevance	Addresses needs of rural farming communities to diversify livelihood sources and reduce risk of food insecurity from losing a single crop commodity to disasters.
Social acceptability	Rice and fish are two main sources of food security in Cambodia, and the technique has high social acceptability.
Gender dimensions	Women generate income from selling fish and/ or processing dried fish or other fish products. This technique can contribute to women's economic empowerment.
Economic Viability	Costs vary depending on the type of rice-fish system adopted. Farmers can recover their cost from selling fish in the market.
Replication potential	Applicable to rural farming communities around Tonle Sap and near river systems, and suitable for wet-rice cultivation.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on rice-fish cultivation techniques. Training for women on processing fish products would add to income potential.
Sustainability	Contributes to sustainable management of wet-rice cultivation systems.

Challenges in Adoption

- Water control is crucial and rice fields cannot be allowed to dry up while fish stocks are present.
- Stocked fish may escape if fields flood. Flood control can be difficult in rain-fed rice systems.
- Areas of rice fields deepened for fish culture may result in less rice growing area.
- Pesticides have the potential for poisoning fish, and some types can be absorbed by the fish and then ingested by humans.

References/Sources	Key Contact
• http://www.fishbase.org • Gregory R. 1997. Rice Fisheries Handbook, Cambodia-IRRI-Australia Project, Cambodia, 38p.	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

4.5 Mountain and plateau areas

4.5.1 Upland agroforestry for agriculture

Sub-sector	Climate Hazards	Adaptation Elements
Agro-forestry	Drought, flooding, wind storms	Livelihood diversification Tree-planting for soil stabilization and wind buffer

Description of the Practice

Agro-forestry techniques are recognized climate-smart practices. Agro-forestry is an integrated approach of production of trees and non-tree crops or animals on the same piece of land. The crops can be grown simultaneously, in rotation, or in separate plots when materials from one are used to benefit another. Agro-forestry can improve the resilience of agricultural production to climate variability as well as to long-term climate change through the use of trees for intensification, diversification and buffering of farming systems. Trees have an important role in reducing vulnerability, increasing resilience of farming systems and buffering agricultural production against climate-related risks. Trees are deep-rooted, have large reserves of moisture, and are less susceptible than annual crops to inter-annual variability or short-lived extreme events like droughts or floods. In addition, trees improve soil quality and fertility by contributing to water retention and reducing water stress.

Nget Chanreasmey is a farmer residing in Seanmorom Town, Mondulkiri Province. He has a 15 ha plantation, with 5 ha currently planted (3 ha for coffee and 2 ha for durian). In the coffee plantation, he plants small trees between the coffee plants, thus reducing wind impact on coffee trees and providing shade for coffee. The leaves and branches of these trees provide fertilizer for coffee and prevent erosion. In addition, he made a raised soil bed at the base of a coffee plant to keep water and prevent erosion. In the durian area, he organized the original soil beds around each tree base to keep water and fertilizer in the coffee plantation. The farmer uses water from a stream below his farm for irrigation. He uses fertilizer purchased from the market on his coffee and durian crops.

Adaptation Outcomes	
Sensitivity/ Exposure	The technique protects the crops from wind storms, reduces soil erosion from drought, and reduces heaving water flow. These are risks in mountain areas that may intensify with the impacts of climate change. The raised soil beds around the base of the durian can store water and nutrients for promoting the growth of crops and reducing soil erosion.
Adaptive capacity	Farmers have higher food security and earn more income from having another source of revenue.
Eco-system integrity	Tree plantations reduce soil erosion and retain moisture, improving the quality of soil. Trees absorb carbon and help to climate change mitigation. Tree plantations can reduce over-exploitation and land degradation of natural forests. This technique needs to be combined with sustainable land-use management to ensure that forests are not further degraded to make land for agro-forestry.
Additional benefits	The shading of coffee plants using fruit trees has improved the crop quality as coffee needs less light. The durian-coffee cropping pattern has increased revenues, although revenues from coffee are variable as coffee prices fluctuate significantly.
Criteria for Adoption	
Relevance	Addresses needs of mountain communities to diversify livelihoods using techniques suitable to the agro-ecological zone.
Social acceptability	Agro-forestry is accepted in communities as it diversifies livelihood sources rather than creating dependence on monoculture.

Gender dimensions	Agro-forestry techniques can reduce women's work burden by improving soil quality and reducing time for water collection. By-products of agro-forestry can also be used for fuel or forage, thereby reducing the need to collect branches in forests.
Economic Viability	Initial capital investment in agro-forestry is high. Farmers will realize a return on their investment but it varies by type of plant and variety. It takes 3-4 years for coffee plants to be ready for cultivation, depending on the variety, and then 2-3 years to realize a return on the investment in the plants. Farmers need alternative sources of income through short-term crops while the longer-term perennials are growing.
Replication potential	Applicable to rural farming communities in higher elevation agro-ecological zones suitable for agro-forestry.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on tree and variety selection, and how to maximize plant quality in local conditions. Improving supply chain for tree nurseries to have better access to affordable inputs for start-up.
Sustainability	Creates a renewable agriculture input and contributes to sustainable

Challenges in Adoption

- Initial capital investment in agro-forestry is high and the return takes years as plants grow.
- Perennials need to be selected carefully and in accordance with standard techniques and location, including ensuring adequate access to water during dry and wet seasons.

References/Sources	Key Contact
Interview of Mr. Nget Chanreasmey at Chamcar Te Village, Spean Meanchey, Mondulkiri Province by Leang Bunhak.	Mainstreaming Climate Resilience into Development Planning/Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

4.5.2 Livelihood diversification along the 3S Rivers

Sub-sector	Climate Hazards	Adaptation Elements
Fisheries Aquaculture	Temperature increase, drought, flooding, shifting climate patterns	Livelihood diversification Adjusting production to shifts in climate

Description of the Practice

The Sekong, Sesan and Sre Pok rivers (collectively known as '3S Rivers') are trans-boundary tributaries of the Mekong River. They support the livelihoods of 3.5 million people living in Cambodia, Lao People's Democratic Republic and Viet Nam. In the 3S River area of Cambodia, climate change has affected fishing activities on which local communities have traditional depended for their livelihoods. Fishers in this area have reported increased frequency of drought, heavy rain, floods, strong wind storms and increasing atmospheric temperature. Decreasing water level at the 3S River is a pressing concern as it is reducing fish population. Declining water levels and adverse climate events are caused by diverse factors including hydropower generation; the impacts are expected to become even more severe with the impacts of climate change. Wider adaptation efforts (including trans-boundary initiatives) will be required to better manage water resources in the long term. In the short and medium terms, local fishers need to adapt by developing alternative livelihoods to supplement the declining revenue from fishing and frog farming.

Stung Teng Province is one of the provinces where livelihoods are dependent on the 3S river system. Talat Commune, Sesan District, Stung Treng Province is one locality where local fishers are adapting their livelihoods in response to the declining water levels and its effects on the fish population. Ten years ago, fishers reported that they fished 10-15 kg per day; however, recently the stock has been decreased to less than 1 kg per day. The quantity of fish is only sufficient to meet the family's consumption needs with no surplus to sell.

In order to compensate for the reduced fish production, communities need to introduce production of another commodity. Adding frog farming for a season makes aquaculture more productive. Groups of women and men in Talat Commune are collaborating in a project to introduce aquaculture techniques that expand production by alternating frog and fish farming with support from the Department of Natural Resource Management and Development of the Royal University of Phnom Penh. This technique allows farmers to cultivate fish and frog products without relying solely on fish stocks that are becoming increasing diminished due to environmental and climatic factors.

To apply this technique, the fishers build earthen ponds of 10 m x 2 m near their houses, and use these for alternate fish and frog farming. In order to prevent high evaporation, the pond is lined with plastic sheet and covered with a sunscreen. The fishers collect natural frog fingerlings from surrounding wetlands and rivers, taking care to not over-exploit this resource. They buy fish fingerlings from vendors in Stung Treng Province, and pump water from Sesen River to supply the ponds.

The fishers sell their surplus products in local markets gaining a price of up to USD 3-4 dollars per kg for fish, and USD 2 per kg for frog.

Fishing activities at Sesan River, Stung Treng Province.

Frog farm and home gardening at Svay Rieng Village, Talat Commune, Stung Treng Province, Cambodia.

Adaptation Outcomes	
Sensitivity/ Exposure	Aquaculture techniques allow farmers to diversity their livelihoods and have a greater number of options in the face of varying water levels and declining fish stocks due to diverse factors including climate change. If techniques are applied correctly, fish and frog farms create a stable production source to replace river fishing. If rice or other crops fail, farmers have another source of food and revenue.
Adaptive capacity	This initiative draws on the communities' traditional skills as fishers, and introduces new techniques for farming fish and frogs where villagers can introduce fingerlings and manage stocks.
Eco-system integrity	Fish and frog aquaculture systems need to be introduced along with sustainable land-use management techniques that protect shorelines and river banks. The producers also need to understand the importance of not introducing harmful chemicals or antibiotics into the waters that may reach wild marine life. This practice values and reinforces local knowledge by linking the adaption technique to the traditional skills in the community.
Additional benefits	This practice significantly increases fishermen's income, and provides alternatives to logging and other fishing and farming activities.

Criteria for Adoption	
Relevance	Addresses needs of rural farming communities to diversify livelihood sources to reduce risk of food insecurity from losing a single crop commodity to disasters.
Social acceptability	Fish are a main sources of food security in Cambodia and the technique has high social acceptability.
Gender dimensions	Women are active in maintaining the ponds as they can combine these tasks with other domestic duties and home gardening. Women are trained in establishing home gardens on the bank of the fish and frog ponds to maintain the quality of the ponds with vegetation as well as to diversify the diet of the family. Women generate income from selling fish and/or processing dried fish or other fish products. This technique can contribute to women's economic empowerment.
Economic Viability	Initial costs include labour for digging ponds, other aquaculture equipment and fingerlings. The annual income from fish and frog farming and home garden activities is approximately USD 2,000 a year.
Replication potential	Applicable to rural farming communities around Tonle Sap and near 3 S river systems.
Institutional needs	Investment in extension services and farmer field schools in order to transfer knowledge on aquaculture techniques. Training for women on processing fish products would add to income potential.
Sustainability	Contributes to sustainable management of fish stocks by avoiding over-fishing in river systems.

Challenges in Adoption

- This practice is most suitable for people residing close to rivers or other water bodies, as it requires access to water source for farming and gardening purposes.
- Initial labour and start-up costs are high compared to fishing wild fish stocks. Villagers need support with start-up in the initial stages.

References/Sources	Key Contact
Discussion with heads and members of five communities in Stung Treng Province, Cambodia.	Mr. Phat Chandara Royal University of Phnom Penh Tel: + (855) 96 944 2750 Email: phatchandara@gmail.com Website: www.rupp.edu.kh

5. WATER RESOURCES MANAGEMENT

5.1 OVERVIEW

Climate change will have an important impact on the Mekong River Basin, resulting in shifts in the water cycle such as changes in timing, duration and intensity of rainfall patterns and seasons. These shifts are likely to change the hydrology of major rivers and tributaries as well as groundwater recharge. Cambodians already experience dramatic changes in the seasonal availability of water, and this variation is likely to increase as dry seasons become longer and wet seasons more intense. Climate change's impact on precipitation and river hydrology will affect the seasonal quantity and quality of water available. Gains made in increasing safe access to water will be threatened, and agriculture and fishery livelihoods will be at risk. Women who have more responsibility for collecting and managing household water will be more vulnerable.

Cambodia will need more solutions to manage the availability and distribution of water throughout seasons, across regions and between users. Indigenous practices for water resource management provide examples of how communities have coped with seasonal variations in the past. Practices such as rainwater harvesting, reservoirs, ponds and irrigation canals allow households and communities to capture different sources of water. They also show how water is treated traditionally as a scarce resource to conserve and store when it is more plentiful, for use in drier periods. Collective decision-making to control the distribution of water resources is a traditional aspect of village life that needs to become even more structured and better managed as water resource become scarcer. The range of adaptation measures needed to address climate change impacts in the Mekong Basin are complex and will require trans-boundary solutions to protect the river system and its associated eco-systems on which water depends. But more application of simple local practices to capture, store and conserve water resources will make a difference in preparing communities to be more climate-resilient.

5.2 WATER STORAGE RESERVOIRS

5.2.1 Coastal water storage reservoirs

Sub-sector	Climate Hazards	Adaptation Elements
Reservoirs	Drought, water scarcity	Water storage for use in dry periods Water conservation

Description of the Practice

Water storage reservoirs have been used in Cambodia for domestic water supply and irrigation for centuries. They come in many forms and sizes, depending on the purpose. Many of the large irrigation reservoirs were built under the Pol Pot regime and are still functional today. They are usually constructed on low-lying land, and most of them have been dug out around natural streams. The original stream water and the collection of rainwater create the water sources for storage.

Three examples of water storage reservoirs for domestic use and farming are found in Koh Kong Province: 1) Boeng Prolean (about 17 ha) located in Khemarak Phoumin municipality, 2) Chitress reservoir and irrigation canal (about 45 ha) in Andoung Toek commune of Botum Sakor district, and 3) Bantiet reservoir (50 ha) situated in Dang Peng commune of Sre Ambel district on National Road 48. These reservoirs provide water for both domestic use and farming, and did not dry up even during the very dry conditions experienced in 2016. Small ponds and open pump wells in Andoung Toek and Chikor Leu communes experienced shortage of water, and local villagers have become heavily reliant upon these reservoir and deep pools in natural streams.

