Kingdom of Cambodia

Ministry of Environment

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE ADAPTATION

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ABBREVIATIONS

CARD	Council for Agricultural and Rural Development
CARDI	Cambodian Agricultural Research Development Institute
CCD	Cambodian Climate Change Department
CDM	Clean Development Mechanism
CDC	Council for the Development of Cambodia
CMDGs	Cambodia's Millennium Development Goals
CRCD	Cambodian Research Centre for Development
DNA	Designated National Authority
EEZ	Exclusive Economic Zone
INC	Initial National Communication
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCA	Multiple Criteria Analysis
MCDA	Multiple Criteria Decision Analysis
MDG	Millennium Development Goal
MEF	Ministry of Economy and Finance
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
NCCC	National Climate Change Committee
NCDM	National Committee for Disaster Management
NIS	National Institute of Statistics
NPRS	National Poverty Reduction Strategy
NSDP	National Strategic Development Plan
RGC	Royal Government of Cambodia
RS	Rectangular Strategy
RUA	Royal University of Agriculture
SEDP	Socio-Economic Development Plan
SNC	Second National Communication
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risoe Centre
WATSAN	Water and Sanitation

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FOREWORD

Cambodia is highly vulnerable to climate change impacts due to a combination of factors: limited financial and human resources, weak infrastructure, an agriculture-based economy, and limited access to climate-friendly technologies. The Cambodian people suffer periodically from floods, droughts, windstorms, high tide, sea water intrusion, and vector-borne diseases such as malaria and dengue fever. Agriculture, water resources, human health and the coastal zone are the sectors most vulnerable to the impacts of climate change. The Royal Government of Cambodia clearly recognises the threats paused by climate change to the country's social and economic development and is therefore fully supportive of efforts to address climate change at both national and global levels.

Cambodia sees technology development, transfer and diffusion as a necessary prerequisite for a meaningful response to climate change since this will help build resilience as well as promote low carbon social and economic development in the country. In this regard, we support the technology needs assessment, particularly the urgent need for transfer and diffusion of technologies for both adaptation and mitigation to developing countries, in particular, to least developed countries.

Due to Cambodia's high vulnerability to impacts of climate change, it is important for the country to assess technology needs and to develop technology action plans for climate change adaptation, which will be necessary for addressing the adverse effects of climate change on rural communities. For this reason, it is important to focus on "no-regret" and appropriate adaptation technologies that would bring immediate and multiple benefits in terms of food security, income diversification, reducing human casualties, strengthening community resilience, local environmental protection, and sustaining social and economic development.

The present Technology Needs Assessments (TNAs) and Technology Action Plans (TAPs) for climate change adaptation technologies have been undertaken in support of Cambodia's national sustainable development objectives as stated in its National Strategic Development Plan Update 2009-2013, the National Adaptation Programme of Action to Climate Change, and complement the Cambodian national policies and plans in adapting to the adverse impacts of climate change. Specifically, we expect the TNAs and TAPs for climate change adaptation be used for the following purposes: (1) as roadmaps for policy making for specific priority sectors in adaptation consistent with the country's sustainable development objectives; (2) as support to Cambodia's position in climate change negotiations in the area of technology transfer; and (3) as a medium to access international sources of funding for the implementation of adaptation activities. As the initial stage, the current TNA aims at assessing technology needs and developing technology action plans for priorities in water resources, including agriculture and water, and the coastal zone. This is only a first step but an important contribution to the efforts to build more climate resilient society in Cambodia.

Implementation of the Cambodian TAPs will significantly contribute to the achievement of the Cambodia Millennium Development Goals and national sustainable development objectives as articulated by the RGC. Therefore, our next task is to mobilise resources for their implementation.

I would like to take this opportunity to express our sincere gratitude to all the national stakeholders, particularly the national Climate Change Committee serving as the Steering Committee of this project and the Inter-ministerial Adaptation TNA Team for their support and cooperation in developing this important document. Specifically, I thank the Global Environment Facility (GEF), the United Nations Environment Programme (UNEP), and the Risoe Centre for their support in preparing the Cambodian TNAs and TAPs. The RGC looks forward to cooperating with all stakeholders to ensure successful implementation of this plan.

Senior Minister, Minister of Environment
Chair of the National Climate Change Committee

Dr. Mok Mareth

Part I: Technology Needs Assessments Report

Executive Summary

As a least developed agrarian and rural country, Cambodia is highly vulnerable to the impacts of climate change. The Cambodian people suffer periodically from floods, droughts, windstorms, sea level rise and vector-borne diseases such as malaria and dengue fever. Agriculture, water resources, human health, and the coastal zone are the sectors most vulnerable to the impacts of climate change. These sectors are considered by the Royal Government of Cambodia (RGC), in its official plans and policies, including the National Adaptation Programme of Action to Climate Change (NAPA) as priority development and climate change adaptation sectors.

The present Technology Needs Assessment (TNA) for climate change adaptation technologies is developed in support Cambodia's national sustainable development objectives, and complements Cambodian national policies and plans in adapting to climate change. Because of time and budgetary constraints, it is not possible for the TNA project to cover all of Cambodia's climate change vulnerabilities. Thus the TNA project aims to assess technology needs and develop technology action plans for priorities in water resources, including agriculture and water, and the coastal zone. Technological options are prioritised by the national stakeholders according to their respective costs and benefits, using a Multiple Criteria Analysis (MCA) framework. Benefits are further divided into four categories: reduction of vulnerability to climate change, economic, social and environmental benefits.

Out of fifteen technologies in each of the water and coastal zone sectors, the following technologies have been selected for the development of Technology Action Plans.

Table 1: Prioritized Sector and Technologies

Sector	No.	Technologies
Water	1	Household Safe Water Supply: - Rainwater Harvesting from Rooftops - Wells for Domestic Water Supply
	2	Community Water Supply: - Small Reservoirs, Small Dams and Micro-Catchments
Coastal Zone	1	Mangrove Management

Chapter 1. Introduction

1.1 Objectives of the TNA Project

The present Technology Needs Assessment Project follows the footsteps of TNA activities supported by the Global Environment Facility (GEF) in Cambodia (additional financing for capacity building in priority areas, 2002-2003) and other countries. However, the TNA reports to be submitted under the current TNA project differ from the previous exercises in the following aspects. The proposed TNAs will not only include a listing of climate change technologies but also focus on Technology Action Plans (TAPs) which set targets to be achieved in technology transfer, diffusion and adoption, analyses barriers to technology transfer, and articulates a framework and action plan for overcoming these barriers. While earlier TNAs in Cambodia only considered greenhouse gas (GHG) mitigation technologies, the present exercise also addresses the country's vulnerabilities to climate change with the identification of adaptation technologies. The UNDP TNA handbooks, as well as sectoral handbooks developed by URC, provide guidance on the conduction of TNA and preparation TNA report. Guidance for the preparation of TAPs is provided by the UNEP Risoe Centre (URC).

1.2 National Sustainable Development Strategies

The National Poverty Reduction Strategy (NPRS) was adopted in 2002 and Cambodia's Millennium Development Goals (CMDGs) in 2003. The goals and strategies of these documents have been included in the National Strategic Development Plan (NSDP) 2006-2010, a framework which harmonizes development efforts and aid-effectiveness in Cambodia. In 2010, the NSDP was subsequently updated for covering the period of 2010-2013. It is the first policy document that states that climate change as the major priority of the Royal Government of Cambodia (RGC). The NSDP update focuses on a number of key climate change actions such as climate change capacity strengthening and mainstreaming into relevant sectors, preparation of a national climate change strategy and action plan, promoting implementation of adaptation (including the National Adaptation Programme of Action on Climate Change or NAPA) and mitigation (including the Clean Development Mechanism or CDM) measures, and climate change education and awareness raising.

The overarching priority of the RGC is to reduce poverty towards the achievement of Cambodia's Millennium Development Goals, which include the eight goals of the United Nations MDG, and a ninth goal to move towards zero impact from landmines and unexploded ordnance by 2012. The Rectangular Strategy (RS) for growth, employment, equity and efficiency guides the government's action in achieving sustainable development and reducing poverty. The Rectangular Strategy has, at its core, good governance and public sector reform, and focuses on agriculture, infrastructure, human resources, and employment through the private sector.

Figure 1: The Rectangular Strategy of the Royal Government of Cambodia

Source: Royal Government of Cambodia (2010)

1.3 Climate

Cambodia's tropical monsoon climate is characterized by two distinct seasons: a wet or rainy season and a dry season. The rainy season, from May to October, is marked by heavy rains which accounts for 90% of annual precipitation. The dry season, from November to April, is associated with the northeast monsoon, which brings drier and cooler air from November to March, and then hotter air in April and early May. The maximum mean temperature is about 28oC and the minimum mean temperature about 22^{o}C. Maximum temperatures above 32^{o}C are common before the start of the rainy season. The average annual rainfall from 1994 to 2004 has fluctuated between 1,400 mm and 1,970 mm. Inland provinces may experience less than 600 mm of rainfall annually, while precipitation may reach 3,800 mm in coastal areas.

1.4 Vulnerability to Climate Change

As an agrarian and rural country, Cambodia is very vulnerable to the impacts of climate change. The country's main vulnerabilities consist of floods, droughts, windstorms, sea level rise and vector-borne diseases.

The frequency and intensity of floods and droughts may increase with changing climate conditions, and cause severe damage to agricultural production (INC 2002, SNC 2010). The floods of the year

2000 were the worst to hit Cambodia in seventy years. Severe floods also occurred in 1996, 2001 and 2002. The 1998 drought led to widespread crop failure.

Figure 2: Frequent Floods and Droughts Occur in Cambodia

Source: Ministry of Environment (2011)

Sea level rise will affect the 435-km long Cambodian coastline, which already experiences storm surges, high tides, beach erosion and seawater intrusion (INC 2002, NAPA 2006). Urban settlements, seaports, fisheries, mangroves forests and coastal ecosystems may be submerged with rises in sea levels.

Vector-borne diseases, in particular malaria and dengue fever, may become more widespread under changing climatic conditions. Cambodia has the highest fatality rate from malaria in Asia, but the actual death toll may be 5-10 times higher than recorded figures (CNM 2003). Large segments of the population do not have access to limited healthcare facilities and cannot afford malaria treatment.