5.2.2 Mountain water storage reservoirs

Description of the Practice

An excavated pond[26] is a simple traditional practice that is used to conserve water in areas that are prone to prolonged dry periods. The excavated pond is designed as the surface water storage system, and its objective is to collect and store rainwater and runoff for later use. This traditional technique is important for many communities to cope with water shortages. The pond water can be used for agriculture, animal husbandry and domestic use during the dry season.

Ponds are easy and relatively cheap to construct. The components include an excavated earthen pond (built ideally on a flat terrain), a pumping machine, a cemented area with roofing to cover the pumping machine, pipes and a tap. The capacity of the reservoir depends on the feasibility of excavation, and small-to-medium ponds are more practical to dig out and maintain. As a result, ponds are a technique used in relatively small villages as a supplement to other water sources. The technique is best suited to locations with impervious soils and where some amount of water runoff and rainfall is expected to fill the pond.

Excavated ponds are preferably located in the topographically low area of small closed drainage basins, or in upland watersheds where the drainage divide is low and the topography is gentle. In some regions, the excavated ponds or small reservoirs can excavate and reach the groundwater table, becoming a more-or-less a permanent water source.

During periods of drought, the pond can become a key source of water. A water user community and regulations of water utilization are an essential part of the technique, particularly during the dry season and prolonged droughts.

Mean Chhey village (Sre Sangkum commune, Koh Nhek district, Mondulkiri Province) constructed a community pond in 2010-2011 with the support from the provincial Department of Rural Development. The pond was excavated in the lowland of the catchment area. Its dimensions are 60 meters long, 40 meters wide and 3 meters deep. The storage capacity of the excavated pond is about 7,000 m^3.

The excavated pond was fenced using wire-net to prevent contamination from animals. Pumping tools such as pumping machine, tube and tap were installed at the bank to prevent people and animals going into the pond and to maintain the quality of the water. Trees, grass and other vegetation have been grown around the embankments to prevent erosion and retain sediments.

The pond is now managed by the Mean Chhey FWUC. The FWUC is responsible

[26] An excavated pond is sometimes referred to as a "pit" or a "dugout." This type of pond is excavated below the existing ground level to store shallow ground water, and in some cases, a small amount of surface runoff. These ponds are most often used to provide a water source for livestock. Source: USDA (undated), Excavated Pond Development, https://efotg.sc.egov.usda.gov/references/public/AL/al378a_ExcavatedPond.pdf.

for ensuring efficient use of water, fair distribution to all local beneficiaries, and promoting practices water conservation. As this traditional reservoirs are now applying pumps as an improved technique, the pond water users make a financial contribution for costs such gasoline for the pumps, and other operation and maintenance. The contribution is charged as a fee of 1,000 riels (approximately USD 0.24) per 220 litre container of water. About 200 households from surrounding villages (Mean Chhey, SeryMongkol and Chamreoun villages) access water from this pond during the dry season. The pond represents a climate change adaption measure that improves local people's resilience to drought. Excavated in 2011, in April 2016 the pond had low water levels due to the dry conditions. The available water was unsuitable for domestic purposes and was used for agriculture and animal husbandry. While a good practice to supplement other water supply, the pond water needs to be managed and well conserved during dry periods.

The pumping machine and station at the community pond in Mean Chhey village, Sre Sangkum commune, Koh Nhek district. It was equipped by a local monk.

Excavated pond fenced by wire-net is in Mean Chhey village, Sre Sangkum commune, Koh Nhek district, built in 2010-2011 by the Provincial Department of Rural Development, and managed by a water user community.

Adaptation Outcomes	
Sensitivity/ Exposure	Collects rainwater and groundwater for communal use, improving resilience to drought. Reservoirs provide additional sources of water for people living in drier zones and reduces risks of water scarcity. Increases water access for poorer households with less resources to purchase water. Increases resilience of households and communities during prolonged periods of drought.
Adaptive capacity	Households and communities have an increased capacity to manage their water supply.
Eco-system integrity	Captures storm water run-off and reduces demand on other water sources.
Additional benefits	Creates a source of water in dry periods for irrigating crops, home gardens and for animals, contributing to livelihood diversification.

Criteria for Adoption	
Relevance	Contributes to meeting water needs of communities.
Gender equality	Reduces time required for water collection and treatment, tasks that are most often performed by women. Women and children are more vulnerable to water-borne diseases, and safely stored rainwater reduces this risk.
Social acceptability	The technique has been practiced for centuries and its social acceptability is high. It improves the community's social network by promoting collaboration on the fair distribution and utilization of water.
Economic Viability	Using deep pools and natural streams as a water source has no additional costs. Digging reservoirs has a high initial costs and labour requirements, but maintenance costs are minimal once the reservoir is in place.
Replication potential	Applicable in rural areas that experience dry conditions and have open areas suitable for digging reservoirs.
Institutional needs	Villagers may need institutional support to dig reservoirs and to organize water user groups. Water users groups could then support maintenance of the reservoir, and promote conservation and equitable distribution of water.
Sustainability	This technique supports communities to sustainably use and manage water resources over the long-term.

Challenges in Adoption

- Reservoir water sources needed to be well managed by the community to avoid overuse and drying up of the reserves.
- If the excavated pond reaches the groundwater table, significant permanent water supplies of the pond can be established. The pond water will probably be used for other agricultural activities which is a much more profitable activity than utilization as water source for domestic purposes.
- Leakage and infiltration of water into the ground leads to the loss of water in ponds or small reservoirs. Hence an earthen pond in an area with high soil infiltration is likely to experience periodic drying-out during the dry season. The techniques of lining the pond bed with plastic or rubber sheets can be appropriate but costly.
- The pond cannot provide a year-round water supply if it is not well managed.
- Permanent surface reservoirs in a hot climate are often subject to health hazards such as parasitic diseases, which are much less common for non-perennial ponds.

References/Sources	Key Contact
United Nations Environment Program (UNEP): http://www.unep.org/publications/ FAO: http://www.fao.org/docrep/R7488E/r7488e00.htm#Contents	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

5.2.3 Surface water reservoirs and canal systems

Description of the Practice

Many Cambodian communities are facing water shortages in the dry season and intense rains in the rainy season; these are expected to become more intense with climate change. This means that water storage and conservation (at household or community level) will become an increasingly critical technique for water resource management.

A surface water reservoir and canal system is an engineering structure to collect and store rainwater using a dam. Such systems can retain the flows of small creeks, streams and surface water runoff by constructing dams at the downstream of the catchment. This technique can vary from small-scale to large-scale systems, depending on the design requirements and topographical features of the area.

The system collects the surface rainwater and runoff, and stores it for utilization in dry periods. It can be an important water source in areas which experience significant rainfall in the wet season but lack conventional, centralised water supply systems. It is also a good option in areas where good quality groundwater is lacking. As the water is not protected from contact with humans or animals, the quality of water is mainly suited for use in irrigation fields, rather than for domestic utilization.

Soil is used to build earthen dykes or dams to retain the rainfall and surface water runoff. Grass and other vegetation is grown along the slope of earthen dykes or dams to prevent their erosion. A sluice gate of the canal helps to retain the water and discharge it during periods of overflow, thus managing the flooding of downstream and upstream catchment villages, as well as downstream irrigation.

The O'Prang irrigation system in Sre Huy village, Sre Huy commune, Koh Nhek district, Mondulkiri is a surface water reservoir and canal system. Built during the Khmer Rouge regime, it is used to collect and store rainwater of the catchment area in Sre Huy commune, which is then used for irrigation. It was rehabilitated during 2008-2009 by MOWRAM, and a FWUC was formed to operate and maintain the system.

Earthen dam and concrete sluice gates were built to retain the rainwater and surface water runoff. The earthen dyke is 1.6 km long, 2.5-3 meters high from the bed of catchment, and 4-5 meters wide. The retained water is stored in the reservoir with a storage capacity of up to 2.2 million m^3.

In addition to the earthen dam, there are sub-canals of 6,275 meters in length, and sluice gates which are used to either retain or release the water from the catchment area or reservoir. This reservoir has capacity to irrigate about 400 ha of agricultural land area, and act as a water source for the villagers of Sre Huy commune and nearby communes. However, the water quality is poor in dry season, meaning that water can be used for agricultural and household purpose only during the wet season. Generally, water from this system can be used for drinking and cooking around six months per year.


Sluice gate of main canal, O'Prang irrigation system and reservoir area (dry season 2016) in Sre Huy village and commune, Koh Nhek district.

Chitress reservoir in Andoung Toek commune of Botum Sakor district. The reservoir is about 45 ha, and serves the people of two villages (Chitress and Brai) for domestic use and farming.

Bantiet reservoir on NR 48 located in Dang Peng commune. It uses the NR 48 as main embankment for water storage.

Adaptation Outcomes	
Sensitivity/ Exposure	The system can be an important water source in areas with significant rainfall and a simultaneous lack of conventional, centralised water supply system or groundwater. This technique promotes infiltration of surface water which increases the available ground water and helps to maintain the soil moisture of the catchment area. It captures water and thus helps to manage flooding, particularly downstream.
Exposure	Increases resilience of households and communities during drought. Stored water can be used for agriculture, animal husbandry and household consumption.
Adaptive capacity	Households and communities have an increased capacity to manage their water supply.
Eco-system integrity	Helps to conserve water and contributes to retaining moisture and improving land quality.

Additional benefits	Increases agricultural crop production and livelihoods of local people.
Criteria for Adoption	
Relevance	Contributes to meeting the water needs of communities.
Gender equality	Reduces time required for water collection and treatment, tasks that are most often performed by women. Women and children are more vulnerable to water-borne diseases, and safely stored rainwater reduces this risk.
Social acceptability	The technique has been practiced for centuries and its social acceptability is high.
Economic Viability	The cost of building such systems can be high depending the type of system. Cost-benefit analysis of the types of systems, hydrological models of quantity of water to be stored and number of households benefiting are needed prior to investment.
Replication potential	Applicable in rural areas that experience dry conditions and have open areas suitable for digging reservoirs.
Institutional needs	Requires support from MOWRAM and local authorities, and potentially external assistance, for analysis of viability of the system, determining priority areas and for infrastructure investment. Villagers require support to organize local FWUCs to operate, maintain and manage water distribution after the system is built.
Sustainability	This technique supports communities to sustainably use and manage water resources over the long-term.

Challenges in Adoption

- There is a possibility of high rates of water loss due to infiltration into the ground.
- If the catchment area is surrounded by residential areas, agricultural fields or industrial zones, the quality of the water collected is not suitable for drinking. Thus this technique is mainly suitable for storing water for agricultural purposes.
- Large-scale land surface catchment-resource systems (e.g. with dykes and sluice gates) need good rainfall before they can provide benefits. They also need to be deep enough to store water to meet demands during dry periods.
- Proper management of the system is essential in order to provide a year-round water source for households and agriculture.

References/Sources	Key Contact
UNEP: http://www.unep.org/publications/ FAO: http://www.fao.org/docrep/R7488E/r7488e00.htm#Contents	Mainstreaming Climate Resilience into Development Planning /Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

5.3 RAINWATER HARVESTING

5.3.1 Rainwater harvesting around Tonle Sap

Sub-sector	Climate Hazards	Adaptation Elements
Water supply	Drought, Water scarcity	Water conservation

Description of the Practice

Using rainwater as a water source is a traditional practice in Cambodia. Estimates of its current use range from 48% to 87% of households, depending on the geographic area Cambodia.[27] Rainwater harvesting systems are an important measure for households and communities who are vulnerable to drought. Cambodian women are traditionally heavily involved in cooking, providing water and ensuring good sanitation for their families. The rainwater harvesting system reduces workload for women by providing a ready supply of water near the home, thus reducing the time women spend collecting water. They are trained in operation, maintenance and safe water storage. Roof-top rainwater harvesting is feasible in both urban and rural environments and can be implemented at household level or on public buildings such as schools. Rainwater harvesting is traditionally used for non-drinking purposes; however, some techniques have been developed through RainWater Cambodia (RWC) to filter rainwater for safe drinking. WC has developed a risk-managed rainwater-harvesting system for domestic and institutional systems, designed to capture rainfall and store enough water to last through the dry season.

Domestic rainwater harvesting systems promoted by RWC include two tanks of 3 m^3 each: the concrete ring tank and the jumbo jar. The institutional systems have different technical options, with the capacity of storage ranks ranging 14-35 m^3. Households should use a solid roof, have at least 3,000 litre capacity of storage, and access to water through a tap. Many households in rural areas own 2-3 jars of 1,200 – 1,500 litre capacity.

It is important to remember that other domestic rainwater harvesting technologies are available, with different size and technical standards. The recommended equipment for this system ensures that the rainwater is captured in pipes and stored in a sealed container. This risk management approach prevents contamination during storage, ensuring the water stays safe to drink.

Support to households to acquire the materials for the rainwater harvesting system is provided through the supply chain, while capacity building for local private entrepreneurs, government agencies and local authorities on construction techniques and monitoring. A project to assist a group of households in a community to access and correctly use these systems takes from six months to 48 months, depending on donors and partners that fund the projects.

[27] JICA. 2002. The Study on Groundwater Development in Central Cambodia. Final Report.

Beneficiaries using the system receive a supply water for drinking and cooking, without the need for other treatment facilities. Each household is taught techniques on how to manage their water supply to ensure they have stored a sufficient supply for the dry season. In addition, they are shown different techniques to avoid contamination such as preventing mosquitoes from breeding in the tank and preventing contamination from humans and animals.

Adaptation Outcome – see 5.3.3 below

Criteria for Adoption – see 5.3.3 below


Concrete ring tank and jumbo jar

References/Sources	Key Contact
• Certification, Energy Globe Award 2016 - National Award • Confederation of European Senior Export Services 2014, National Institute of Statistic, The Kingdom of Cambodia • K. Pheng, Brief research paper 2014, 37th Water, Engineering and Development Centre International Conference, Hanoi, Vietnam "Rainwater harvesting formulization in rural Cambodia" • JICA 2002, The Study on Groundwater Development in Central Cambodia Final Report, P 8-4 • Water and Sanitation Program 2015, Service delivery assessment, Water and Sanitation Program – World Bank, p.23	Mr. Pheng Kea Rain Water Cambodia (RWC) Organization Tel: 012 755 365 Email: pheng.kea5@gmail.com

5.3.2 Rainwater harvesting in Pursat Province

Description of the Practice

Pursat Province experiences severe water shortages and drought during the dry season. Rainwater harvesting in some form or another is practiced by large numbers of rural households, even where there is access to permanent rivers and streams. The different forms of rainwater harvesting often include collection of rain in ponds from the surrounding land, but most commonly from the house roofs. The roof of the house provides the surface and the gutters along the roof edges provide the means of collection of rain. Collection is more efficient on a corrugated metal or tiled roof, but is also possible on roofs made of natural materials such as wood or palm leaves.

Today, gutters and pipework for collection of the water are usually made of plastic, and a flexible arrangement of pipes leads to the water storage tanks or jars (so that when one jar has been filled up, the pipe can be moved to the next jar).

Different forms of storage can be used depending upon the size of the house and the water needs of the household. Most commonly, these are concrete jars of 0.5-1.5 m^3 capacity; a small household would have at least three such jars for drinking water to last them through the dry season. However, tall tanks have been constructed using three concrete culvert pipes stacked one on top of the other; larger blue plastic tanks have also been used to store rainwater collected from the roofs.

When full, a concrete jar is covered with a concrete lid, sometimes with an additional smaller lid for regular use. Some concrete jars also have taps at the bottom for water access that does not involve dipping. This reduces the risk of contamination, but also increase the risk of losing the stored water if the tap is left open or damaged by a passing child or animal.

Discussions with householders in Pursat indicate that three jars of 1 m3 capacity can be easily filled during the rainy season from a regular-sized house with a roof surface area of 6x10 m. Larger houses have been observed with up to 10 large jars.

The use of stored rainwater depends on the number of people in the household. Usually the stored water is only used for drinking and cooking, not for washing or bathing. In Pursat villages, one jar of 1 m^3 can last up to one month for normal household use with 5-6 people. With only three large jars, there is likely to be a shortfall towards the end of the dry season.

In the drought of April 2016, water storage jars were filled up from private water trucks. Householders could buy the water privately or provided by emergency supplies organised by government.

In 2010, the MRD provided three jars per household in selected Pursat villages as part of an ADB-funded water supply project. If villagers want more jars, they have to buy them. In Tuol Cheav Village in Bakan District, there is a workshop constructing concrete jars; each 1 m^3 jar costs USD 35. This is a considerable expense for most rural households, although the alternative of buying drinking water is likely to be even more expensive – with bottled water priced at 1000 riel per litre, the cost of a 1 m^3 jar could be recouped within 5-6 months. A local NGO operates a loan scheme for the purchase of such jars, whereby households pay for the jars they have ordered from the workshop over a six-month period.

Rainwater harvesting and storage can be improved by:

- Improving the efficiency of collection (e.g. ensuring gutters and pipes do not leak)
- Avoiding using the first rains, which will wash off dust and contaminants off the roof
- Ensuring the jars are securely covered to minimise evaporation
- Covering jars with a thatched roof to prevent water from heating up in hot weather
- Fitting with taps that automatically shut off and are protected from accidental damage

Adaptation Outcome – see 5.3.3 below

Criteria for Adoption – see 5.3.3 below

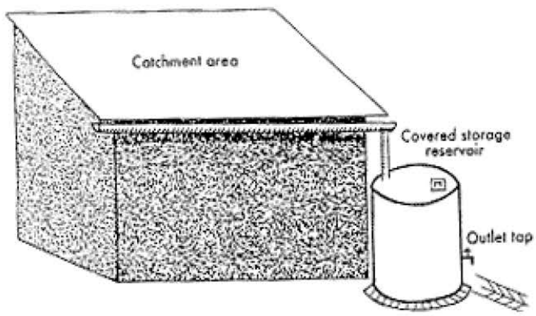
References/Sources	Key Contact
Data collected during village vulnerability assessments in Pursat Province for the Community-Based Disaster Risk Management (CBDRM) component of the Greater Mekong Sub-region (GMS) Flood and Drought Management Project.	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

5.3.3 A simple roof rainwater collection system in Mondulkiri Province

Description of the Practice

A rainwater harvesting system consists of three basic elements: (1) collection system, (2) conveyance system, and (3) storage system. The collection systems can vary from simple household types to bigger systems where a large catchment area contributes to an impounding reservoir from which water is either gravitated or pumped to water treatment plants. The size of the system depends on factors like the size and nature of the catchment areas and location settings.

The roof rainwater collection system is a small-scale rainwater harvesting system, traditionally built in the house to collect the rainwater from the eaves of roofs or via simple gutters into traditional jars, pots and tanks (i.e. storage system). The main components are the roof catchment area, conveyance system-gutter and the piping that leads to the container, and the container (jar, pots or tank). The purpose of system is to collect and store the rainwater for household use.



Example of a roof catchment system

The roof rainwater collection system is a traditional method that has been practiced in Cambodia for thousands of years, and is still used today in rural and remote areas. In Sre Houy and Norng Khiloek communes (Koh Nhek district, Mondulkiri Province), more than 10% of villagers practice the roof rainwater harvesting system. The systems have been installed in individual households, incorporating a pot, large-jar or others water container, gutters at the edge of the house roof, and a drainpipe connecting the gutters to the container. In addition to household systems, a roof rainwater harvesting system for Sre Houy community hall was built by the Provincial Department of Water Resources and Meteorology in 2015.

The materials used and the degree of sophistication of the system largely depend on the initial capital investment. Some cost-effective systems include containers made of wood, plastic, cement, ferro-cement, etc. Cost of other elements such as gutter and drainpipe is less than cost of the storage containers. Previously, the gutters and drainpipes were made by bamboo and wood, but in recent years zinc, steel and plastic have become more common.

The storage unit for the Sre Houy community hall is a plastic container with capacity of 2,500 litres. The conveyance system (i.e. the gutter) was installed at the eaves of the hall's roof, and a plastic pipe connects the gutters to the container.

Another example of the system is traditional roof rainwater collection practiced by a family in Norng Bour village, Norng Khiloek commune of Koh Nhek district. The system was built in 2012 with the storage system consisting of a wooden tank with dimensions of 4×3×2.5 m, and the water storage capacity of about 24 m3. The system collects sufficient rainwater to provide for year-round household use. The investment cost of system is approximately USD 300, including constructing the wooden tank, plastic tap, pipe, and plastic sheet for lining the bottom of the tank. The system is currently functional.

A roof rainwater collection system of Sre Houy community in Sre Houy village, Sre Houy commune, Koh Nhek district, Mondulkiri province.

A roof rainwater collection system with a typical wooden tank, Norng Bour village, Norng Khiloek commune, Koh Nhek district, Mondulkiri province. It was built in 2012 by the residing family.

The roof rainwater harvesting system can be built by individual household or the community, serving as a private or communal structure. While the above examples are from a rural community, these systems can also be installed in cities and towns.

Traditional forms of rainwater harvesting

Adaptation Outcomes	
Sensitivity/ Exposure	Provides additional source of water for people living in drier zones, and reduces risks of water scarcity. Households can install such systems to provide water for domestic use during drought. The capacity of the rainwater harvesting system can be expanded with additional storage jars if sufficient rainwater is available. Increases resilience of households and communities during drought. Storage units reduce exposure to contaminated water in the flood season. Increases water access for poorer households with less resources to purchase water.
Adaptive capacity	Households and communities have an increased capacity to manage their water supply and water quality.
Eco-system integrity	Captures storm water run-off and reduces storm drainage load, thus reducing street flooding and erosion. Reduces demand on other water sources.
Additional benefits	Access to clean drinking water and improved sanitation, leading to improved health and reduced expenditure on water purchases and medicine.
Criteria for Adoption	
Relevance	Contributes to meeting the water needs of communities.
Gender equality	Reduces time required for water collection and treatment, tasks that are most often performed by women. Women and children are more vulnerable to water-borne diseases, and safely stored rainwater reduces this risk.
Social acceptability	Community acceptance is favourable as rainwater harvesting is a long-time practice that can be applied to individual homes or community buildings with either traditional or modern materials.
Economic Viability	Different types of equipment can be purchased at various cost levels for different types of buildings or surfaces. The cost varies based on the materials used for capture and storage and water volume to be harvested and stored. Reduces the need to purchase water and so can provide a return on investment after installation.
Replication potential	Applicable in both urban and rural homes. Rainwater harvesting equipment is readily available on the market for both modern and traditional buildings.

Institutional needs	Creating supplier and/or consumer incentives to develop a market for quality rain-water harvesting equipment at various price points across geographic locations. Support from MOWRAM, local authorities and external services providers is needed to maximize the use of systems and to disseminate proper techniques.
Sustainability	This technique supports communities to sustainably use and manage water resources over the long-term.

Challenges in Adoption

- One of the main challenges for wider implementation has been found to be the financing of the improved systems.
- More than 90% of the systems installed were subsidised, showing the difficulty experienced in working with non-subsidised approaches.
- Initial cost to install a rainwater harvesting system can be high depending on the type of system.
- Because rainfall is hard to predict, it is important not to rely too heavily on rainwater as the only source of water in areas with limited rainfall.
- The size of the storage containers must be suited to the amount of rainfall so that they do not become empty for long periods. Cement or clay storage units may dry out and crack during prolonged dry periods, causing leakage when they are filled again.
- Regular cleaning of the container and gutters is necessary to avoid system blockage and water contamination.

References/Sources	Key Contact
UNEP: http://www.unep.or.jp/ietc/publications/urban/urbanenv-2/index.asp	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

5.4 OTHER WATER RESOURCE MANAGEMENT PRACTICES

5.4.1 Farmer Water User Communities (FWUCs)

Sub-sector	Climate Hazards	Adaptation Elements
Water supply	Drought, water scarcity	Water conservation

Description of the Practice

The history of irrigation development in Cambodia stretches back as far as the third century AD. From ancient through to colonial times, the responsibility for implementing irrigation-related activities rested with the village and commune chiefs. After the country's independence in 1953, the philosophy of self-help in water control structures was introduced. Beneficiary involvement in irrigation development and management was promoted under the direction of local authorities and monks. The government employed gate operators (dyke keepers) for the reservoir schemes but other tasks were allocated to the community. At this time, a large number of cooperatives involved in agribusiness were established all over the country. After the conflict and fall of the Polpot regime, this system was reintroduced informally, and then more formally as the Ministry of Water Resources and Meteorology (MOWRAM, formed in 1999) was mandated to improve management of the country's irrigation schemes. MOWRAM introduced a formal system of Participatory Irrigation Management and Development (PMID) in 2000.[28]

Under PMID, FWUCs' mandate is to ensure the efficient and sustainable utilization and management of irrigation systems. While the provincial and district officials support the formalization of these groups with statutes and operational procedure, their effective functioning relies mainly on traditional community organization and community-led decision-making systems for sharing water among farmers. The importance of strengthening FWUCs is illustrated in the example of the Prasat Irrigation System, described below.

Irrigation System: The Prasat Irrigation System was built in 1978 under the Khmer Rouge regime, covering Kampong Thom province. The system was rehabilitated by MOWRAM, ADB and Chinese government in 2010. This rehabilitation increased the food security and livelihood of communities in Kampong Svay district, Kampong Thom province (particularly Sanko, Thbeng and Domry Slab communes) by increasing water supply, allowing for cultivation rice during the dry season. The components of this system are bridge culverts and sluice gates which open concrete canals in the main canal. Tributary canals were also rehabilitated

The irrigation canals of Prasat system are earthen except for some concrete parts of the main canal. The main canal bed was cemented in order to protect the bank from erosion, and reduce infiltration during the dry season. A local grass species

[28] Perera, L.R. 2006. Factors affecting the formation of FWUCs in institution building for PIMD in Cambodia: Two case studies. Working Paper 113. Colombo, Sri Lanka: International Water Management Institute.

has been grown on the contour of the canal slopes to further protect from erosion. The sluice gates were built at the main canal and at the start of each tributary canal in order to control the water supply to farmers' fields and prevent flooding. The rehabilitation works made an important difference to the availability of water in the area and expanded the cultivation area in the communes, in particular for the dry season.

Farmer Water User Community: To be sustainable, these infrastructure improvements require system management such operating the main and tributary sluice gates, cleaning the canals, protecting the vegetation areas and other maintenance. In addition, the equitable sharing of water is important to maintaining community cohesion and avoiding tensions, especially during periods of water shortage. To address these factors, the Provincial Department of Water Resources and Meteorology (PDOWRAM) integrated a component to strengthen the organization of a FWUC as part of the system rehabilitation. Villagers who had irrigated land in the scheme are members of the local Water User Groups (WUG) and send a representative to the FWUC. The FWUC has representatives from six villages of two communes (Sanko and Thbeng commune).

The FWUC provides administrative and planning support to operate and maintain the scheme, especially the main and secondary canals. The villagers are responsible for ensuring maintenance of the tertiary canals. The FWUC is also mandated to collect user fees to invest in maintenance.