Table 2: Main Natural Disasters in Cambodia 1991-2002

Year	Disaster Event	No. of Persons Affected
1991	Flood	650,000
1994	Flood	29,000
1995	Drought	2,500,000
1996	Drought	2,500,000
1996	Flood	1,300,000
1998	Famine, Crop Failure	900,000
1999	Flood	527,904

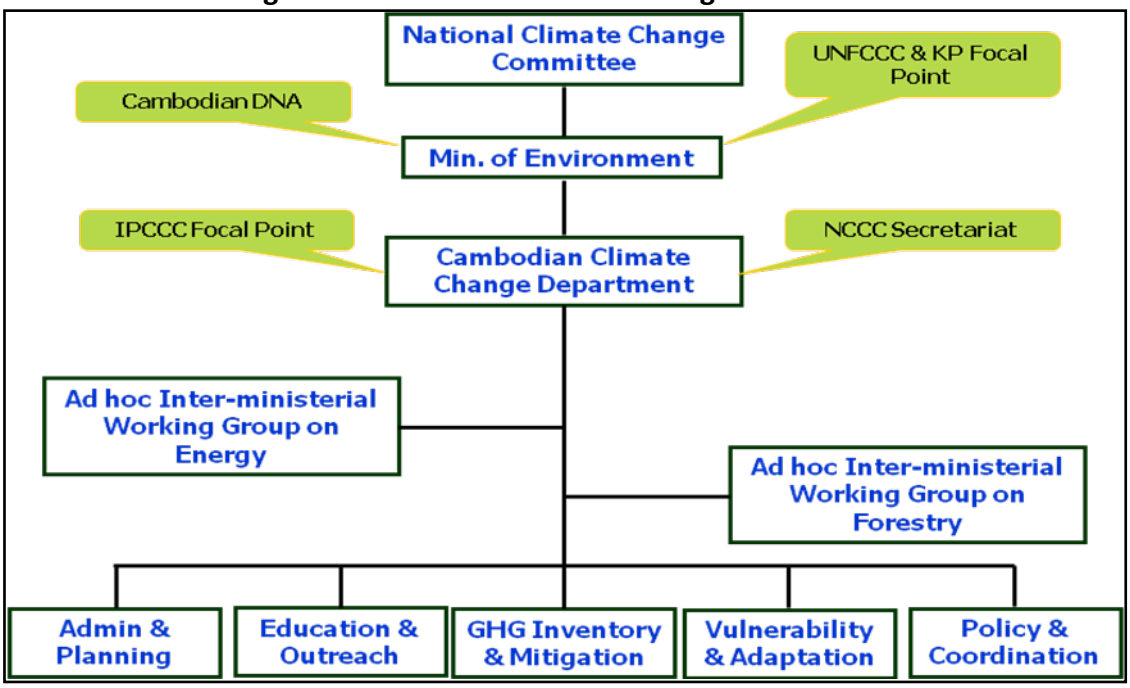
Year	Disaster Event	No. of Persons Affected
1999	Flood	106,670
2000	Flood	3,448,629
2001	Flood	1,669,182
2001	Drought	300,000
2002	Drought	2,017,340
2002	Flood	1,439,964

Source: National Committee on Disaster Management (2002), Ministry of Environment (2010)

1.5 National Climate Change Adaptation Policies and Activities

Cambodia's climate change institutions have grown in complexity the issue gained higher prominence on the national agenda and with the increased awareness of policy makers. A graph describing the national institutional framework for responding to climate change is provided below. Cambodia's National Climate Change Committee (NCCC) is an inter-ministerial mechanism with the mandate to prepare, coordinate and monitor the implementation of policies, strategies, legal instruments, plans and programs of the Royal Government to address climate change issues. The Committee is cross-sectoral and multidisciplinary and is composed of high-level representatives (Secretaries and Under-Secretaries of State) of 20 Ministries and other concerned government agencies. The NCCC is a policy-making mechanism chaired by the Minister of Environment. The Prime Minister accepted the role of the Honorary Chair of the NCCC in late 2009. The Cambodian Climate Change Department (CCCD) provides administrative and technical support to the NCCC in fulfilling its mandate including all tasks related to the implementation of the UN Convention on Climate Change (UNFCCC). CCCD coordinates inter-ministerial working groups specialized in sectors (energy and forestry), and along climate change themes (GHG inventory, mitigation, vulnerability and adaptation, and UNFCCC implementation). The Ministry of Environment (MoE) through CCCD is the national focal point for the UNFCCC and its Kyoto Protocol, the secretariat of the Cambodian Designated National Authority for the Clean Development Mechanism, and the coordinating agency for the TNA Project.

Figure 3: Cambodia's Climate Change Institutions



Source: Ministry of Environment (2010)

In 2006, Cambodia was among the first least developed countries to complete its National Adaptation Programme of Action to Climate Change. Cambodia's aim was to develop a realistically achievable country-driven programme of priority activities addressing the urgent and immediate needs for adapting to the adverse impacts of climate change. The climate hazards addressed are flood, drought, windstorm, high tide, salt water intrusion and malaria. The formulation of the NAPA relied on a broad consultation process at both the national and sub-national levels, including a nation-wide survey of local authorities, non-governmental organisations, and more than 700 households in 17 provinces, to identify coping mechanisms and climate change adaptation needs. Cambodia has selected "no regrets" adaptation options: these priority projects are already justified by current climate conditions and would provide immediate social and economic benefits for local communities if implemented. Under changing climate conditions, including higher frequencies of climate hazards, the selected priority activities would be even more attractive.

1.6 TNA Relevance to National Development Priorities

It is envisaged that the TNAs and TAPs produced under the TNA Project will be used for the following purposes: (1) as roadmaps for policy making for specific priority sectors in mitigation and adaptation consistent with the country's sustainable development objectives; (2) as support to Cambodia's position in climate change negotiations in the area of technology transfer;, and (3) as a medium to access international sources of funding for the implementation of mitigation and adaptation activities. As such, the TNAs and TAPs should not be viewed as stand-alone documents. They are developed in support of Cambodia's national sustainable development objectives, and may complement Cambodian national policies and plans in mitigating GHG emissions and in adapting to climate change.

Chapter 2. Institutional Arrangement for the TNA and the Stakeholders' Involvement

2.1 TNA Team, National Project Coordinator, Consultants, etc.

To ensure synergies, country driven initiative and sustainability, Cambodia decided to use the existing climate change institutional structure to support the implementation of the TNA project. Thus, the NCCC serves as the national TNA Project Steering Committee, CCCD as the Project Coordinator and selected members of the two Inter-ministerial Working Groups and the National Climate Change Technical Team are invited to join the National TNA Teams (both mitigation and adaptation). The National TNA Teams are supported by national consultants/experts.

The Inception Workshop for the TNA Project took place in Phnom Penh in September 2010, and was chaired by H.E. Thuk Kroeun Vutha, Secretary of State of the Ministry of Environment. The workshop was attended by more than fifty participants representing government, non government organisations, academia and the private sector. They were introduced to the objectives and planned activities of the TNA project. Small group break out discussions allowed participants to discuss and draw a preliminary list of priority sectors for adaptation and mitigation. Members of the national TNA team for respectively adaptation and mitigation were formally enlisted by the project in the weeks following the Inception Workshop drawing from key line ministries and agencies of the government.

Figure 4: TNA Inception Workshop in Phnom Penh

Source: Ministry of Environment (2011)

2.2 Stakeholder Engagement Process Followed in TNA– Overall Assessment

The TNA project is coordinated in Cambodia by the Climate Change Department (CCD) of the Ministry of Environment, with the technical support of the Cambodian Research Centre for Development (CRCD), a non-profit non government organisation, and the Royal University of Phnom Penh (RUPP). The TNA report reflects a six month discussion and consultation process, which involves small group meetings as well as face to face meetings. A list of the stakeholders involved in the technology prioritisation process is provided in the appendices. It includes representatives of ministries and other government agencies, academic institutions and non-governmental organisations. While the TNA team members are the joint contributors to the TNA report, the choice of sector and technology priorities is validated by a broad range of stakeholders. The Adaptation TNA report is in line with the national sustainable development objectives of the Royal Government of Cambodia and the Cambodian Millennium Development Goals. The Adaptation TNA report also draws from the strategic choices of Cambodia's National Adaptation Programme of Action to Climate Change (NAPA), and aims to assess in greater detail specific climate change adaptation technologies. While the NAPA process relied on stakeholder consultations from the grassroots up to policy makers, the limited budget of the TNA focused mainly on expert input from government, academia and non-government organisations. Thus, the TNA prioritisation of technologies had to build upon earlier stakeholder consultations and government policies as well in order to provide a contribution coherent with national development objectives.

Figure 5: Meeting of the TNA Adaptation Team at the Cambodian Climate Change Department

Source: Ministry of Environment (2011)

Chapter 3. Sector prioritisation

3.1 An Overview of Expected Climate Change Impacts and Vulnerable Sectors

The Cambodia's Initial National Communication (INC 2002) and Second National Communication (SNC 2010) to the UNFCCC, as well as National Adaptation Programme of Action to Climate Change (NAPA 2006), discuss the country's vulnerability to climate change, including forecasted climate conditions under different scenarios.

Using General Circulation Models (GCM), Cambodia's National Communications conduct vulnerability assessments to climate change in the sectors of agriculture, water resources, forestry, human health, and the coastal zone. Cambodia's priority activities as articulated in its NAPA rely on a combination of sources: a nationwide household survey, national and provincial consultation workshops on priority activities, face-to-face interviews of government and non-government stakeholders, and an assessment of policies to address climate change impacts. The priority sectors of the Cambodian NAPA are: agriculture, water resources and coastal areas. The activities are also distributed according to climate related hazards: flood, drought, coastal protection and malaria.