This FWUC, as others in Cambodia, must still overcome constraints such as limited organizational and administrative capacity, limited resources for travel and other meeting costs, and various challenges in collecting and managing user fees. However, such village-based groups have traditionally existed to manage natural resources in Cambodian rural areas, and reinforcing and modernizing collective systems for water management will be more critical as water availability becomes more variable and unpredictable due to climate change.

Main canal of Samseb-Kanha Dam in the Prasat irrigation system in Kampong Thom Province, rehabilitated and renovated by ADB project (pictured on 7th October 2015)

The concrete canal in the main canal of Samseb-Kanha Dam in the Prasat irrigation system in Kampong Thom Province, rehabilitated and renovated by a China-funded project (pictured on 7th October 2015)

Tributary canal (Samdach Techo Canal) of Prasat system in Kampong Thom Province, rehabilitated by Military Engineering Forces in 2008 (pictured on 7th October 2015)

Culvert and sluice gate in the rehabilitated tributary canal of the Prasat system in Kampong Thom Province (pictured on 7th October 2015)

SPCR team holding discussions with a FWUC in Kampong Thom Province

Adaptation Outcomes	
Sensitivity/ Exposure	Strengthening FWUCs is a key measure to ensuring sustainable water management to deal with increased variability in water levels due to changes in precipitation patterns due to climate change.
Adaptive capacity	FWUCs provide a mechanism for farmers to participate in decisions about operation and maintenance of the irrigation systems. This contributes to better maintenance of these systems. A more participatory approach to irrigation system management will encourage farmers to be more active in maintaining the canals.
Eco-system integrity	Participatory community approaches reinforce effective and sustainable management of natural resources and contribute to water conservation.
Additional benefits	Access to working irrigation systems increase the agricultural crop production and livelihood of local people.
Criteria for Adoption	
Relevance	Contributes to meeting the water needs of communities.

Gender equality	Promoting women's participation as members and leaders of FWUCs involves them in community decision-making on water use, which is highly relevant for women. Women's viewpoints can contribute to developing more effective systems as they often have the main responsibility for water collection. Engaging women in decision-making on water resources contributes to women's empowerment.
Social acceptability	All villages are represented in the FWUC, which creates a platform to discuss water issues based on agreed guidelines. This approach is conducive to building social cohesion around water resources management.
Economic Viability	Irrigation system development is a significant investment, and detailed cost benefit analyses and hydrological models need to be produced in order to determine the economic viability of a particular system.
Replication potential	FWUCs are key local organizations in Cambodia and can be strengthened in any area with existing or new irrigation / water resource systems to be operated and maintained.
Institutional needs	FWUCs are organized with support of the PDOWRAMs and district officials for the management and operation of water resources and water-based infrastructure, including secondary irrigation systems.
Sustainability	This technique supports communities to sustainably use and manage water resources over the long-term.

Challenges in Adoption

- The villagers are often not accustomed to paying a service fee for irrigation water; building a readiness to pay thus takes long-term efforts. The water user fee needs to be developed with community consensus, and small groups formed to manage collection for their area. Without the collection of water user fees and capacity to manage these effectively and transparently, the FWUC would have difficulty to function on an ongoing basis.
- Since this irrigation scheme covers a large area, the capacity of the FWUC and WUGs needs to be strengthened to achieve the necessary level of administrative and organization capacity. The FWUC needs to be in a position to collaborate closely with its WUGs and help to manage the system effectively and use the water sustainably.

Source	Key Contact
Discussion with local officials and farmers in Kampong Svay District, Kampong Thom province	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

5.4.2 Utilization of upland spring water for dry-season rice farming

Sub-sector	Climate Hazards	Adaptation Elements
Water supply	Drought, water scarcity	Drought, water scarcity, flooding

Description of the Practice

Traditionally, ethnic minority communities living in Cambodia's mountain areas practiced shifting cultivation or single season rice cultivation. The limits to land availability for shifting agriculture and risks associated with depending on single season rice cultivation resulted in periodic food shortages. As a result, many ethnic minority farmers have transitioned towards sedentary farming practices, growing agro-business crops such as cassava, pepper, cashew nut, tobacco and rice in both the wet and dry season to supplement their incomes and increase food security. These communities traditionally rely on natural spring water and so they have developed techniques to irrigate their fields with natural spring water.

The Charay minorities in Dal Veal Veng village, Nhang commune, Andoung Meas district, Ratanakiri province have been using upland springs for irrigation. The community built a 700 meter long and 0.5 meter wide canal to bring water from the springs to the rice field. With this system, they are able to rely on upland natural springs for dry-season rice farming, home-gardening and cash crop farming. The spring also supplies water for wet-season rice whenever drought occurs. Some families use the water for domestic purposes in both dry and wet seasons. Because springs are close to their farmland, many minority people also started to use the water for home-gardening and small-scale animal raising.

Upland spring water for dry-season rice farming

Adaptation Outcomes

Sensitivity/ Exposure	Provides additional source of water for people living in drier zones, and reduces risks of water scarcity. Increases resilience of households and communities during droughts. Small canals from upland streams add drainage for storm run-off and can reduce flash floods and landslides as mountain areas experience more extreme weather events due to climate change.

Adaptive capacity	Households and communities have an additional supply of water for irrigation and other uses.
Eco-system integrity	Use of canals from upland springs provides a safe source of water. Use of canals reduces risks of water contamination by keeping animals and humans away from the source. Care needs to be taken to ensure water conservation is still applied and streams are not over-exploited, resulting in downstream water shortages.
Additional benefits	Production increased with the addition of dry-season rice, home gardening and cash crops. The increased farm production reduces the high dependency on timber harvesting and migration for jobs.
Criteria for Adoption	
Relevance	Contributes to meeting the water needs of communities.
Gender equality	Reduces time required for water collection and treatment, tasks that are most often performed by women. Women and children are more vulnerable to water-borne diseases, and safely stored rainwater reduces this risk.
Social acceptability	Community acceptance is favourable as use of upland springs is a long-time practice that can be applied to individual homes or community buildings with either traditional or modern materials. Community members are getting more involved in protecting the upstream forest essential to the natural recharging of the springs.
Economic Viability	The construction of canals for use of upland spring water for irrigation is a low-cost investment in irrigation as the canals are small and can be made of earthen material. Using cement or other materials will increase costs but can also reduce water losses.
Replication potential	Applicable in small communities in upland areas that have sufficient access to nearby spring water.
Institutional needs	Support from local authorities to ensure balanced use of water resources in springs and streams. Development of FWUCs to ensure maintenance and conservation of water.
Sustainability	This technique promotes conservation and efficient use of available water supply. Properly managed the technique will enhance the sustainable access to natural water sources.

Challenges in Adoption

- Earth canals can only reach a certain number of households, the current spring water can only reach about two hectares of paddy field in the village for about 4-5 families.
- Spring water can irrigate about 40 ha of rice field, but this same water is needed for domestic water supplies and so priorities for water use need to be organized within the community.
- There is a need for community-based water management if the area of dry-season rice cultivation is to increase.

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5.4.3 Traditional weather forecasting systems

Sub-sector	Climate Hazards	Adaptation Elements
Water supply	Drought, water scarcity	Water conservation

Description of the Practice

There are several traditional weather forecasting practices in rural areas of Cambodia. The weather can be forecast from the behaviour of certain animals and insects, from the growing characteristics of plants, or by looking at the clouds and the sky. Some forecasts are seasonal, while others are daily or weekly.

Ritualistic practices are used to predict the upcoming wet season, such as at the end of the Royal Ploughing Ceremony, when the royal oxen were relieved of their harnesses and led to seven golden trays containing rice, corn, sesame seeds, beans, grass, water and wine to feed. The seasonal weather forecast depends upon which trays the oxen choose to feed from. For example, in 2015, the royal oxen chose to eat out of only three trays with varying percentages of rice and corn while they largely ignored the trays of sesame seeds, grass, water and wine. The forecast was as follows: farmers would enjoy a moderate output for their rice harvest but good yields in secondary crop production, especially corn and beans. Because the royal oxen only sniffed on the tray of water and turned away from the wine, the prediction was made that farmers would not suffer any serious floods.

Traditional end of the Royal Ploughing ceremony

Appearance of white bugs in the soil. Around the Tonle Sap, villagers can tell from the position and number of darker bands on the bodies of white bugs whether there will be dry periods during the upcoming monsoon season. White bugs are the larvae of scarab beetles that live in the soil, especially underneath palm trees. As they develop, darker bands may appear on the bodies of the larvae. If the larvae are generally white all over, there will be few dry periods during the wet season; if there are darker bands, then there are likely to be periods of drought during the growing season. The position of the darker bands can indicate when this is likely to occur.[29]

Red Ants. Weaver ants (Oecophylla smaragdina) live in trees and are known for their unique nest-building behaviour, where worker ants construct nests by

[29] Village discussions in Pursat province as part of CBDRM component of GMS Flood and Drought Management Project 2016.

weaving together living leaves using larval silk. They eat small bugs, sip nectar, and tend tiny scale insects in or near the nest: the scale insects pay for their protection by excreting honeydew that the weaver ants 'milk' and consume. The behaviour of red ants can be used to predict floods. When floods are likely to occur the red ants will move higher up the trees and build their nests above the floods. When rains are likely to start, there will be much movement of red ants up and down the trees.

Weaver ants are territorial and workers aggressively defend their territories against intruders. Farmers use them as natural biocontrol agents against agricultural pests by introducing a weaver ants' nest into the orchard and encouraging the ants to colonise all the trees by linking them with 'ant bridges' made from rope or bamboo. Fruit trees harbouring weaver ants show less leaf damage by herbivores, require fewer applications of synthetic pesticides, and produce juicier, shinier fruits.[30]

Dragonflies. Dragonflies can be used to predict rainfall and the direction from which rain will come. They fly high when sunny skies are approaching, low when rain is coming, and at an average altitude when it is cloudy.

Clouds and sky. In the Mekong delta, the clouds and sky are used for daily weather forecasts. Referring to the colour of clouds as "chicken-fatted" means wind, and "dog-fatted" means rain.

Tamarind trees. Tamarind trees are also observed for signs of rain, as they fold their leaflets at night and in overcast weather.


White bugs and red ants

[30] http://www.socambodia.com/skunspidersanctuary/Factsheet%20weaver%20ants.htm

Adaptation Outcomes	
Sensitivity/ Exposure	While more research on the link between these practices and actual weather events is needed, the rituals and knowledge conserved through traditional weather forecasting can be an important building block for developing community-based disaster risk management systems that rely on both modern and traditional techniques. The application of traditional weather forecasting maintains community members' sensitivity and attentiveness to their natural environment. Such characteristics are positive for following combined traditional and scientific weather alerts.
Adaptive capacity	The use of traditional practices for weather forecasting are conducive to maintaining knowledge and information on what to do or not do in the event of extreme climatic conditions. This knowledge can be applied when both traditional and modern warning systems are used.
Eco-system integrity	Such systems contribute to valuing the natural environment and maintaining balance of natural eco-systems.
Additional benefits	Maintaining traditional rituals such as the Royal End of Ploughing ceremony maintain heritage and culture traditions.
Criteria for Adoption	
Relevance	Modern scientific weather forecasting and communication of warnings of extreme events to local people in rural areas is improving and becoming more reliable, so they are used more often than traditional weather forecasting. However, traditional practices still have a place and there is need to use local indicators, indigenous knowledge and conventional knowledge of weather forecasting to help reduce impacts of rainfall and temperature variability on smallholder farmers. Research is needed to verify traditional practices and link with actual weather patterns experienced.
Gender equality	Such systems value oral traditions for transferring knowledge from generation to generation and women's understanding of natural environments.
Social acceptability	The practices are traditional in many communities, so acceptance is high.
Economic Viability	Traditional weather forecasting practices are free.

Replication potential	As these traditions are passed down, they are not highly replicable but warrant valuing and conservation in communities where they do exist. However, research on the practices and their links to actual learning events could produce learning on climate patterns that could be shared with other communities.
Institutional needs	Description and verification of such practices could be a small research project or a component of a flood-and-drought forecasting programme.
Sustainability	The practices have been passed down for centuries and so are sustainable as long as they are remembered and preserved by the community.

Challenges in Adoption

- Research is needed to understand what relation traditional practices weather forecasting has to actual climate events.
- Modern weather forecasting and climate information for farmers should supplement traditional forecasting practices to ensure all information source are used to prepare for the season or immediate climate events.

Source	Key Contact
Discussion with community at Bakan district in Pursat Province	Mainstreaming Climate Resilience into Development Planning/Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

6. SETTLEMENTS AND TRANSPORT

6.1 OVERVIEW

One of the major climate change impacts facing Asian countries is vulnerability to increased flooding, causing damage to infrastructure and settlements and resulting in loss of life.[31] Infrastructure investment represents a significant portion of government and international donor resources dedicated to reducing poverty and stimulating growth in developing countries such as Cambodia. Infrastructure expands people's access to basic services and creates new economic opportunities. Given the pressing need for more services, the materials and techniques used to build infrastructure in developing countries are often selected to allow for more rapid expansion rather than durability. As a result, such infrastructure is more vulnerable to damage and consequently more at risk from climate change impacts.[32]

Countries such as Cambodia that are embarking on cross-sector planning processes to address climate resilience of infrastructure are at the forefront in building methods and tools to guide adaptation planning. Examining indigenous and traditional practices for infrastructure development is a key part of determining what methods to use to optimize infrastructure investments to address the impacts of climate change.

Making infrastructure more climate-resilient does not necessarily involve using more expensive and durable materials. For example, building homes with materials that are locally available for repair and replacement renders structures more climate-resilient in ways that are cost-effective and in control of households. Choosing sites for settlements and associated infrastructure is as critical to protection from flooding and other climate events as what materials to use (see 6.2.1 and 6.4.1). Analysis of the best methods for erosion control, slope protection and other factors involves drawing on and improving upon engineering techniques that have been used for centuries and shared across various parts of the world. Examples below provide a starting point for closer examination of the ways that traditional techniques for building and settlement planning can be integrated into more climate-resilient infrastructure development in Cambodia.

[31] Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change: Summary for Policy-Makers [Field, C.B., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 23.

[32] United Nations Development Programme. 2011. Paving the Way for Climate-Resilient Infrastructure: Guidance for Practitioners and Planners. New York, New York: United Nations Development Programme, p. x

6.2 PLAINS

6.2.1 Living with floods in lowland areas

Sub-sector	Climate Hazards	Adaptation Elements
Settlements	Floods, storm surges	Safer settlement planning

Description of the Practice

Rural life in the lowland areas of Cambodia is inseparably linked to the annual cycle of flooding, deriving in part from local rainfall but mainly from floods in the Mekong River. Normal floods are not considered disasters by persons living in these areas; rather, they are seen as a source of livelihood and sustenance. Because the communities have developed coping mechanisms to live with flooded conditions, annual floods become water disasters only when they are more severe than normal: deeper than average, unexpectedly fast in onset, or unusually prolonged. Large and swift-onset floods cause loss of life due to drowning and illness; destruction of crops, houses, and other possessions; loss of livestock; and worsening poverty in rural areas. A series of floods can be particularly devastating for poor farmers and fishers for whom recovery (replanting of crops, purchase of inputs and livestock, repair of houses and fishing gear) entails borrowing. The burden is much more onerous when annual floods are preceded or succeeded by droughts. Within Cambodia, the four provinces of Kandal, Prey Veng, Svay Rieng, and Takeo in the lower Mekong River Basin are among the most seriously affected areas.

To cope with annual floods, which can last for up to six months a year, rural communities have traditionally built safety hills to keep people and animals above the level of floodwater. These are simply mounds of earth on which houses and storage facilities can be sited. Given that flood water depth can exceed 4 m, the effort involved in creating such refuges is quite onerous. Rural communities have a deep understanding and knowledge of the extent of flooding they can expect, and they choose relatively high ground on which to construct safety hills.

Two villages were visited to observe the application of safety hills and other reinforcing adaptation mechanisms: Cham village (Cham Commune) in Kampong Trabaek District and Trapieng Proboss village (Senareach Odom Commune) in Preah Sdach District of Prey Veng Province.

Provided that safety hills are high enough to remain above the flood level, the family may be able to continue its daily routines with little interruption. All families have small boats for traveling to markets, schools, clinics, etc. Many farmers become fishers during the wet season, supplementing their livelihood from agricultural production. Boat building is a highly developed skill that has been fully adopted as a local source of employment.

In general, safety hills that have been in place for some time include trees, bamboo and other vegetation on the perimeter of the living area. These provide some protection against the ravages of waves. A relatively inexpensive addition to the safety hills would be stone pitching to protect trees from being uprooted. Inhabitants in these locations note the increased intensity of storms in recent years, together with prolonged dry seasons. The increased storm intensity is generally accompanied by strong winds and waves that can damage safety hills and make boat travel more hazardous.

Safety hills providing refuge from flooding for a single house

Children learn to swim and handle boats from an early age

Boat building is a well-developed skill within communities in the flood zone

Adaptation Outcomes	
Sensitivity/ Exposure	Reduces sensitivity to rising water levels and mitigates disaster risks. To cope with worsening flood depth under future climate change scenarios, families may need to raise the safety hills and make them more structurally adequate. Reduces vulnerability to low and moderate floods and to prolonged inundation. Decreases risks of drowning and disease spread, in particular among women and children. Protects assets from being lost to flooding. May be less effective for strong storms and very intense flooding.

Adaptive capacity	Widespread adoption of safety hills shows that rural communities have the capacity to work together to reduce their vulnerability to climate change, and their traditional coping mechanisms are highly appropriate (although inadequate in the face of increasingly severe disasters). Following disasters, villagers initiate rescue and relief activities long before officials and other sources of aid arrive on site. The safety hills can provide sites for evacuation and storage of emergency supplies during higher-than-usual flooding.
Eco-system integrity	Flood defences made from earth and vegetation protect human settlements while maintaining integrity of aquatic and land habitats.
Additional benefits	Families maintain close access to water systems that are traditionally central to their transport and livelihoods activities.
Criteria for Adoption	
Relevance	A long-time practice that has allowed people to live with floods and is becoming even more relevant as Cambodian communities experience the impacts of increased flooding due to climate change.
Social acceptability	The measure is developed and implemented by the whole community based on traditional decision-making processes.
Gender equality	Women are affected more directly than men by long-duration floods, due largely to the need for them to continue to meet all of their domestic and productive work obligations under extremely difficult circumstances. Women are more often responsible for caring for children and elderly during floods. This measure provides women a means to ensure the safety of their family and assets when men leave flood-affected areas in search of employment.
Economic Viability	Safety hills are a low-cost intervention. Costs are primarily labour, vegetation and materials to reinforce slopes. The approximate cost to enhance an existing safety hill or provide an adequate safety hill where none exists is of the order of USD 300-1,000 per household hill. The provision of funds for paying local labour to construct safety hills would provide an additional benefit to communities where sources of paid employment are few.
Replication potential	Applicable for villages close to rivers where communities are accustomed to designing and sharing common settlement areas. The practice can be also be applied to individual houses along river banks.

Institutional needs	A general program by national, provincial and local government of raising safety hills and making them more resistant to erosion would help local communities adapt to climate change. Providing external assistance for this activity would be an effective way to enhance traditional coping mechanisms.

Challenges in Adoption

- For the poorest households, the construction of an adequately fortified safety hill may be beyond their means. In cases of extreme poverty and where safety hills are inexistent or inadequate, the provision of assistance in terms of funds to pay for the hiring of earthmoving equipment would be highly effective.
- More training needs to be provided to communities on what to do before, during and after flooding to ensure safety and better hygiene. In particular women, who often bear greater burden for post-disaster clean-up and maintaining the health of the family, need to be prioritised for technical training on community-based disaster risk reduction.

Source	Key Contact
Discussion with community in Kampong Trabaek and Preah Sdach Districts, Prey Veng Province	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

6.2.2 Seawater protection dykes in Koh Kong Province

Sub-sector	Climate Hazards	Adaptation Elements
Coastal flood protection	Floods, storm surges, sea level rise, salt water intrusion	Structural measures to mitigate coastal erosion, flooding and saltwater intrusion.

Description of the Practice

Sea dykes are a practice that has been used for centuries to protect coasts and prevent saltwater intrusion into fields or other land areas. They are commonly planted with small mangrove species on each side of embankment and with grasses on slopes to protect from soil erosion by heavy rain. The dykes are usually built near the seawater on lowland coastal areas with tidal regimes. Sea dykes are often built with roads running along the top part of the raised soil or other material.

Initially, the location and design of dykes were based on the observations and experience of local inhabitants, where the dyke elevation was set based on the highest water levels either experienced directly onsite or suggested by the available history for the area. Where dykes were exposed to open water, the elevation of the dyke was increased to allow for exposure to storm-related wind and wave setup and wave run-up, again based on local experience. As engineering practice evolved, more-modern practices using modelling to determine height and other design feature of sea dykes have been developed.

Sea dykes are an important adaptation measure to deal with sea-level rise and flooding due to climate change. The demand for sea dykes, in particular cemented ones, is increasing as each community seeks maximum protection for its buildings and land to protect from erosion and increased flooding. However, there are limits to the extent to which communities can or should rely on structural protection to adapt to climate change, since coastal erosion is a natural and inevitable process and sea dykes can lead to a false sense of security.

Sea dykes need to be considered as one option in the context of other coastal protection measures, including reinforcing natural embankments and mangrove areas. These other coastal protection measures need to be incorporated into sea dyke design guidelines in order to protect coastlines from protected changes in sea level due to climate change.

The coastal province of Koh Kong has 12 sea dykes and two dykes are currently being planned (one in Pream Krasop commune and another in Andoung Toek commune). In addition to protection of sea-water intrusion, these typical sea dykes are also utilized for transportation, connecting coastal villages to urban areas and national roads. Each dyke is equipped with at least one sluice gate to regulate the rainwater runoff in the wet season. The typical dimension of the sea dykes found in Koh Kong are 6 m (base), 4 m (top), 0.5-1 m (height) and 1-2 m (slope gradient). The dimensions vary according to the size of the lowland area covered by the dyke. Built during past regimes – most probably Late King father (1960-1970) and Khmer Rouge (1975-1979) – and rehabilitated in the 1990s, they are maintained using funding support from the MOWRAM, its provincial department and international donors.

All of these dykes are mainly built to protect farmland and settlement area from saltwater intrusion, as well as for road transportation. A dyke in Tany village of Chikor Leu commune was built across the mangrove forest to make a road to the village and to prevent saltwater intrusion into the rice paddy fields. It also plays the role of a freshwater reservoir for use in dry season. The seawater level is higher in dry season than in wet season. Therefore, the risk of saltwater intrusion is high in the dry season, especially when the water level may result in flooding of the residential area. In the dyke locations visited, rice cultivation is rain-fed, as an irrigation system is not installed in these locations.

Dykes are commonly constructed with earthen materials such as stone and gravel available from the nearby mountain. They are commonly planted with small mangrove species on each side of embankment and with grasses on slopes to protect from soil erosion by heavy rain. The cost of each dyke is related to its purpose (purely for protection of saltwater intrusion, road transport, or for both) and its dimension such as width, height, and length, and includes the earthen work of excavation.

Sea Dyke in Pream Krasop Wildlife Sanctuary, Khemarak Phoumin, Koh Kong

Banks of a sea dyke are planted with grass and small mangrove plants for slope protection.

Sea dyke in Chimeal village, Andoung Toek Commune, Botum Sakor district. It is used to prevent seawater intrusion into farmland.

The dyke protects farmland from saltwater.

Adaptation Outcomes	
Sensitivity/ Exposure	Reduces sensitivity to sea level rise and mitigates salt water intrusion and disaster risks associated with sea surge, storms and flooding. Mangrove plantations along dykes protect coastal embankments and roads from erosion.
Adaptive capacity	Increases community capacity for flood and storm protection. A structural measures for flood protection that can be optimized by combining with community-based disaster risk management, early warning systems and other non-structural measures.
Eco-system integrity	Any development of dykes requires environmental and social impact assessments to identify and mitigate impacts on eco-system integrity.
Additional benefits	Improves road transport for coastal communities. Possibly improves recreational areas along the coastline.
Criteria for Adoption	
Relevance	The demand for sea dykes, in particular cemented ones, is increasing as each community seeks maximum protection for its buildings and land from erosion and increased flooding. However, there are limits to the extent to which communities can or should rely on structural protection to adapt to climate change, since coastal erosion is a natural and inevitable process and sea dykes can lead to a false sense of security.

Social acceptability	Overall, it is a socially accepted structural measure for flood protection but requires community consultations and environmental and social impact assessments to determine potential positive and negative impacts. Community members need to be involved in determining socially acceptable design at site and any nearby affected location.
Gender equality	Women are affected more directly than men by long-duration floods, due largely to the need for them to continue to meet all of their domestic and productive work obligations under extremely difficult circumstances. Women are more often responsible for caring for children and elderly during floods. Dyke protection, combined with engaging women in community-based disaster risk management programs, provides women a means to ensure the safety of their family and assets when men leave flood-affected areas in search of employment.
Economic Viability	Costs of dykes vary considerably depending on the location, length and materials for construction. A cost-benefit analysis is required to determine viability of an investment compared to settlements and assets to be protected.
Replication potential	Dyke construction is practiced widely in Cambodia and is applicable for coastal areas.
Institutional needs	Dyke development requires cooperation between different ministries responsible for agriculture, roads and water resources as well as between different levels of government. Community involvement and engagement is essential to ensure relevance and appropriateness of infrastructure to respond to community priorities. Requires regular maintenance from local authorities and communities.
Sustainability	Participatory approaches to dyke development combined with community-based disaster risk management are important to ensuring maintenance of structures.

Challenges in Adoption
• Because dykes are relatively large and multi-purpose, operation and maintenance are complicated, and construction is expensive. • Some dykes are constructed on a mudflat of mangrove forest, and they easily break when impacted by strong waves or high loads of vehicle transport. • Rising sea levels will dictate that sea dykes must be raised periodically, and considerable land area behind the dykes will need to be acquired for the dyke right of way. • To ensure long-term survival of the dyke systems, financial commitment will be needed for upgrading and maintenance.

Source	Key Contact
• Report of field mission to Koh Kong province to document the adaptation measures in April 2016. • Linham, M. M. and Nicholls R. J. (2010). Technologies for Climate Change Adaptation: Coastal Erosion and Flooding. UNEP and Global Environment Facility Technology Needs Assessment Guidebook series, University of Roskilde.	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

6.3 AROUND TONLE SAP

6.3.1 Khmer ancient bridge masonry

Sub-sector	Climate Hazards	Adaptation Elements
Roads Bridges	Floods, storm surges	Structural measures to mitigate erosion and flooding

Description of the Practice

The Khmer road and bridge system has its origins in the pre-Angkorian period and was well-developed between the 11th and the 13th centuries. Roads and bridges were traced on routes to facilitate regional and international communication, and enabled the Khmer to effectively control their core territories. Masonry bridge technology in Cambodia can be traced back to at least the 12th century. Several examples of early Khmer bridge masonry can be found around the Angkor Wat site, including the Kampong Kdei Ancient Bridge (also known as Spean Praptos or Spean Preah Toeus). The continued existence and use of some of these historic structures are testament to engineering designs and construction that lasts.