Thus, the findings from previous climate change enabling activities conducted in Cambodia under the UNFCCC indicate that agriculture/forestry, water resources, human health, and the coastal zone are the sectors most vulnerable to the impacts of climate change. These sectors are considered by the Royal Government of Cambodia, in its official plans and policies, as priority climate change adaptation sectors. Previous stakeholder consultations, in particular the NAPA, confirm the agreement of a broad range of national stakeholders. However, because of time and budgetary constraints, as well as the limited number of existing in-depth climate change adaptation studies in Cambodia, it is not possible for the TNA project to cover all of Cambodia's climate change vulnerabilities. The project aims to assess technology needs in two to three sectors, and develop technology action plans for two to three technologies in each sector. In Cambodia, the lack of familiarity of national stakeholders with climate change technologies in the health sector also meant that although a priority sector, in particular with regards to malaria, more significant resources would have been needed to fully assess needs and develop technology action plans. The wide scope of the agriculture sector, including water and agriculture issues, also meant that a comprehensive assessment would have used up time and human resources, leaving less for other priority sectors. Thus, the consensus among Cambodia stakeholders, with the support of the project coordinating agency, is to focus on the two sectors of water resources and the coastal zone. Water resources discussed in the TNA report cover the subsector of water use in the agriculture sector.

3.2 Process and Criteria of Prioritisation

As articulated in the National Adaptation Programme of Action to Climate Change, Cambodia has made a clear choice of selecting "no regrets" options. The NAPA projects are already justified by current climate conditions and would provide real and tangible social and economic benefits for local communities if implemented. Under changing climate conditions, including higher frequencies of climate hazards, the selected priority activities would be even more attractive. As in the NAPA,

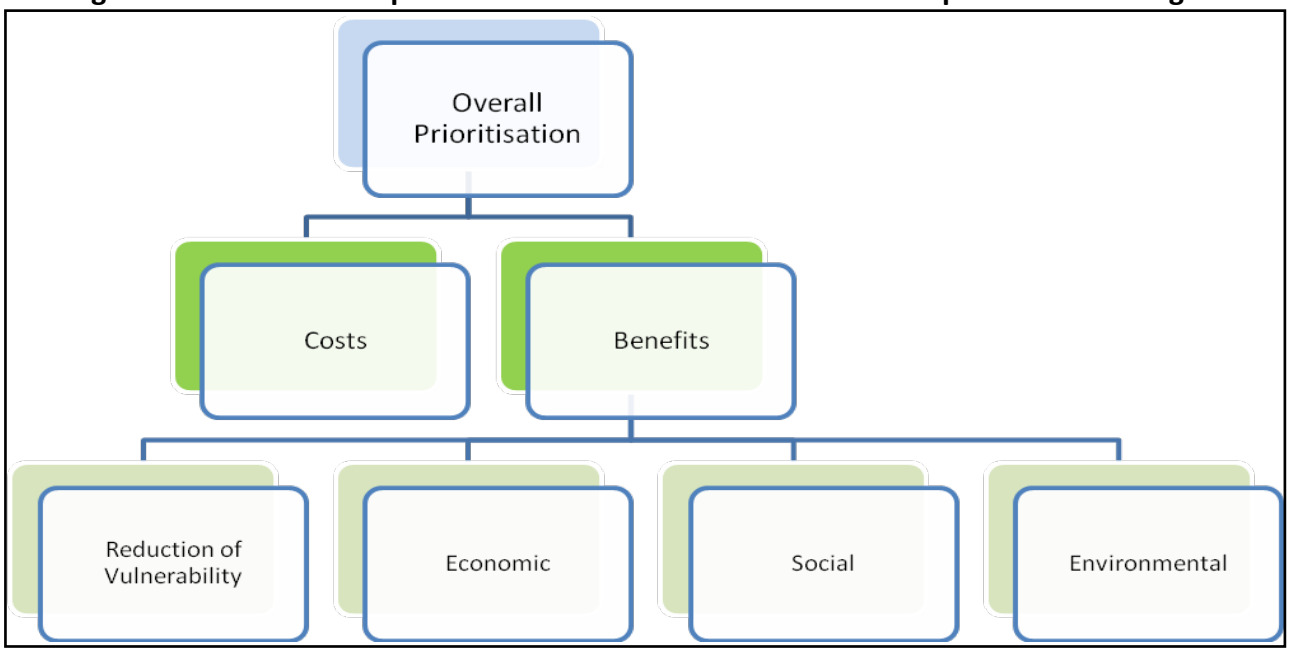
the prioritisation process of technologies for climate change adaptation by the TNA Team uses criteria based on the Royal Government of Cambodia's development priorities as articulated in the Rectangular Strategy for Growth, Employment, Equity and Efficiency, the National Strategic Development Plan Update 2009-2013, the Cambodian Millennium Development Goals (CMDG) and other policies and plans.

The available technologies for water resources and coastal zone adaptation are prioritised according to their respective costs and benefits, using a Multiple Criteria Analysis (MCA) framework. Benefits are divided into four categories: reduction of vulnerability to climate change, economic, social and environmental benefits. The correspondence between the fourteen NAPA prioritisation criteria and the TNA technology prioritisation criteria is given below. It is to be noted that the NAPA criteria reflect the preference of the Royal Government of Cambodia for the provision of appropriate and usable technologies to local communities which would complement international donor support in technical assistance, capacity building and awareness raising activities.

Table 3: Criteria for Assessing the Benefits of Adaptation Technologies

TNA Criteria	NAPA Criteria
Reduction of vulnerability to climate change	
- Reduction in human casualties - Reduction in physical damage to property, infrastructure and economic output	- Death and casualty
Economic benefits	
- Support for sustainable development - Provision and maintenance of infrastructure - Increase in productivity	- Sustainability, synergies with other projects
Social benefits	
- Creation of employment and income generation opportunities - Improvement of public health - Improvement of education and public awareness - Improvement of local living conditions	- Livelihood, human health, food security, Responsiveness to immediate needs of affected communities, cultural and historical heritage.
Environmental benefits	
- Improvement of air and water quality - Avoidance of soil pollution - Conservation and sustainable use of resources - Use of appropriate and environmentally friendly technologies (at a minimum technologies that do not cause harm to the environment)	- Water quality, biodiversity and other environmental goods and services, appropriate and environmentally friendly technologies

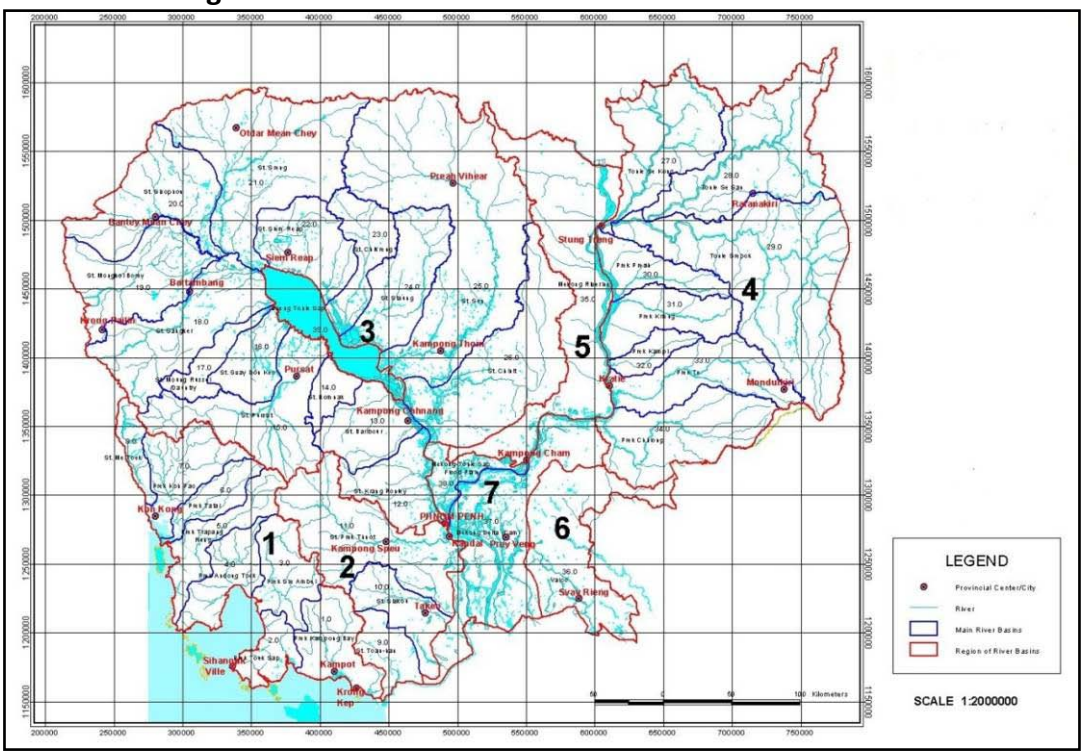
Figure 6: Hierarchical Representation of Costs and Benefits of Adaptation Technologies



3.3 Inventory/Current Status of Technologies in the Water Sector

Cambodia's topography and hydrology are dominated by the Mekong, Tonle Sap, Tonle Bassac and their tributary rivers. Phnom Penh, the capital city, is located at the confluence of the three rivers in south-central Cambodia. The central plains where most of agriculture and human settlements are concentrated form a catchment area surrounded by mountains and the coastline. The Mekong River which originates in the Tibetan Plateau, flows through China, Myanmar, Thailand, Laos, Cambodia and Vietnam. Cambodia contributes 10 to 20% of its total annual flow. In Phnom Penh, the Tonle Sap River connects the Mekong to Tonle Sap Lake, the largest permanent freshwater lake in Southeast Asia also known as Cambodia's Great Lake. During the rainy season, the Tonle Sap River reverses its course with flood water from the Mekong and swells the lake to cover an area of up to 16,000 km2. This seasonal pattern of flood is central to Cambodian traditional livelihood and culture. Water resources are intricately linked to Cambodians' staple foods: rice and fish. The Tonle Sap Lake is one of the most productive fisheries in the world, as the surrounding inundated forest and floodplain provides breeding and feeding ground for aquatic life. Flood waters of the Mekong and its tributaries provide water and silt for cultivating paddy fields. Flood waters replenish aquifers and are stored in household ponds and village reservoir that help communities endure the dry season.