Kampong Kdei Bridge is located on the National Road N.6 at Kompong Kdei commune, Chikreng district, Siem Reap province, about 70 km from Seim Reap town. It is one of 11 remaining historic bridges in the area. The construction date is not known for certain but it is associated with the era of the King Jayavaraman VII (C.E. 1181-1220), with many reconstructions and restorations over time. As part of conservation efforts, a bypass was recently constructed on National Road 6 to divert heavy traffic away from the bridge and maintain it for local traffic and tourism development.

Ancient bridges are made up of narrow arches, mounted on large pillars, on which rests a deck of variable thickness. Kampong Kdei Bridge is the longest corbelled stone-arch bridge in the world, with 20 pillars and 21 corbelled arches. The bridge was built from 98% laterite stone and 2% sandstone. The average dimensions of each block for the construction are 50 centimeters in width, 150 to 170 meters in length and 40 centimeters in thickness. The bridge is 85 meters in length, 16 meters in width and 10 meters in height. There are four wing walls (four retaining walls) used as stabilizer for the bridge and its foundation (see Figures 2 and 3).

The bridge builders had to have a good understanding of the hydraulic flow constraints to address the problems of water pressure on the structure and the erosion it causes at the foot of the pillars and on the aisles of the bridge. The canalization of the water towards the bridge was obtained by the creation of lateral embankments that extend over the entire height of the roadway or the depth of the river bed. The good flow of water was obtained by choosing to compensate for the narrowness of the arches by a natural or artificial widening of the river bed at the point where the bridge was built. This position made it possible to lengthen the bridge, to multiply its arches and thus to increase its drainage capacities. Moreover, in order to avoid scouring problems in the soft soils, the builders raised their work on largely overflowing rafters that consist of several layers of laterite blocks. Compared to smaller bridges, the base of the pillars was made to be wider.

In environmental studies conducted at the time of constructing the bypass, local villagers reported that the Kampong Kdei Bridge water flows and levels had fluctuated over the previous decade, but that the bridge has never suffered serious impact from any seasonal flooding. This was the case even during the year 2000, when many villages were inundated.

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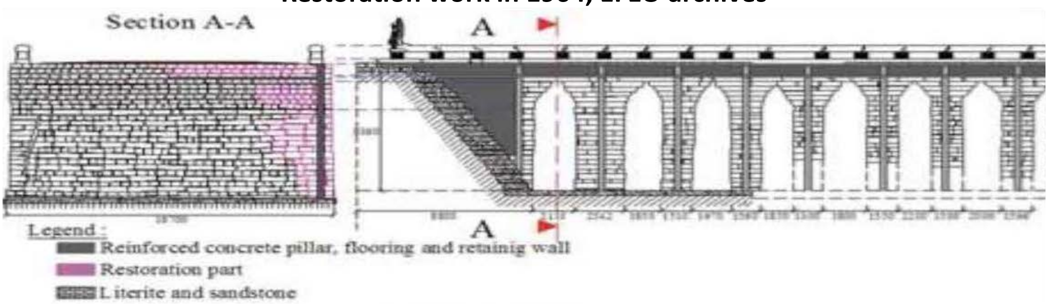
Kompong Kdei Ancient Bridge

Restoration work in 1964, EFEO archives



Restoration section

Adaptation Outcomes	
Sensitivity/ Exposure	Understanding the techniques behind historic bridge masonry can serve as a reminder of foundational principles to integrate into building design to make structures stronger and more enduring in the face of more extreme climate events.
Adaptive capacity	The ancient bridge structures have been rehabilitated and maintained to continue to be useful over centuries. The techniques show a high adaptive capacity of Khmer engineering that can be harnessed to provide future engineering solutions for changing local conditions in the face of climate change.
Eco-system integrity	The bridge structures have been designed to allow water flow and drainage, and avoid disruption of natural river systems.

Additional benefits	Maintaining the historical structures of the ancient Khmer transportation systems is an important effort for conserving traditional knowledge, valuing Khmer history and contributing to tourism development.
Criteria for Adoption	
Relevance	The techniques behind the ancient Khmer masonry remain relevant today in understanding how to build durable structures in keeping with typical hydraulic conditions in Cambodia. The ongoing resilience of such structures can provide indications of how to build lasting structures in the face of changing climate conditions.
Social acceptability	Villagers value ancient structures due to their durability through various extreme climate events. While new structures are needed for modern transportation conserving ancient bridges and integrating ancient bridge techniques in new structures can contribute to climate resilience as well as tourism value.
Gender equality	Related tourism offers livelihood opportunities for women and can contribute to their economic empowerment.
Economic Viability	Conserving traditional Khmer masonry requires regular investment in maintenance. Provides return on investment from income earned from tourism development.
Replication potential	Studying and conserving ancient bridge techniques will promote the use of traditional Khmer masonry for modern constructions.
Institutional needs	Maintaining the structures requires developing conservation and tourism development plans for the structures and their surroundings.
Sustainability	Because ancient bridges have lasted several hundred years, the technique highlight the importance of building sustainable structures in keeping with local conditions.

Challenges in Adoption

- The bridge was weakened due to exposure to heavy traffic and vegetation growing between the rocks. The bridge remains a key monument in the region. While restoration efforts and the construction of the bypass have contributed to its preservation, the density of development on both banks of the river near the bridge and other factors contributing to bank destabilization could threaten its continued conservation.

Source	Key Contact
• Bruguier, Bruno. Les ponts en pierre du Cambodge ancien [Aménagement ou contrôle du territoire]. In: Bulletin de l'Ecole française d'Extrême-Orient. Tome 87 N°2, 2000. pp. 529-551. • Teck, Srun. Preservation and Enhancement of Cultural Heritage: The Ancient Bridge Community Project. ACCU the Seventh Regular Report. Nara, Japan: Asia-Pacific Cultural Centre for UNESCO (ACCU), 2011. • Hendrickson, Mitch. Historic Routes to Angkor: Development of the Khmer Road System (Ninth to Thirteenth Century AD) in Mainland Southeast Asia. Antiquity 84 2010, 480 – 496. • SBK Research and Development. Environmental Assessment, Kampong Kdei Bridge on National Road 6, 2004.	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

6.4 MOUNTAINS

6.4.1 Settlements near bamboo forest and thatch meadows

Sub-sector	Climate Hazards	Adaptation Elements
Settlements Land-use management	Floods, storms	Safer settlement planning

Description of the Practice

Bamboo forests and thatch meadows are some of the traditional resources for indigenous people to adapt to their environment and the increased risks of disaster due to climate change. Indigenous people in Mondulkiri Province plant their crops surrounded by meadows of long thatch grass and bamboo that become a natural fence protecting their crops from storm or strong wind. The vegetation growing in these meadows is sustainably harvested for building homes and other household items. These protected areas play a vital role in the context of climate change. Local indigenous knowledge shows that such vegetation can protect slopes from erosion and landslides. However, this traditional practice is in decline due to expansion of commercial farming, even among indigenous people. A continued degradation of bamboo forests and meadows could lead to more frequent disasters such as soil erosion and landslides that would be intensified by the impacts of climate change in the future.

The Bunong are an indigenous minority ethnic group, living mostly in Mondulkiri province, in the eastern mountain region of Cambodia. They are the largest indigenous upland ethnic group in Cambodia with their own language, Pnong.

Settlement pattern: Bunong villages are located near bamboo forests, with houses located in upper slopes and farms and gardens cultivated in lower slopes near streams, meadows and bamboo forests. The houses are built away from streams that may be prone to flash floods, and the fields are close to water and are surrounded by thatch meadows to prevent erosion.

Housing structure: The Bunong build houses with a bamboo structure and thatch roofing shaped like a turtle shell. They are a traditionally mobile people due to their practice of shifting cultivation. Bamboo and thatch are ideal materials for quickly building houses in new locations, and can be easily repaired in case of damage.

Conservation of bamboo forest and thatch meadows: The bamboo and thatch are important materials for Bunong people to build homes, and to surround their crops for protection from winds and erosion. Thatch is harvested only at certain times of the year, and bamboo stalks and bamboo shoots are extracted in a sustainable way. Elderly people provide guidance on how much bamboo stalks can be harvested, while women know the best time to harvest thatch for roofing their houses.

Traditional bamboo and thatch houses on sloped land

Construction of houses using bamboo and thatch

Adaptation Outcomes	
Sensitivity/ Exposure	Promoting continued practice of bamboo forest and meadow protection and valuing traditional materials and settlement patterns for upland communities will enhance soil conservation and promote greater resilience of homes and livelihoods to disasters. Protects assets from being lost to flooding. May be less effective for strong storms and very intense flooding.
Adaptive capacity	The traditional settlement patterns practiced by the Bunong people show their experience in adapting to adverse climate events and provide insights for developing adaptation measures.
Eco-system integrity	Bamboo and thatch meadows and forests protect human settlements and crops while maintaining integrity of forest eco-systems.
Additional benefits	Bamboo shoots are also collected as a food source for indigenous people.
Criteria for Adoption	
Relevance	Indigenous people have used this practice to protect their settlements from adverse climate events for generations, and it is becoming even more relevant as Cambodian communities experience the impacts of climate change.
Social acceptability	The measure is accepted but needs conservation to ensure that traditional knowledge and valuing of traditional renewable materials are maintained in communities practicing this method.
Gender equality	The ready access to bamboo forest and thatch meadows is beneficial to women as they have access to materials used for housing and other daily use.

Economic Viability	This practice is a low-cost measure as it mainly relies on local resources that are easily accessible to upland ethnic minority people.
Replication potential	Applicable for villages in mountain areas that have access to land for meadows and forests.
Institutional needs	A general program by national, provincial or local government of valuing traditional housing and community-based forest management would assist local communities to continue this technique as opposed to changing house materials and land-use practices. Providing external assistance for this activity would be an effective way to enhance traditional coping mechanisms.
Sustainability	Traditionally, Bunong people place a value on managing the resource sustainably to protect it for future use.

Challenges in Adoption

- There are no legally designated bamboo forest areas or protected bamboo forest and meadows areas to provide natural protection from salt water intrusion. Having plantations nearby dykes prevents their erosion.

Source	Key Contact
• Mondulkiri Indigenous People Association for Development (MIPAD) "Indigenous People Communities' Climate Change Adaptation and Disaster Risk Reduction in Mondulkiri" Project, funded by ADB and managed by PLAN International. • MIPAD learnt about bamboo and meadow land conservation during its feasibility study on the need for new innovations in upland adaptive farming among indigenous farmers including agro-forestry, upland and Sloping Agricultural Land Technology in the target areas.	Mr. Kat Bun Heng Mondulkiri Indigenous People Association for Development Tel: 012 974228 Email: kat.bunheng@gmail.com Website: www.mondulkiri-centre.org

6.5 Across regions

6.5.1 Macadam base roads

Sub-sector	Climate Hazards	Adaptation Elements
Roads	Floods, storms, erosion	Climate-resilient construction techniques

Description of the Practice

The macadam road method is a two-centuries-old road-making technique which originated in the United Kingdom and was brought to Cambodia by the French in 1930. It was first used in Cambodia for building roads in Phnom Penh. The technique uses a simple method of building a well-compacted sub-grade using local soil and small stones covered with a hard surface to protect from water and wear. The technique uses a sloped subgrade surface to improve drainage with angular aggregate (maximum size 75 mm) in two layers for a total depth of about 200 mm. A pavement surface (about 50 mm thick with a maximum aggregate size of 25 mm) is placed on top. The total depth of a typical macadam pavement is about 250 mm.

Since it is long-lasting and adaptable to wet conditions, the macadam method is climate-resilient and relatively low-cost technique for constructing roads in areas where increased flooding and moisture is expected. It is a durable cover and ensures sustainable and long-term access to roads through all seasons. Examples of this technique are provided for two provinces coastal Koh Kong and mountainous Mondulkiri.

Koh Kong Province is located in a coastal eco-zone that is threatened by impacts of climate change such as (1) seawater intrusion, high tides and sea-level rise; (2) storms and storm surges; and (3) heavy rain and flooding. It is defined as a tropical monsoon area with annual rainfall between 2,000 and 4,000mm.

A macadam road was built for the Provincial Road No. 1489A, running through Bak Khlang commune in Mondul Seima district. This road was built on a seawater floodplain with soft-soil pit foundation. The Department of Public Works and Transportation (DPWT) of Koh Kong used soil mixed with amour rock to form the road subgrade. Due to high tide seawater overflows on the road, water may soak the sub-base of the road. The DPWT used a macadam sub-base stone since it can drain well and withstand the wet conditions. For erosion prevention, DPWT used amour rock to protect the toe and the slope of the embankment.

Mondulkiri Province is located in a mountainous eco-zone, with annual rainfall of 1,800 mm. It has historically experienced annual flooding events. These floods often occur swiftly and last for short periods, with very heavy rainfall. Although brief, these intense rains have the potential to cause severe damage to village crops and infrastructure.