Figure 7: Cambodia River Basins and Catchment Areas

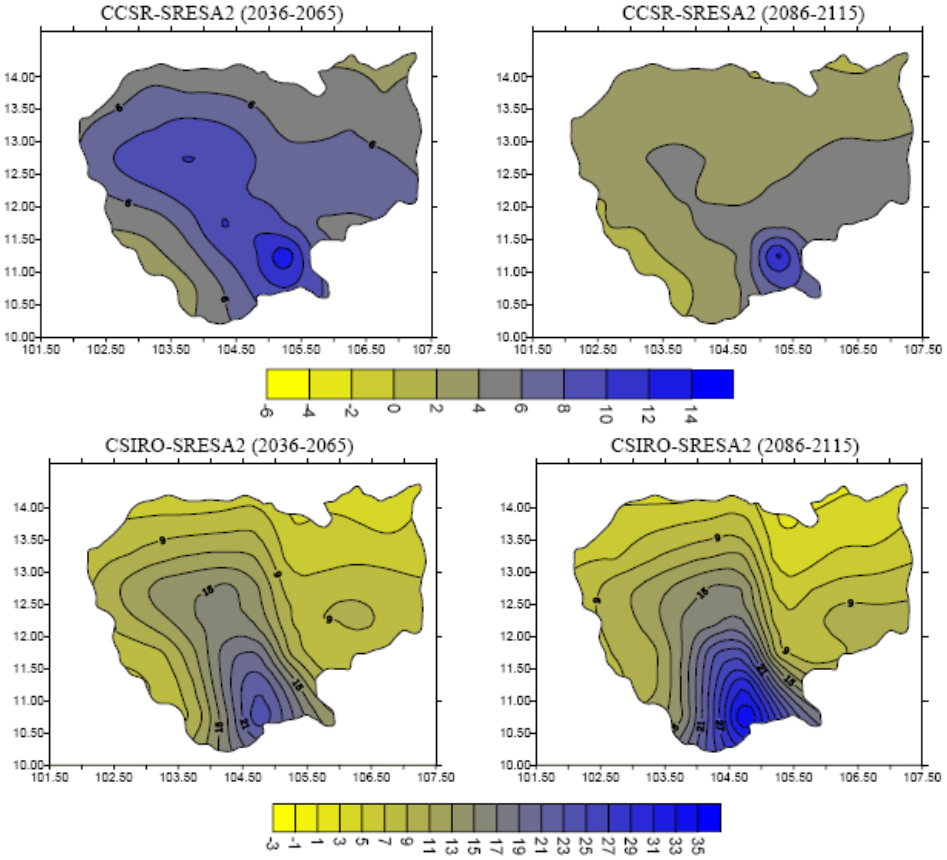


Source: Ministry of Environment (2010)

The country's water catchments have been degraded by deforestation, pollution from agriculture, mining, industries and urbanisation, and excessive water withdrawal. These pressures affect both water quality and quantity (SNC 2010). The sustainable management of Cambodia's water resources is essential to improving livelihoods, increasing fisheries and agriculture production, reducing casualties and physical damage from flood and drought, and allowing transport of people and goods. A nationwide household survey conducted by the National Adaptation Programme of Action to Climate Change shows that 54% of households suffer from water shortages all year-round (NAPA 2002). In 1997, the national census reported that 68% of the rural population only had access to unprotected sources of water, including dug wells, ponds, rivers and streams. Over a decade, progress has been slow, as the 2007 national census reports 61% of rural households with only access to unprotected sources of water. Piped water remains largely limited to urban areas. The incidence of water-related disease is high in rural areas, with negative impacts on work, school attendance, and healthcare expenditures. During the wet season, rural Cambodians are overwhelmed by floods which damage infrastructure, property and crops and cause loss of life. While in the dry season, there is not enough water for consumption and rural people spend considerable time searching for water supply. Around a quarter of the Cambodian population has access to safe drinking water.

Historical records of Cambodian weather stations show that seasonal rainfall patterns have already changed (SNC 2010). Wet season precipitation is increasing, while dry season precipitation shows a decreasing trend. Management of water resources and water related development will be more challenging. Climate change will induced greater rainfall irregularities in Cambodia, and intensify competition between domestic, agriculture and industrial water extraction, and flow maintenance for ecological preservation.

Figure 8: Mean Annual Rainfall Change (%) Using CCSR, CSIRO GCM and Emission Scenario SRESA2



Source: Ministry of Environment (2002)

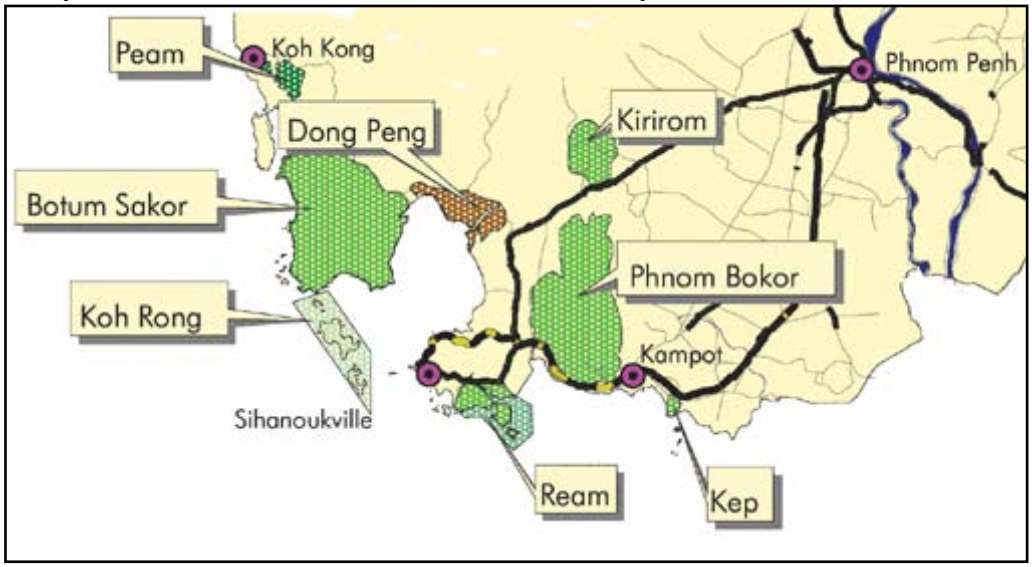
3.4 Inventory/Current Status of Technologies in the Coastal Zone

To the south of Cambodia, the coastline extends for about 435 km along the Gulf of Thailand. The country's coastal zone comprises estuaries, bays and about 64 islands of varying sizes, including three offshore islands. Cambodia's coastal zone covers a land area of about 17,237 km^2 and an additional Exclusive Economic Zone (EEZ) of 55,600 km^2. Under the United Nations Law of the Sea, the EEZ stretches from Cambodia's territorial sea out to 200 nautical miles. There are three provinces and one main municipality lying along the sea with a total population of 960,480 in 2008, increasing from 845,000 in 1998, and 675,000 in 1995. This implies an annual growth rate of 2.7%. Although most of Cambodia's population is concentrated in the central low lying provinces, coastal areas are increasingly economically and socially significant.

Major population settlements include the areas surrounding the municipalities of Sihanoukville, Koh Kong and Kep. Sihanoukville, with a population of more than 220,000 people, is the largest coastal city and Cambodia's only seaport to international standards. Sihanoukville is connected to Phnom Penh via a national highway and rail link. It is the main base from which the navy controls Cambodia's EEZ, and the home port for offshore oil and gas exploration. The city is of vital strategic and economic importance. The coastal area is equally rich in biodiversity and natural landscapes. Six protected areas are located along the seaside. These include four national parks (Bokor, Botomsakor, Kep, Ream), a wildlife sanctuary (Peamkrasoap) and a multiple use area (Dong Peng). Native ecosystems include mangroves which provide local communities with a host of

environmental services and natural products, notably storm protection, breeding grounds for fisheries, timber and food. Reefs accommodate 48 known species of soft and hard corals, and around 435 fish species have been identified in Cambodia's marine waters (SNC 2010).

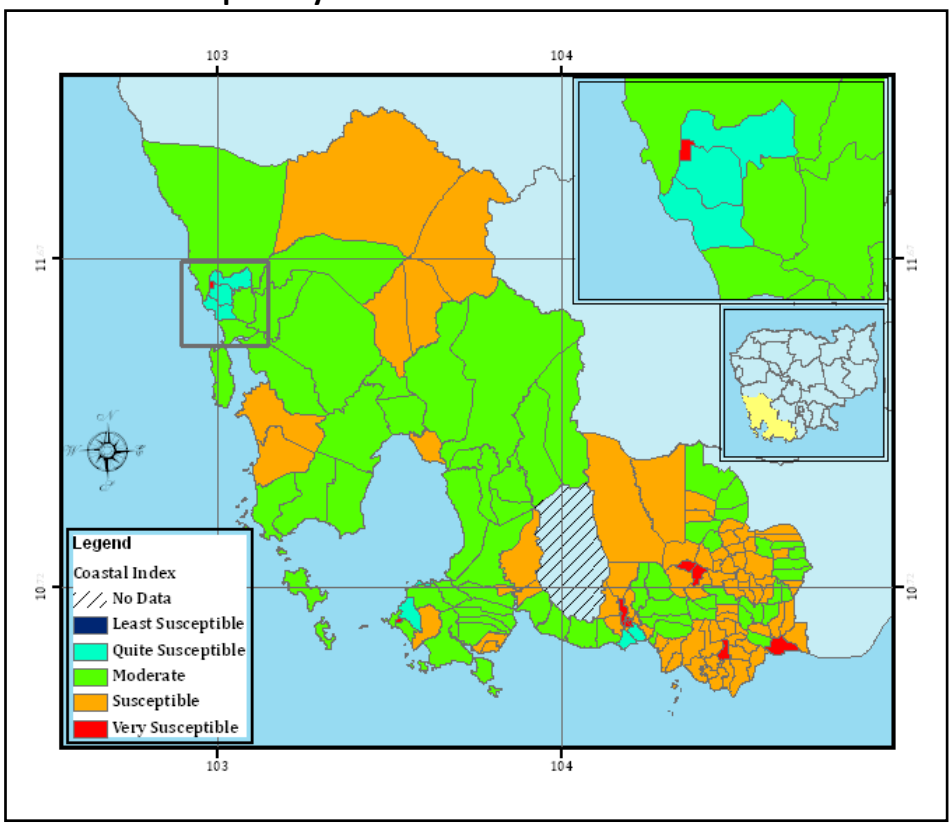
Figure 9: Map of Cambodia's Coastal Zone with Main Population Centres and Protected Areas



Source: Ministry of Environment (1997)

The coastal zone is prone to storm, high tide, seawater intrusion, flood and drought. Cambodia is however sheltered from the worst impacts of typhoons by its neighbours. A survey of coastal provinces conducted by the NAPA reports that underground water salinisation and seawater intrusion are common problems. Sea level rise would disrupt rice, shrimp and salt farming and have negative consequences on local livelihoods. There are approximately 5,300 ha of saltpans in Kampot and Kep, producing up to 80,000 tons a year to meet Cambodia's domestic demand. The Second National Communication uses a Coastal Susceptibility Index (CSI), to assess the capacity of coastal communes to withstand the potential impacts of climate change. The Coastal Susceptibility Index is a factor of housing materials, land use and population density. A projection of wind speeds using General Circulations Models shows that the southern part of Cambodia's coastal zone is the most vulnerable.

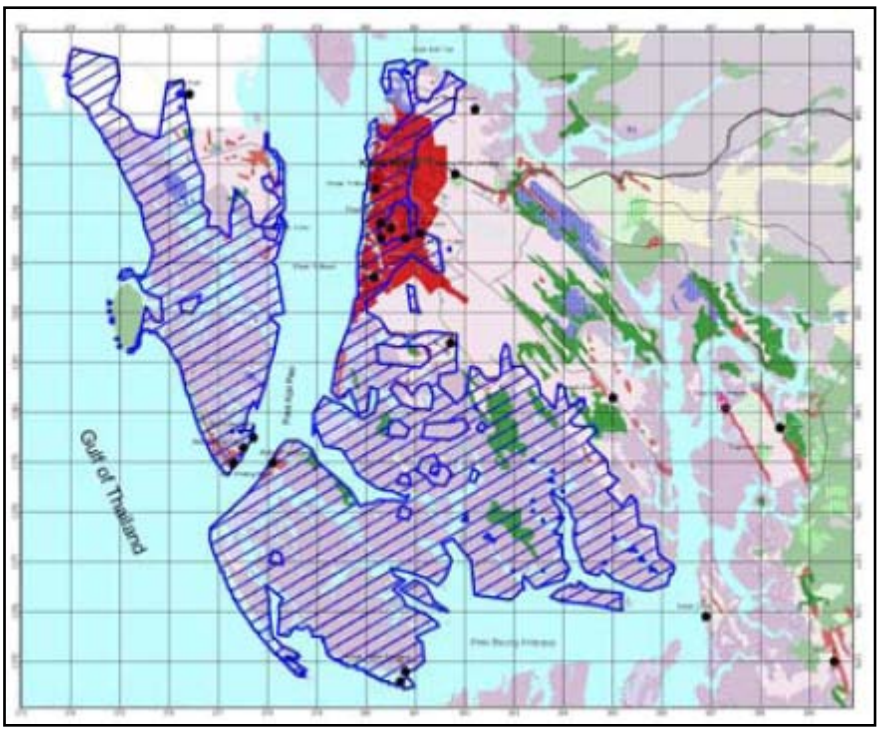
Figure 10: Coastal Susceptibility of Communes Located in the Cambodian Coastal Zone



Source: Ministry of Environment (2010)

Sea level rise is expected to further erode beaches and inundate low lying areas, in particular along the municipality of Koh Kong. The Initial National Communication conducted a simulation of a one-meter sea level rise, which would have profound impacts on the economy of the coastal zone and living conditions of local communities. Sea level rise threatens coastal infrastructures, including ports, tourism resorts, human settlements, as well as coastal fisheries, agriculture and ecosystems. More than half of the city area of Koh Kong would be submerged by a one-meter sea level rise. The total inundated area in the province would total 44 km2, 70% of which mangrove forest.

Figure 11: Municipality of Koh Kong - Simulated Impact (Shaded Area) of a One-Meter Sea Level Rise



Source: Ministry of Environment (2002)

Figure 12: Vulnerable Coastal Communities Protected by Mangrove Forests

Chapter 4. Technology Prioritisation for the Water Sector

4.1 An Overview of Possible Adaptation Technology Options in the Water Sector and their Benefits

Cambodia's National Adaptation Programme of Action to Climate Change identifies specific high priority projects in the water sector: development and improvement of community irrigation systems (#6), water gates and water culverts construction (#7), rehabilitation of multiple use reservoirs (#21), rehabilitation of multiple-use dams (#25). The NAPA considers to be of medium priority the establishment of farmer water user communities (#8), and the construction of cement water tanks (#15). Based on national sustainable development objectives, the NAPA project profiles, the TNA Guidebook on Technologies for the Water Sector (URC 2011), and a broader review of the literature, the TNA Adaptation Team, in consultation with national stakeholders has established a list of fifteen available technologies for water resources. These cover a range of hard technologies, as well as institutional and organisational knowhow.

These technologies can also be divided between: diversification of water supply, groundwater recharge, preparation for extreme weather events, resilience to water quality degradation, stormwater control and capture, and water conservation. The technologies and practises prioritised by the TNA team cover more than one category as they can contribute to more than one aspect of climate change adaptation. The TNA Adaptation Team and the Cambodian stakeholders have favoured community intervention and technologies applicable by households, rather than large scale technologies that would have an impact on the entire country. Below are key considerations for selecting adaptation technologies:

- Diversification of the resources of water supply can reduce Cambodia's vulnerability to climate change, because the country's precipitation patterns are projected to become more variable.
- Groundwater may show a slower response than surface water since the response of water sources to flood and drought varies widely. Technologies that contribute to groundwater recharge will contribute to the sustainable use of Cambodia's water resources.
- The preparation of Cambodia to drought is essential, as local communities are suffering periodically from shortage of water. Under changing climate conditions, the likelihood of such extreme climate events in Cambodia is likely to increase.
- Climate change will have adverse impacts on water quality. Since the majority of rural Cambodians only have access to unprotected sources of water, resilience to water quality degradation will contribute to climate change adaptation.
- Technologies for stormwater control and capture has traditionally been used in Cambodia to prevent flooding in the rainy season, but also to stock water for the dry season.
- With economic development and urbanization, per capita consumption of water has increased in Cambodia. Water conservation measures and practices increase resilience to drought and may postpone the need for expansion of water reservoirs and treatment facilities.

4.2 Criteria and Process of Technology Prioritisation

Each of the fifteen adaptation technologies for the water sector has been scored on a scale of 1 to 100 according to the prioritisation criteria (costs and benefits), with 100 being of the highest priority. The overall score for a specific technology is obtained by averaging its scores for individual criteria. The final ranking represents a consensual position among the members of the TNA adaptation team and has been obtained through a series of discussions and consultations facilitated over the course of a six month period.

Table 4: Prioritisation of Adaptation Technologies for the Cambodian Water Sector on a Scale of 1 to 100

No.	Criteria Technology Options	Costs	Benefits				Total Score
			Adap-tation	Economic	Social	Environ-mental	
1	Rainwater Harvesting from Rooftops	90	90	75	75	70	78
2	Small Reservoirs, Small Dams and Micro-Catchments	90	90	85	75	50	78
3	Wells for Domestic Water Supply	80	90	85	75	50	76
4	Community Irrigation Systems	70	90	90	80	50	76
5	Household Water Treatment and Safe Storage	90	80	60	75	70	75
6	Water Use Efficiency	90	70	70	50	90	74
7	Leakage Management	90	70	70	50	90	74
8	Water Gates and Water Culverts	80	90	75	75	50	74
9	Upper Mekong and Provincial Waterways	50	90	75	75	50	68
10	Water Reclamation and Reuse	50	70	75	50	90	67
11	Community Flood Preparedness	85	90	50	75	35	67
12	Water User Communities	90	75	60	65	40	66
13	Community and Household Flood Safe Areas	90	70	50	75	35	64
14	Drainage for Roads	70	70	75	50	50	63
15	Awareness Raising and Education on Climate Change Issues	70	55	50	50	35	52

4.3 Results of Technology Prioritisation

The prioritisation of adaptation technologies for the water sector is broadly in line with the priorities identified by the NAPA. The top five technologies are (1) Rainwater harvesting from rooftop, (2) Small reservoirs, small dams and micro-catchments, (3) Wells for domestic water

supply, (4) Community irrigation systems, and (5) Household water treatment and safe storage. Rainwater harvesting, small reservoirs, wells and household water treatment all contribute to safer water supply at the village and household level. Community irrigation systems primarily target village crops and household agricultural plots. The next two technologies on the prioritisation list are concerned with water efficiency and water conservation.

There is only a 10% score difference between the first and the eighth technology, which implies that these technologies are significant for Cambodia in terms of adaptation benefits. Beyond mere ranking and numbers, it is important to note that the higher rated technologies broadly correspond to Cambodia's adaptation priorities. However, because of budgetary and time constraint, it is not possible to develop, at this stage, Technology Action Plans for all technologies. Thus, rainwater harvesting from rooftops, small reservoirs, small dams and micro-catchments, wells for domestic water supply, and community irrigation systems, and household water treatment are selected for the purpose of developing TAPs. Technologies 1, 3 and 5 directly address household concerns with regards to a clean and safe supply of water, while technologies 3 and 4 address community concerns in multiple use reservoirs and small scale agricultural irrigation. It is proposed that TAPs be developed for these two sets of technologies.

Figure 13: An Open Well with Manual Pump and a Community Reservoir

Chapter 5. Technology Prioritisation for the Coastal Zone

5.1 An Overview of Possible Adaptation Technology Options for the Coastal Zone and their Benefits

Cambodia's National Adaptation Programme of Action to Climate Change identifies specific high priority projects in the coastal zone: rehabilitation of coastal infrastructure (#26), community mangrove restoration and sustainable use of natural resources (#29). The NAPA considers to be of lower priority an assessment needs for setbacks, vegetation buffers and protection structures (#30). Based on national sustainable development objectives, the NAPA project profiles, the TNA Guidebook on Technologies for Climate Change Adaptation – Coastal Erosion and Flooding (URC 2010), and a broader review of the literature, the TNA Adaptation Team, in consultation with national stakeholders has established a list of fifteen available technologies for the coastal zone. These cover a range of hard technologies, as well as institutional and organisational knowhow.