As part of its rural road improvements, in 2003 MRD built a 14 km macadam road from a commune centre (Krong Sen Monorom) up the Pou Trom Mountain to Memang. The road rises on the slope, leading from the valley up to the mountain. Initially the road had a laterite surface, but in 2004 the section running through the town was upgraded to a macadam base double bituminous surface treatment (DBST) surface by the MPWT. DPWT of Koh Kong explained that the macadam method is better suited to Mondulkiri because: (i) it can withstand the wet climate of Mondulkiri; (ii) it provides better slip resistance for a sloping road; and (iii) the road is more easily repaired locally when it is damaged.

Three elements of subsurface drainage are important to ensure water is channelled away from the road and into the creeks and streams.

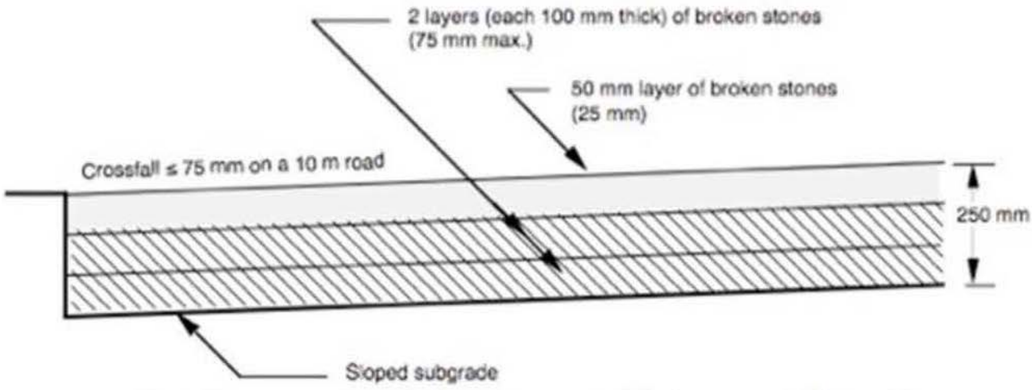
- Drainage across the surface of the subgrade (by using a crown slope)
- Drainage through the road surface (by using permeable stone)
- Drainage out of the edge of the road (by placing the road on top of the earth)

A road built on a seawater floodplain. The project was started in 2009 and finished in late 2013. (Photo: April 2016)

Amour rock used to protect bank erosion

A road built on a slope of mountain. The project was finished in 2004. (Photo: April 2016)

DPWT upgraded the Laterite road built by MRD to macadam base DBST pavement (section in town)



[http://www.pavementinteractive.org/article/pavement-history/]

Macadam road in Koh Kong (finished 2013), Photo: April 2016. It passed through two monsoon seasons and the pavement is in good condition.

Macadam road in Mondulkiri (finished-2004), Photo: April 2016. It passed through 12 monsoon seasons and the pavement is in good condition.

Macadam base course works: the stone to be laid by hand (source: Mondulkiri's DPWT)

Macadam base course works: the aggregate to be laid by hand (source: Mondulkiri's DPWT)

Adaptation Outcomes	
Sensitivity/ Exposure	Macadam road base is resistant to floods and water damage, as it drains well and the stone skeleton is less susceptible to water erosion. The macadam road surface is a good option in areas that are vulnerable to climate threats such as seawater intrusion, high tides, storms and storm surges, heavy rain and flooding. The key issues to be considered for a climate-resilient road are: (i) soft-soil pit foundation; (ii) wet conditions; (iii) erosion due to storm; and (iv) slope.
Adaptive capacity	Provides an accessible engineering solution to building climate-resilient roads. The use of accessible materials for road building increases capacity of communities and local authorities to maintain roads and manage simple repairs, ensuring continued access even after climate events.
Eco-system integrity	The building technique includes drainage options to ensure that water flows back to creeks and streams. Planting vegetation can prevent soil erosion and protect land on slopes and along the roadside. Requires an environmental assessment at the specific site to identify and mitigate any impacts on the eco-system.
Additional benefits	Macadam has proven itself over the years as a high-quality, durable base type with a labour-intensive component. It uses simple techniques and some locally sourced materials so that building the road can generate local employment, creates ownership and facilitates maintenance.
Criteria for Adoption	
Relevance	Macadam roads are a common road building technique in Cambodia, particularly in rural areas.
Social acceptability	This road building techniques is generally well-accepted in Cambodia. As with all infrastructure, its application requires building community consensus on road planning and design.
Gender equality	Creates reliable road access that provides women with greater mobility to access markets and services. The use of local labour in building these roads can create employment opportunities for women.
Economic Viability	A typical road width of 7 m involves labour of about 20 people to complete 1km road length within 60 days. Costs schemes depend on location, labour, availability of material, transport and the amount of minor works of the system, and need to be analyzed against benefits to be derived from road access in specific locations.
Replication potential	Can be applied as a supplementary adaptation measure to roads and other infrastructure (such as parking, open storage, airfield, etc.) for road base work.

Institutional needs	Building macadam roads needs to be integrated as a climate-resilient technique within road building investments by district, provincial and national authorities.
Sustainability	A variety of modifications to the macadam technique have been introduced in Asia and elsewhere to improve the technology based on up- to-date engineering knowledge, and ensure superior road performance and sustainability.

Challenges in Adoption

- Road construction requires heavy labour, as the stone layers have to be placed by hand in neat rows.
- The stone pieces used in macadam road are keyed together by means of sand and clay. The binding effects of the sand and clay will vary depending on pressure and moisture in the area.

Source	Key Contact
• Supplementary Appendix M - CAM GMS BCC- Pilot Program for Climate Resilience, Climate Change Impact Modeling and Vulnerability Assessments for Koh Kong and Mondulkiri Provinces in Cambodia, March 2014 • Road Network of Cambodia, Mr. Nou Vaddhanak, Deputy Director of PWRC/MPWT, 29th August 2008 • http://curbstone.com/_macadam.htm • http://www.pavementinteractive.org/article/pavement-history/ • http://www.fhwa.dot.gov/rakeman/1823.htm • http://www.tanken.com/hosou.html • http://www.sakainet.co.jp/english/news/e_news66.html	Mainstreaming Climate Resilience into Development Planning/Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: kat.bunheng@gmail.com Website: www.mondulkiri-centre.org

6.5.2 Rock slope protection (RSP) for erosion control

Sub-sector	Climate Hazards	Adaptation Elements
Roads Bridges	Floods, storms, erosion	Climate-resilient construction techniques

Description of the Practice

The term “rock slope protection” (RSP) refers to a group of measures to protect infrastructure such as bridges and roads. RSP is the placement of rock on the surface of the soil to protect against wind and water erosion and buttress the slope against lateral movement. Such rock-stacked retaining walls can be built with no mortar to bind the rocks together. Rock-stacked walls may be considered either gravity walls that rely on their weight or as mechanically stabilized earth walls with geo-synthetic reinforcement. Rock-stacked retaining walls are an ancient building technique that has been widely used in different parts of the world (including Cambodia) for centuries.

When used in conjunction with an underlying geo-synthetic fabric, RSP can also use vegetation to retain soil in place and prevent slope failures and movement of material down steep slopes.

The RSP technique of has been employed at Tatai Bridge, Koh Kong province. The rock slope protects the bridge abutment and bank of the canal from erosion by storm runoff. The canal was built to drain the storm water from the hill nearby to the Tatai River. The bank is three meters high with a steep slope of about 75 degrees. The rock revetment for this steep bank is acting as i) a gravity wall to protect the slope, and ii) erosion control and protection against storm water.

The rock slope reduces the exposure of the slope to the hydraulic impacts by covering the soil that is more susceptible to runoff. The rock revetment is made with the stone, wire mesh and reinforced concrete beams.

As with this example, the measure is most suited to areas that are too steep for mowers and maintenance equipment. The best use is from the toe of the slope to the edge of any natural vegetation that is to be retained. To limit visual impacts, RSP height should not exceed 7 m.

Stone wall protecting a steep slope (Tatai Bridge, Koh Kong), Photo: April 2016

Stone wall as a storm water drain (Tatai Bridge, Koh Kong), Photo: April 2016

Bridge abutment protection by Rock stacked wall at Kampong Kdei Bridge (Siem Reap, CAMBODIA), 12th century.

Bank slope protection at Phnom Chiso Temple (Takeo province, CAMBODIA), 11th century.

Toniná in Chiapas, Mexico, 10th century

Example of recent application in United States.

Adaptation Outcomes	
Sensitivity/ Exposure	Reduces exposure of roads and bridges to hydraulic impacts and provides protection from increased flooding and moisture expected from climate change.
Adaptive capacity	Provides an accessible engineering solution to build climate-resilient roads. Easy to install and repair with conventional equipment.

Eco-system integrity	Can be combined with techniques to use stones and natural vegetation to maintain eco-systems appearance and integrity.
Additional benefits	Rock color can be matched and treatment selectively vegetated to blend with the context. Permeon or similar stains may be applied to accelerate the appearance of weathering. In some situations, RSP also provides the benefit of slope armouring and buttressing.
Criteria for Adoption	
Relevance	Represents a common building technique that continue to be applied today combined with modern construction techniques.
Social acceptability	This technique is generally well-accepted in Cambodia and is similar to many Khmer historic building techniques. As with all infrastructure, its application requires building community consensus on road planning and design.
Gender equality	Creates reliable road access that provides women with greater mobility to access markets and services. The use of local labour in building these roads can create employment opportunities for women.
Economic Viability	Requires materials such as stone (rock), wire mesh and reinforced concrete beams. Costs vary depending on the location and need to be analyzed against benefits to be derived from road access.
Replication potential	RSP is recommended for slopes in natural rural and transition areas that are too steep for mowers and maintenance equipment (3:1 or greater) but should not exceed 1:1, for vegetation control purposes. Best use is from the toe of slope to the edge of any natural vegetation that is retained. To limit visual impacts, RSP height should not exceed 7 m. The use of RSP in areas of concentrated runoff or in drainage facilities should be coordinated with district officials responsible for water management.
Institutional needs	Must be integrated as a climate-resilient technique within road building investments from district, provincial and national authorities.
Sustainability	Contributes to greater resilience of infrastructure investments.

Challenges in Adoption
• May not be suitable in all cases. For aesthetic purposes, gravel rather than RSP is recommended for flat slopes <3:1. • The maximum height restriction is 3.7 m for gravity walls and 4.6 m for mechanically stabilized earth walls, unless otherwise approved by relevant government authorities.

Source	Key Contact
• Provincial DPWT in Koh Kong Province • http://www.australianrockwalls.com.au/gallery • http://www.australianretainingwalls.com.au/project/b-grade-cut-sandstone-boulder-retaining-wall/	Mainstreaming Climate Resilience into Development Planning/ Technical Assistance, SPCR Department of Climate Change, General Secretariat of National Council for Sustainable Development Tel: 023 5314 777 Email: adbspcrta8179@gmail.com Website: http://www.spcrcambodia.org

7. WAY FORWARD

International attention to the impacts of climate change on vulnerable developing countries has highlighted the need to deepen understanding of ITKP in order to find solutions to adaptation rooted in the local context. As demonstrated by the array of practices in this publication, ITKP are an essential ele ment of climate change adaptation efforts in agriculture, water resources management, settlements and transport in Cambodia. A collection of practices in other sectors would likely reveal similar findings as such practices represent the evolution of how Cambodians have adapted over time to their unique natural environment, create settlements, build livelihoods, meet their basic needs, acquire knowledge and educate future generations.

ITKP are a basis for building new knowledge or adapting modern techniques to the local context. For example, rainwater harvesting can be improved through technology to purify water and increases its quality. The principle of starting with what communities are already practicing results in more viable and effective adaptation measures that communities can implement with their own resources or with minimum use of external resources. Researching and building scientific evidence of why certain techniques – such as Khmer masonry – are more resilient is necessary for replication. Efforts to understand the rationality of local knowledge and take steps to prevent its erosion are vital for adaptation and sustainable development.[33]

The documented practices largely result from initiatives by national civil society, academic institutions and sector programs to understand local practices as part of the participatory process to implement community-based development or adaptation programs. Scaling up the u se of ITKP for adaptation involves finding ways to value and systematize this knowledge as a resource for guiding adaptation efforts, integrating both the recognition and the learning into national policy frameworks for climate change adaptation.

Cambodia's Department of Climate Change within the National Council for Sustainable Development has initiated integration of ITKP into policy-making by their oversight to the collection of practices and development of this publication. The practices were also featured at a November 2016 'Conference on Cambodia's Response to Climate Change' that brought together policy makers. This knowledge-sharing event highlighted how these measures tend to be low-cost, easily adopted, and practised by women and men, making replication more feasible. It also highlighted the importance of developing policies and programs that value and promote indigenous practices to address climate change impacts. Integration of ITKP into wider adaptation policies and programs involves:

- More research on the rationality behind the local practices and how these correspond with scientific research on adaptation and development approaches.
- Piloting and evaluation of how to optimize the effectiveness and efficiency

[33] Srinivasan, IGES.