These technologies can also be divided between: protection, accommodation and retreat approaches. Protection defends vulnerable areas along the Cambodian coast line that are of economic, social or environmental significance. Accommodation allows vulnerable areas to remain occupied, but requires changes in land use and human activities, and improvements in the awareness and preparedness of local communities along the Cambodian coast. Retreat consists in abandoning currently developed areas and resettling people further back from the shore. This may not be a preferred option, as Cambodia is a least developed country with pressing economic and social concerns. The risks of human casualties would however leave no alternative but retreat.

5.2 Criteria and Process of Technology Prioritisation

Each of the fifteen adaptation technologies for the coastal zone has been scored on a scale of 1 to 100 according to the prioritisation criteria (costs and benefits), with 100 being of the highest priority. The overall score for a specific technology is obtained by averaging its scores for individual criteria. The final ranking represents a consensual position among the members of the TNA adaptation team and has been obtained through a series of discussions and consultations facilitated over the course of a six month period.

Table 5: Prioritisation of Adaptation Technologies for Cambodia's Coastal Zone on a Scale of 1 to 100

No.	Criteria / Technology Options	Costs	Benefits				Total Score
			Adap-tation	Economic	Social	Environ-mental	
1	Mangrove Management (Conservation, Restoration, Sustainable Use)	70	80	80	80	80	78
2	Seawalls, Dikes, Barriers	70	95	75	75	75	78
3	Storm and Flood Early Warning	85	80	60	60	65	70
4	Flood Proofing	70	85	65	70	50	68
5	Community Flood Preparedness	85	90	50	75	35	67
6	Vegetation Buffer	70	70	60	60	75	67
7	Flood Drainage	70	80	60	75	50	67
8	Flood Hazard Mapping	70	70	70	80	35	65
9	Emergency planning	80	80	60	60	40	64
10	Beach Nourrishment	50	80	60	70	35	59
11	Desalination	40	80	50	70	50	58
12	Coastal Setbacks	70	70	60	50	35	57
13	Managed Realignment	50	70	60	70	35	57
14	Saltwater intrusion barriers	70	70	45	40	45	54
15	Awareness Raising and Education on Climate Change Issues	70	55	50	50	35	52

5.3 Results of Technology Prioritisation

The prioritisation of adaptation technologies for the coastal sector is broadly in line with the priorities identified by the NAPA. The top two technologies (1) Mangrove management, and (2) Seawalls, dikes and barriers have the same overall score, which detaches them from a closely clustered group of (3) Storm and flood early warning, (4) Flood proofing, (5) Community flood preparedness, (6) Vegetation buffer, and (7) Flood drainage.

There is only a 10% score difference between the first and the ninth technology, which implies that these technologies are significant for Cambodia in terms of adaptation benefits. Beyond mere ranking and numbers, it is important to note that the higher rated technologies broadly correspond to Cambodia's adaptation priorities. However, because of budgetary and time constraint, it is not possible to develop, at this stage, Technology Action Plans for all technologies. Thus, mangrove management (conservation, restoration, sustainable use) is selected for the purpose of developing TAPs.

Chapter 6. Summary/Conclusions

Agriculture/forestry, water resources, human health, and the coastal zone are the sectors most vulnerable to the impacts of climate change in Cambodia. These sectors are considered by the Royal Government of Cambodia, in its official plans and policies, as priority climate change adaptation sectors. However, because of time and budgetary constraints, it is not possible for the TNA project to cover all of Cambodia's climate change vulnerabilities. Thus, the consensus among Cambodia stakeholders is to focus on the two sectors of water resources and the coastal zone. Water resources discussed in the TNA report cover the subsector of water use in the agriculture sector.

As articulated in the National Adaptation Programme of Action to Climate Change, Cambodia has made a clear choice of selecting "no regrets" options. Under changing climate conditions, including higher frequencies of climate hazards, the selected adaptation technologies would be even more attractive. The prioritisation process of technologies for climate change adaptation by the TNA Team uses criteria based on the Royal Government of Cambodia's development priorities. For each sector, a list of fifteen technologies and practises are examined. The available technologies for coastal adaptation and the water sector are prioritised according to their respective costs and benefits. Benefits are divided into four categories: reduction of vulnerability to climate change, economic, social and environmental benefits.

A total of four adaptation technologies are selected for the development of Technologies Action Plans: (1) rainwater harvesting from rooftops, (2) wells for domestic water supply, smalls reservoirs, (3) small reservoirs, small dams and micro-catchments, (4) mangrove management.

Table 6: Adaptation Technologies Prioritised and Selected for the Technologies Action Plans in Cambodia

Sector	No.	Technologies
Water	1	Household Safe Water Supply: - Rainwater Harvesting from Rooftops - Wells for Domestic Water Supply
	2	Community Water Supply: - Small Reservoirs, Small Dams and Micro-Catchments
Coastal Zone	1	Mangrove Management

Part II: Technology Action Plans

Kingdom of Cambodia

Executive Summary

The development of this climate change adaptation technology action plan draws from the IPCC and UNFCCC definitions of climate change adaptation. Adaptation is defined as adjustments or additional efforts to the current activities, projects, programs and plans in order to cope better with climate variability and change. Two sectors: water and coastal zone are selected for this technology action plan. Three technologies are prioritized within the water sector. Two of the proposed technologies are to address safe water supply for domestic consumption: rainwater harvesting from rooftop and well construction. The third technology prioritized, small reservoirs, small dams and micro-catchments, is to address water supply for agriculture. Mangrove forest management is the selected priority technology for the coastal zone.

The implementation of these technologies is under the mandates of different ministries in cooperation with their respective development partners. The implementation of the two water supply technologies is the responsibility of the Ministry of Rural Development, especially the Department of Rural Water Supply and the Department of Rural Health Care. The implementation of water for agriculture technology requires joint commitments of two ministries – the Ministry of Agriculture Forestry and Fisheries and the Ministry of Water Resources and Meteorology, while mangroves forest management is under the mandates of MAFF and the Ministry of Environment, as well as the Coastal Steering Committee chaired by MOE.

Barriers anticipated for the implementation of the technologies within the water sector consist of institutional capacities constraints, including research and information management, lack of climate change considerations in existing policies and strategies, weak law enforcement and lack of financial resources to overcome high rural poverty prevalence. Similarly, barriers and challenges for the implementation of mangroves forest management include elite capture (mangroves areas encroachment and beach reclamation), weak institutional capacities, especially the authority of MAFF, MOE and the Coastal Steering Committee in addressing illegal activities, insufficient local participation, limited research and information for planning and decision making, and a lack of financial resources.

A number of solutions are proposed for each technology considered, ranging from promoting research and information management to the strengthening of the roles, responsibilities and capabilities of the key ministries. A total of 14 project ideas, readily implementable, aim to address the most urgent problems in climate adaptation and resilience. These are open to donor funding and cover a wide range of proposed activities: some are enabling projects, for example mainstreaming and institutional capacity building, and others are practical field implementation, for instance the provision of rainwater harvesting and climate proofed wells.

Chapter 1. Water Sector

1.1 Preliminary Targets for Technology Transfer and Diffusion

The TNA project is coordinated in Cambodia by the Climate Change Department (CCD) of the Ministry of Environment. The TAP report reflects 12 months of discussions and consultations which included national workshops, as well as small group meetings and brainstorming as well as individual interviews. A list of the stakeholders involved in the TAP process is provided in the appendices. It includes representatives of ministries and other government agencies, academic institutions and non-governmental organisations.

The development of the Technology Action Plans, including project profiles, is validated by a broad range of stakeholders and supported by government. The Adaptation TAP report is in line with the national sustainable development objectives of the Royal Government of Cambodia and the Cambodian Millennium Development Goals. The TAP report draws from the strategic choices of Cambodia's National Adaptation Programme of Action to Climate Change (NAPA), in particular project profiles already prioritized by the Royal Government of Cambodia. While the NAPA process relied on stakeholder consultations from the grassroots up to policy makers, the limited budget of the TAP has restrained input to representatives from government, academia and non-government organisations. While national workshops provided opportunities for assessing barriers to technology transfer and collecting contribution towards the Technology Action Plans, smaller meetings with stakeholders already familiar with the chosen technologies were used to develop project ideas.

Three water related adaptation technologies were prioritized by consultative stakeholders, of which two are safe water supply technologies for domestic consumption: rainwater harvesting from rooftop and well construction. The third technology prioritized, small reservoirs, small dams and micro-catchment, is to address water supply for agriculture. The two domestic water supply technologies are generally of a household scale; however dug wells can be constructed for either individual families or small water user groups. Similarly, rainwater harvesting system can be constructed in a larger capacity for schools, health care centres and pagodas, according to available roof's surface areas and budgets. The technologies are suitable for rural residents who live without access to safe water supply. By nature, the two technologies work in different climatic and hydrological conditions, e.g. rainwater harvesting is more appropriate in areas where rainfalls are fairly high or groundwater is limited or contaminated (especially by high level of arsenic concentration).On the other hand, dug wells are appropriate in areas with high level of and good quality groundwater. Thus selection of these technologies should be based on local conditions (especially groundwater and climatic conditions).

Previously in rural Cambodia the emphasis has been on accessing drinking water through ground water sources such as tube wells and surface water sources such as rivers and shallow ponds. It is now evident that not all these sources meet drinking water standards and not all areas have enough water to meet even basic needs. Problems range from arsenic and iron contamination in groundwater to pesticide residue contamination and concentrating in open ponds. During the height of the dry season some villagers must travel for up to five hours followed by long waits in queues to access the nearest water sources, which may be of extremely poor quality.

Due to these issues, considerable effort has been directed into methods that provide "point of use" treatment for drinking water. In particular household filters such as bio-sand filtration or ceramic filters have been developed along with approaches such as solar disinfection, chlorination and boiling. Piped water from small scale water treatment plants are now being developed for bigger villages-typically consisting 300 or more families. These methods have proven effective in dealing with fecal contamination and some other pathogens. Unfortunately they cannot effectively address heavy metal contamination or remove agricultural waste contamination; they are also of limited benefit where insufficient water exists in the first place.

According to the 2008 Cambodian Statistical Yearbook, the number of rural households using rainwater in 2004 was only 25.5% in rainy season and 1.6% in dry season. The statistics in 2007 were 29.8% and 2% respectively, indicating some increase especially in dry season. Therefore, it is a potential option that could contribute to the Government commitment to provide improved access to safe water to all people in Cambodia by 2025. Rainwater harvesting from rooftop is a traditional practice of many rural Cambodians. However, it was mainly done in small capacity, storing in jars to meet days or weeks of domestic consumptions. Improved rainwater harvesting technology consists of a larger capacity system that can store and supply water for longer periods, especially covering dry season duration(at least for drinking and cooking purposes) when water is scarce. The tanks may be equipped with filtering media to ensure that the water is safe for domestic consumption.

Many people throughout Cambodia already practice rainwater harvesting on an informal basis through collecting run off in large jars, typically of about 500 litres in capacity. Each household may have several of these jars depending on income level, but very few have enough to reach the national standard of 3,000 litres of storage capacity per household. The jars are usually left uncovered, which can lead to the breeding of mosquitoes and the growth of algae and pathogens in the jars. The large opening also encourages the use of dippers to access the stored water, a further source of contamination in villages where open defecation is widespread.

These issues are not insurmountable and some local organizations have been working to establish a formalized method of rainwater harvesting to provide high quality, disease and heavy metal free rainwater to thousands of households, community centres and schools. Training of local entrepreneurs to follow risk management approach to rainwater harvesting can help them develop their own businesses.

Groundwater can be considered as a pathogen-safer source of water supply. Open wells are a traditional method of collecting groundwater without much technology requirement. Hand pump wells or tube wells are an improved technology, aiming at protecting the well water from any nearby pollution sources and collect water at deeper water table. Basically, the wells are equipped with tubes/pipes to collect water at deeper groundwater table and a pump is connected to assist in pumping water up (picture 2b and 2c). There are a few designs of hand pump wells, varying mainly from one engineer to another; however, the depth of the wells depends on the location of groundwater tables. Both technologies are common in rural Cambodia, especially where the availability of surface water is limited. Nonetheless, an increasing concern of chemical contamination, especially high concentration of arsenic in groundwater, is a prime challenge in for groundwater extraction technologies. Information on groundwater availability and quality is the

prerequisite for decision-making on whether or not the technologies are suitable for a specific location.

Development of small reservoirs, small dams, and micro-catchment for agriculture is more suitable for implementation at community level. However, appropriate local institutions need to be involved and in some cases established taking into consideration existing local social capital, together with the delivering of associated infrastructure. In so doing, it will maintain the functioning of the system after handing over to local communities for management and ownership. Alternatively, a hybrid form of public-private partnership, mobilizing local resources, may also be suitable. The selection of a development model should be done in thorough consultations with local authorities and communities, ensuring that the decisions respond to local needs and are socially and culturally acceptable. It is noteworthy that agricultural cropping in Cambodia is dominantly rain-feed, making it highly sensitive to climate catastrophes, especially drought and flood. According to the Royal Government of Cambodia (2001), flood causes up to about 70 percent of total rice production losses in the country and drought adds 20 percent up to the figure during 1996 to 2001. Water resources management and development of irrigation infrastructure is one of the key components of the Government's Rectangular Strategy and so does promoting agriculture productivity and diversification. Similarly,Cambodia's National Adaptation Programme of Action to Climate Change also suggests a development and improvement of community irrigation systems.Therefore, promotion of small dams, small reservoirs and micro-catchment are necessary for boosting agriculture productivity which is well aligned with the government's strategies. The potential for application of the technology on a large scale nationwide is high as Cambodia is essentially a small holder agrarian economy. Small reservoirs, small dams, and micro-catchment are perfectly adapted to the needs of Cambodian farmers as they provide community management over local water resources with limited environmental downsides. Large scale irrigation schemes would be in contrast less appropriate in the Cambodian context, as the country lacks large scale plantations and livestock production.

1.2 Barrier Analysis

1.2.1 Barrier Identification and Analysis for the Transfer and Diffusion of Rainwater Harvesting from Rooftop

Though the system can be considered as a low cost low technology option, there are still a number of barriers, due to socio-economic and institutional factors as well as environmental and climatic conditions. Key barriers are explained hereunder.

***Roof surface area and quality*:** insufficient roof surface areas together with quality of the building roofs of rural households, especially the poor (whose houses are small, and covered by palm leaves/thatch), are the prime barrier for application of this technology. Sufficient roof surface area is needed to collect enough amount of rainwater for consumption during the rainy season and storing for dry season, at least a few months if not the entire season. Similarly, the quality of roof impacts quality of collected water. According to the 2008 Cambodian Statistical Yearbook, only 36% of the 2.3 million dwellings in Cambodia in 2004 used aluminium, galvanized iron and other metal sheets for roofing. Up to more than 70% of the dwellings were only of one room-size.

Capital costs: this is a major barrier especially for rural poor households if the technology is not subsidized. Based on the strategy for rural water supply 2011-25, communities need to share capital cost and be responsible for operation and maintenance. The installation costs of rainwater harvesting systems vary from one design to another and so does different kind of materials used in the construction.

Figure 14: Rainwater Harvesting Systems

1a. Jumbo jar

1b. Ring tanks

1c. Ferro-cement tank

Retrieved from: http://www.rainwatercambodia.org/Index.html, dated June 02, 2012

Table 7: shows installation cost of different designs. Given the fact that there is still high poverty incidence in rural Cambodia, 39% of households below the official poverty line of about a dollar a day (2008 Cambodian Statistical Yearbook), the implementation of technology cannot be implemented on a large scale if sufficient adaptation fund is not available.

Table 7: Installation Costs of Rainwater Harvesting Systems

Type of System	Capacity(L)	Installation Cost (US$)
Jumbo jar	3,000	165
Concrete ring tanks	5,000	230-350
Ferro-cement tank	5,000	800
Ferro-cement tank	25,000	1,500

***Institutional capacity*:** unlike traditional rainwater harvesting systems, an improved system can be designed differently, and use different types of construction materials, reflecting available budget, storage volume, and available roof surface area. Design criteria include, but are not limited to, size and shape of the tank(s), connection pipes and valves, installation of filtering system, cover, and sludge removal slope. Appropriate design will ensure high quality of water as well as ease in operation and maintenance (this is of particular importance for households headed by widows). It is important to equip the storage containers or facilities with covers to prevent mosquito breeding as well as to have filtering media to ensure safe water quality which provides good health co-benefits. Therefore, engineering capacity of the department of Rural Water Supply of the Ministry of Rural Development and its provincial departments as well as its development partners should be strengthened in order to diffuse the improved technologies.

Figure 15: Different Types and Designs of Well

2a. Open well, Rattanakiri province

2b. Community tube well, Rattanakiri province

***Climatic vulnerabilities and risks*:** with climate change, it is expected that rainfall patterns and amounts will vary in times and spaces. If the amount of rainfalls received is less than expected, then larger roof surface area is required. Therefore, climate change will exacerbate risks on the technology as well as the achievement of the government's targets, due to an increasing frequency and intensity of extreme events as well as changes in rainfall and humidity patterns.

1.2.2 Barrier Identification and Analysis for the Transfer and Diffusion of Wells for Domestic Water Supply

Lack of groundwater information: Information about groundwater in Cambodia, including information on availability of aquifer or its quality, is limited. Lack of such information may prevent informed planning and decision-making process. A few organizations working in the area of rural water supply observed that some wells had deficient groundwater supply; while, many wells were detected with elevated concentration of arsenic. Areas where groundwater has high level of arsenic concentration have been mapped out. It is to be noted here that the arsenic mapping was done based on wells water quality information, not detailed groundwater quality survey and monitoring. The information, though may not be sufficient, could provide some basis for decision-making on where groundwater is arsenic free and safe for drinking.

Limited institutional capacities: Rural water supply is under the supervision of the Department of Rural Water Supply of the Ministry of Rural Development together with its vertical line agencies at provincial level. Though the governmental organizations in partnership with some non-governmental organizations have worked for years in this area, specific engineering capacity needs strengthened in order to address emerging problems such as arsenic contamination, and climate risks and vulnerabilities.

High upfront capital cost: the construction cost of wells depends on the different types and depths of well, construction materials, local geology, and remoteness of a location. A basic hand dug well costs about US $150 dollars to build but only provides low quality of water (often with high turbidity in the dry season) and in limited quantities (Tabitha, 2012). Higher quality semi-open wells combining an upper section of up to ten meters of high quality cement tubes and a lower section drilled down to twenty meters to reach the water table, cost in excess of US $1000 dollars per unit (Sustainable Cambodia, 2012). Because the prevalence of rural poverty (30.1% of the population in 2007 lived under the poverty line with less than US $1/day), especially those who live in remote areas, the implementation of the technology needs a fair amount of funding support to not only cover transaction costs, but also construction costs, subsidies especially for poor communities. Experiences from the field in Cambodia show that expecting co-financing or monetary participation from villagers, even at a modest symbolic level (10% of the cost of the well for a high quality semi-open well, or roughly the equivalent of US $100) is unrealistic. Households simply do not have the cash and savings in hand to pay for the capital costs. Even when construction costs are fully borne by donors, it may still be the case that villagers will be unable to fund spare parts for future maintenance and repairs. This situation explains the prevalence of low quality/low maintenance hand dug wells and household ponds in rural Cambodia (see below). Quite clearly, villages can only contribute labour and manpower to well construction.

Lack of local maintenance capacity: Wells are generally constructed for either an individual household or a small water user group. Unlike open wells, tube wells require more maintenance works for proper functions. Past experiences indicate that local maintenance capacity of water user group was limited due to insufficient maintenance budget, limited local skills, and unavailability (in some remote areas) and high cost of spare parts. For those reasons many wells constructed were not functioning after a few years. This soft component needs to be properly combined with hard

form technology if the open wells are developed and delivered to community for management and ownership.

Climate vulnerabilities: Some locations are either flood or drought prone which make decision-making on rural water options even harder. Wells are considered an appropriate water supply option for drought prone areas, but may not be a best option in flood prone areas. Appropriate locations, e.g. flood safe areas, and flood safe-designs need to be identified and evaluated for well construction in flood risk areas.

1.2.3 Barrier Identification and Analysis for the Transfer and Diffusion of Small Reservoirs, Small Dams and Micro-Catchment

Unavailability of community land: Small dams, small reservoirs and micro-catchment are collective assets. Therefore, unavailability of community's land would make it hard to develop these facilities. Unlike in the past, today most farmland areas are under private ownership in present day Cambodia.