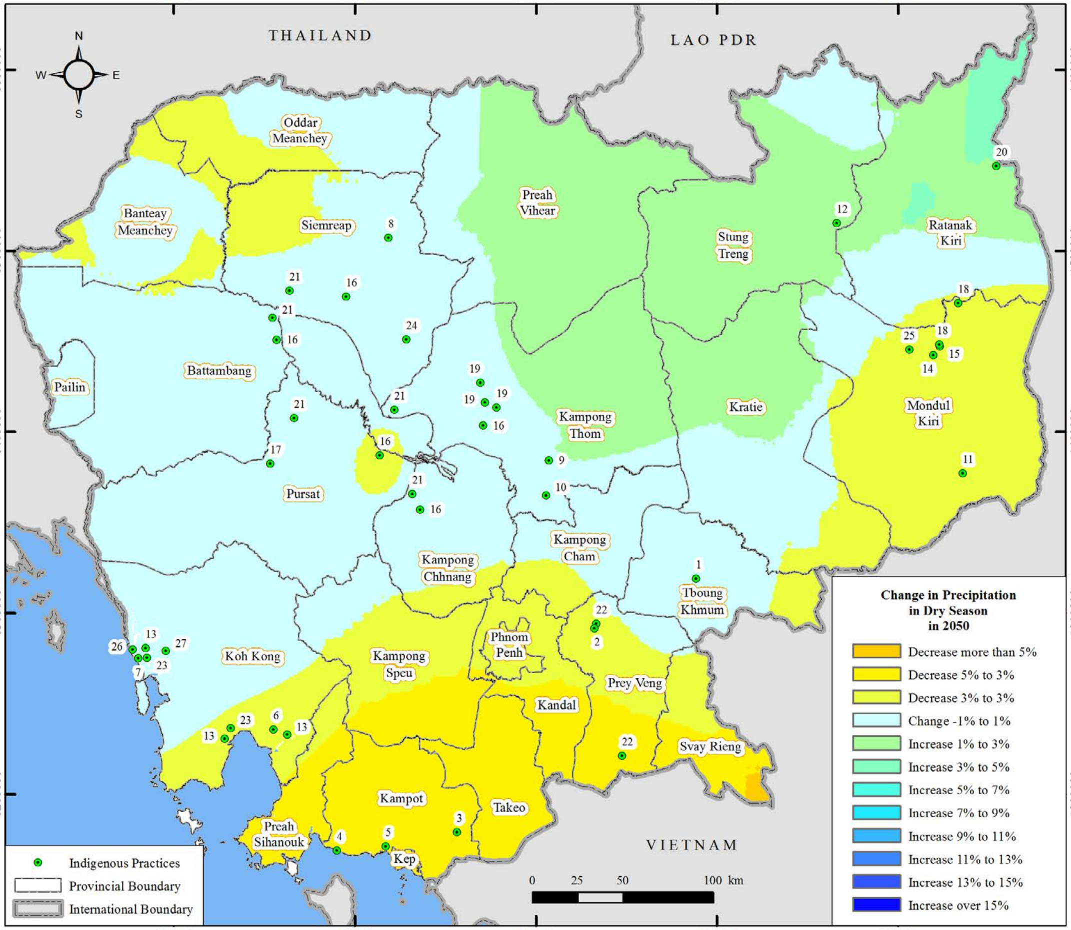
of indigenous and traditional practices.

- Community participation and assessment of how to integrate new technology to improve local practices.
- Institutional support at national and sub-nation levels for conserving, improving and replicating ITKP to solve adaptation problems.
- Better conceptualizing the meaning of ITKP in the context of Cambodia and integrating them into learning programs in formal and non-formal education.

As climate change exacerbates extreme weather events, indigenous practices on their own will not overcome the adaptation deficit that Cambodians must overcome with the support of their development partners. However, learning from these traditional practices and combining this knowledge with scientific research and new technology will generate new solutions to addressing the challenges of climate-resilient development for now and in the future.

8. ANNEX: MAPS OF LOCATION PRACTICE IN RELATION TO PROJECTED CLIMATE CHANGE

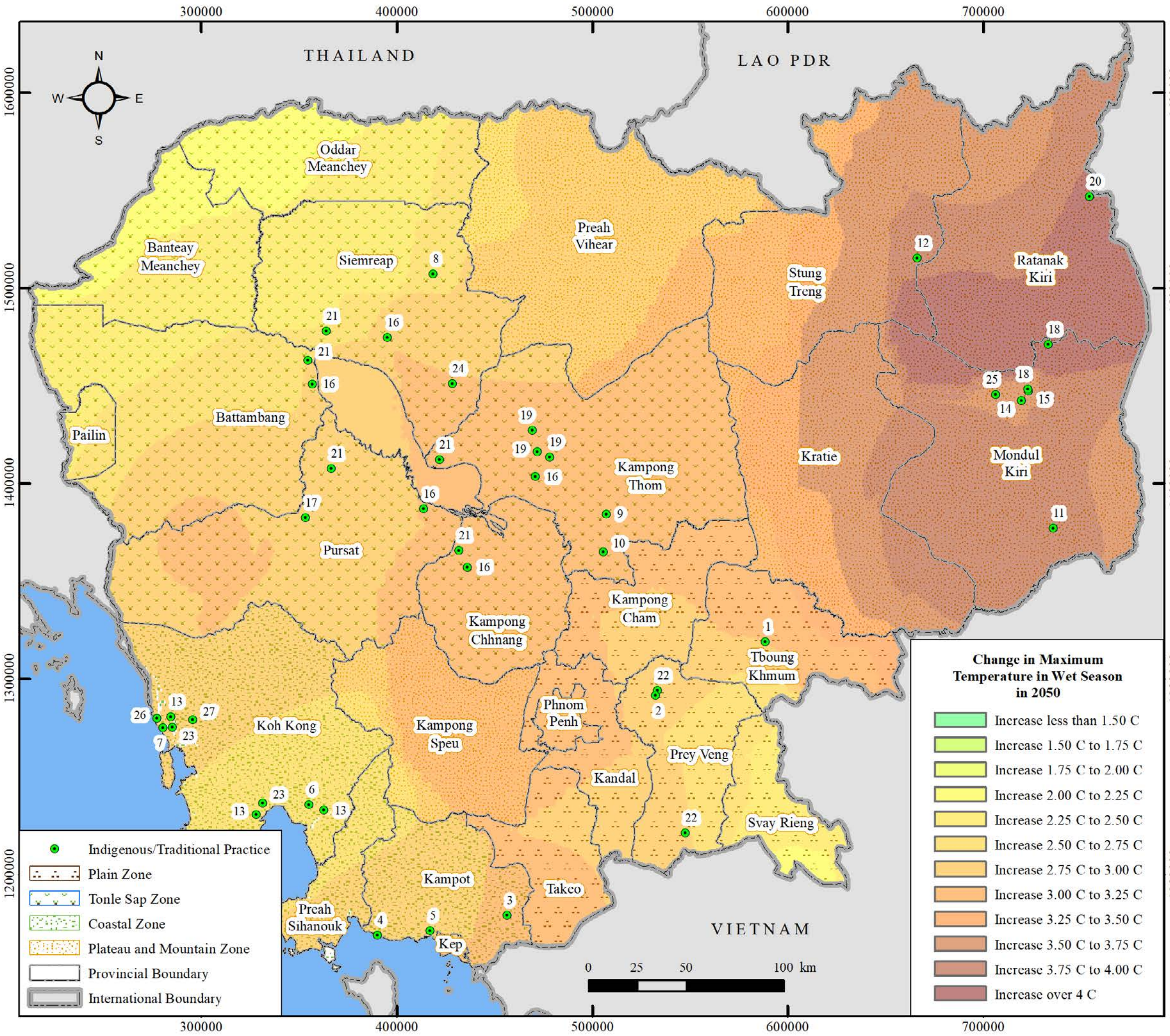
Map 4 – Location of practice in relation to projected dry-season precipitation change



Code	Indigenous Practices
1	Growing forage to enhance animal husbandry
2	Adopting shorter-season rice varieties
3	Multi-crop farming systems using biomass waste
4	Preserving food products through solar drying
5	Regeneration of mangroves in fishery communities
6	Cultivating local rice varieties
7	Raising green mussels in coastal communities
8	Improved poultry-raising techniques
9	Seed and grain storage
10	Integrated rice-fish systems
11	Upland agroforestry for agriculture
12	Livelihood diversification along the 3S Rivers
13	Coastal water storage reservoirs
14	Mountain water storage reservoirs
15	Surface water reservoirs and canal systems
16	Rainwater harvesting around Tonle Sap
17	Rainwater harvesting in Pursat Province
18	A simple roof rainwater collection system in Mondulkiri
19	Farmer Water User Communities (FWUCs)
20	Utilization of upland spring water for dry-season rice farming
21	Traditional weather forecasting system
22	Living with floods in lowland areas
23	Seawater protection dykes in Koh Kong Province
24	Khmer ancient bridge masonry
25	Settlements near bamboo forest and thatch meadows
26	Macadam base roads
27	Rock slope protection (RSP) for erosion control

Source: www.mekongarcc.net

Map 5: Location of practice in relation to projected wet-season temperature change



Code	Indigenous and Traditional Practices
1	Growing forage to enhance animal husbandry
2	Adopting shorter-season rice varieties
3	Multi-crop farming systems using biomass waste
4	Preserving food products through solar drying
5	Regeneration of mangroves in fishery communities
6	Cultivating local rice varieties
7	Raising green mussels in coastal communities
8	Improved poultry-raising techniques
9	Seed and grain storage
10	Integrated rice-fish systems
11	Upland agroforestry for agriculture
12	Livelihood diversification along the 3S Rivers
13	Coastal water storage reservoirs
14	Mountain water storage reservoirs
15	Surface water reservoirs and canal systems
16	Rainwater harvesting around Tonle Sap
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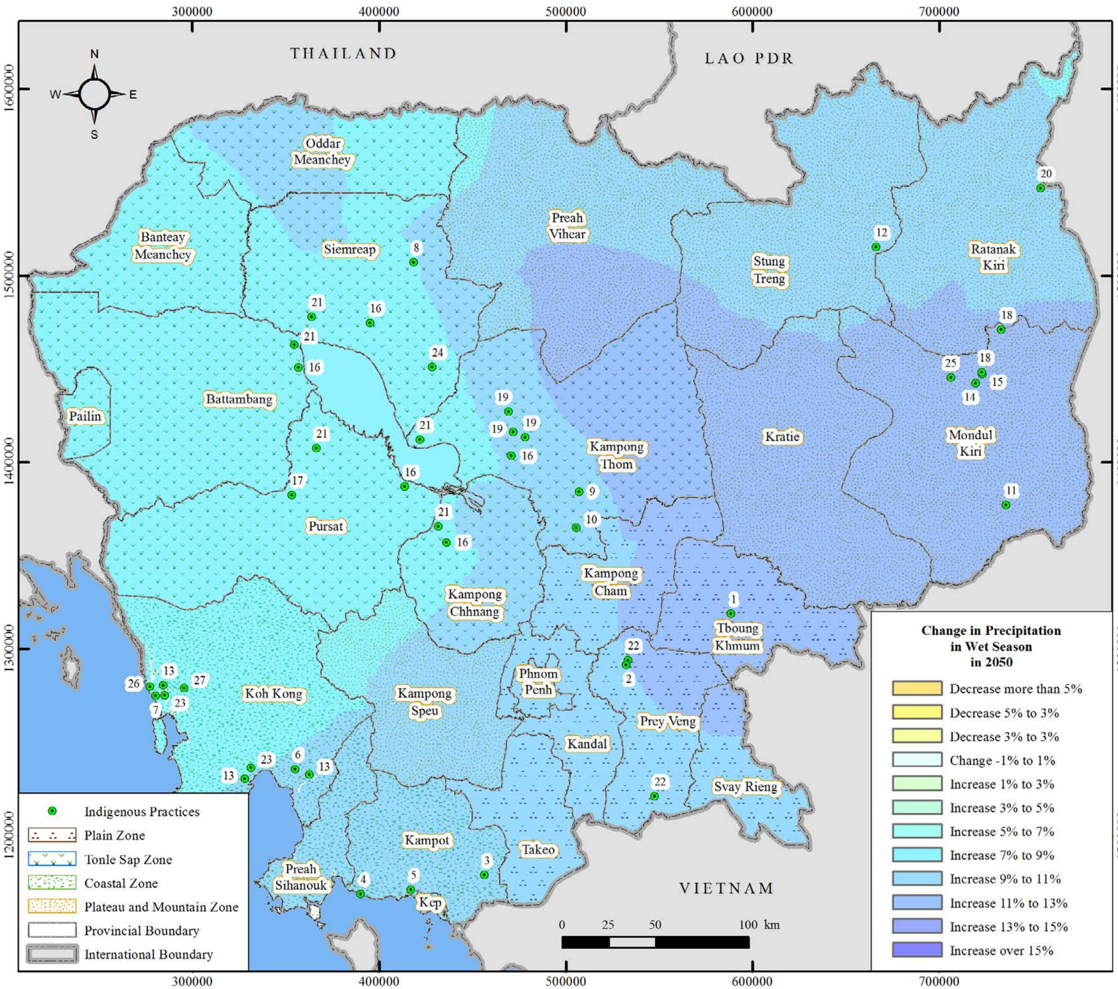
22	Living with floods in lowland areas
23	Seawater protection dykes in Koh Kong Province
24	Khmer ancient bridge masonry
25	Settlements near bamboo forest and thatch meadows
26	Macadam base roads
27	Rock slope protection (RSP) for erosion control

Source: www.mekongarcc.net

Map 6: Location of practice in relation to projected wet-season precipitation change



Code	Indigenous Practices
1	Growing forage to enhance animal husbandry
2	Adopting shorter-season rice varieties
3	Multi-crop farming systems using biomass waste
4	Preserving food products through solar drying
5	Regeneration of mangroves in fishery communities
6	Cultivating local rice varieties
7	Raising green mussels in coastal communities
8	Improved poultry-raising techniques
9	Seed and grain storage
10	Integrated rice-fish systems
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12	Livelihood diversification along the 3S Rivers
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23	Seawater protection dykes in Koh Kong Province
24	Khmer ancient bridge masonry
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Source: www.mekongarcc.net

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