Investment cost: Due to high prevalence of rural poverty, the investment costs of small reservoirs, small dams and micro-catchment may not be affordable among local communities, especially the poorer of the poor who usually are the most vulnerable group.

Operation and maintenance budget: Apart from the high capital costs, operation and maintenance budget is another challenge, as evidenced in many past projects. The government has promoted community participation in rural infrastructure development, and the transfer of infrastructure to community for management; however the capacity of local people in basic technical maintenance and the scarcity of available savings at the household and village levels make sustainability problematic sustainability of the infrastructure. According to MOWRAM's policy on sustainable irrigation (Circular No. 1 released by the RGC in 1999) the government was expected to subsidise 80% of costs in the first year, 60% of costs in the second year, 40% of costs in the third year and 20% of the costs in the fourth year for community-based irrigation. Nevertheless, the implementation of the policy remains limited because of limited financial resources and inadequate manpower at the provincial levels, which leaves rural communities without adequate technical and financial support for operations and maintenance.

Weak social capital and local institutions: The development of small reservoirs, small dams and micro-catchment requires collective action, a form of social capital. As indicated by Adger (2003) and the World Bank's Environment Department (n.d.), social capital is central to climate adaptation strategies as it is an important medium for economic transaction and collective action. More importantly, social capital that builds for non-economic purposes in a community is important for collective action such as a development of small reservoirs, small dams and micro catchments. Additionally, collective action in conjunction with appropriate institutions is a driver to achieve successful adaptation at a community level. Local institutions in least developed countries like Cambodia are generally poorly developed. The concepts are particularly relevant for the development of small scale reservoirs, dams and catchments as the Royal Government of Cambodia is committed to promoting community-based irrigation systems. Therefore it is necessary to build organizations and institutions at the local level as part of the infrastructure development. In

addition, because of a history of internecine conflicts and the rule of the Khmer Rouge, which resulted in the senseless killing of the Cambodian educated, the population is still recovering from low levels of social capital where social interaction and mutual trust remain relatively weak.

1.2.4 Linkages of the Barriers Identified

The implementation (diffusion and transfer) of the two water supply technologies: rainwater harvesting and wells construction is under the authority of the Department of Rural Water Supply; thus they share almost the same barriers. Limited institutional capacities, especially at sub-national level in integrating climate change risks in development planning and decision-making, as well as limited capacity in monitoring and evaluation of projects are a main challenge. Insufficient scientific information related to either groundwater or climate conditions and associated risks makes a sound informed planning and decision-making even harder. Another critical challenge is to meet the capital cost of infrastructure due to high prevalence of rural poverty. Though there is high demand of both technologies among the rural population, high prevalence of rural poverty may limit the market demand if only limited subsidies can be provided, especially among those who live under the poverty line. Institutional capacity building that enables key actors to mainstream climate risks into their implementation plans to thus minimize anticipated climate vulnerabilities and risks will contribute to its sustainability. Similarly, improved local maintenance capacities will also contribute to the sustainability of infrastructure and services. The longer the infrastructure can last, the fewer capital investments are required to achieve the government targets.

Because development of small dams, small reservoirs and micro-catchment requires collective action, diffusion of this technology may be constrained by weak social capital and low capacity of local institutions, limited local investments, and limited policy implementation together with inadequate institutional capacities at either national or sub-national levels. In this situation, building social capital and local institutions including local government may be more urgent. In doing so, community resilience to climate change and variability will be strengthened.

1.3 Enabling Framework for Overcoming the Barriers

1.3.1 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Rainwater Harvesting from Rooftop

Informed decision-making and planning processes: Rainwater harvesting system should be introduced to locations that have reasonable levels of rainfalls or areas where rainfalls are projected to increase. Therefore, selecting appropriate locations is important for the transfer and diffusion of this technology. There is only limited mention of climate change and disaster risks in the rural water supply strategy 2011-25. The strategy sees the provision of water supply and sanitation services as a response in disaster risk management. Along the line with this view, it is also important to consider the impacts of climate change and disaster risks on delivering services and infrastructure. Proper decisions need to be made in term of what technologies would work well under local climate conditions and stresses. Similarly, buildings with sufficient and quality roof surface areas, e.g. houses with sufficient roof surface area, school buildings, health care centres, and pagodas, are appropriate for the application of this technology. Therefore, relevant decision-making and planning need to base on such information to thus ensure that the diffusion of the

technology responds to local climate conditions as well as the availability of local water sources. There is a need for practical research and information gathering for planning rainwater harvesting systems from rooftops. This needs not be academic and theoretical but can be more simply based on indigenous and local conditions of weather patterns and climatic conditions. Local authorities and local communities can participate in surveys to determine the appropriateness of rainwater harvesting. Information collected would include: local climate conditions and stresses, characteristics of existing buildings and seasonal needs for rainwater collection.

Institutional capacity strengthening: Capacity building and strengthening for national or sub-national level officials in charge of rural water supply, considering their existing capacities and the required capacities for implementing the newly developed 'National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25' is important. Gaps in capacities include: understanding of basic climate change concepts and science, awareness of current climate vulnerabilities and expected climate impacts, experience of conducting climate vulnerabilities assessment and implementing climate adaptation measures (including the provision of infrastructures), and technical skills and knowledge in hydrology, water resources planning and management. The Department of Rural Water Supply of the Ministry of Rural Development (MRD) is responsible for supplying water to rural residents. Along the line with an implementation of the Cambodian organic law, MRD branches at sub-national levels play increasingly important role in the preparation and implementation of rural water supply policies and strategies. The organic law provides a legal background for the national decentralization process, which aims to institutionalize and strengthen responsibilities in implementing development activities at the sub-national levels (away from central government towards provincial, district, commune and village authorities). Each ministry has local departments in each province of Cambodia. These local departments are expected to gain additional responsibilities and capacities to implement development activities on their own in collaboration with other local authorities. Therefore, appropriate capacities of not only MRD, but also their provincial level departments are required.

Coordination and cooperation: The Department of Rural Water Supply of the MRD and its respective sub-national level units are key government institution mandated to realise the Government's commitments in delivering rural water supply service. In addition to government organizations, a number of development partners, e.g. RainWater Cambodia, Good Hands Cambodia, International Relief and Development, Engineers Without Borders Australia, have also worked in cooperation/partnership, or to complement activities. Good cooperation between government organizations and development partners are important to effectively use scarce resources, avoiding overlapping activities and minimizing inconsistency in communication messages especially to the communities.

Financial mechanism: As indicated in the rural water supply strategy 2011-25, investment is to be shared by local communities and operation and maintenance costs to be fully borne by local communities. Due to high level of rural poverty, appropriate subsidy mechanisms need to be developed to ensure that the poorer households also be able to benefit from the technology as well as to guarantee that the entire rural population have accessed to an improved water supply by 2025. Much of the construction work can be undertaken by locally based artisans and small rural enterprises. The private sector could play a role in providing more advantageous financing terms such as credit for initials costs of construction against appropriate collaterals from households, or

monthly payments over several years. This will however also depend on the ability of rural enterprises to secure financing from financial institutions for their customers.

Promotion as socially acceptable technologies and increase in customers' awareness: A package of hard and soft measures can ensure that technology also meets customers' preferences and needs. To increase local awareness and understanding of the technologies, information and promotion campaigns need to be conducted. Training for operation and maintenance will lead to longer term sustainability. Alternative water treatment and supply options need to be considered for those households who are unable to use this technology because of technical reasons (e.g. limited roof surface area).

1.3.2 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Wells for Domestic Water Supply

Improving research and information management: Research capacities (manpower, facility, finance, and institutional mechanism) of local universities and research institutions are limited, and they are even more so for science and technology related fields. This constrains an informed decision-making and planning process, which is vital for a sound sustainable development of infrastructures and services. For instance, if wells are constructed in arsenic prone areas or in locations where groundwater level is insufficient, they waste scarce resources. Improving research capacities of local universities such as the Faculty of Sciences of the Royal University of Phnom Penh, the Institute of Technology of Cambodia, and non-government organizations such as Resources Development International-Cambodia are critically important. These organizations are trying to increase their capabilities, and have trained technicians and staff, and set up water quality laboratories that are the foundation for scientific and technological studies. Furthermore, improving interfacing of the research institutes with the Ministry of Rural Development, and the water and sanitation (WATSAN) Technical Working Group and the WATSAN informal working group will contribute to better information, research findings and experience sharing.

Strengthening and building institutional capacities: Capacity building and strengthening for national and sub-national level officials of rural water supply, considering their limited existing capacities for implementing the newly developed 'National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25' is important. The Department of Rural Water Supply of the Ministry of Rural Development is responsible for supplying water to rural residents. Along the line with an implementation of the Cambodian organic law, MRD sub-national levels play an increasingly important role in planning and implementing the rural water supply policies and strategies. Therefore, appropriate capacities of the institutions are required, including the capacity to mainstream climate change considerations into decision-making and to design more climate proof wells.

Linking networks: The Department of Rural Water Supply of the MRD and its respective sub-national level units are key government institution mandated to implement the Government's commitments in delivering rural water supply service. Despite the government organizations, a number of development partners, e.g. the Asian Development Bank, UNICEF, Oxfam, and Plan International have supported the Department of Rural Water Supply technically and financially to reach the set targets. The existence of WATSAN Technical Working Groups, both formal and

informal, is vital for networking and sharing information, though it may also be important to linking this network to other networks such as disaster risk reduction forum, climate change forum and other research network such as the development research forum to improve their understanding and cooperation.

Financing mechanism: As indicated in the rural water supply strategy 2011-25, investment cost must be shared by local communities and operation and maintenance costs need to be fully borne by local communities. Due to the high level of rural poverty, appropriate subsidy mechanisms are required to ensure that the poorer of the poor also receive the technology and service as well as to guarantee that the entire rural population have accessed to an improved water supply by 2025. More importantly, it is necessary to improve local maintenance capacities so that the expected life of the infrastructure can be guaranteed.

1.3.3 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Small Dams, Small Reservoirs and Micro-Catchments

Having acknowledged that water resources in Cambodia is poorly developed, the Royal Government of Cambodia underlines a need to improve water resources management (the Rectangular Strategy, the Strategy for Agriculture and Water Resources 2009-13) through strengthening laws and regulations, enhancing institutional capacities, promoting research and education, and implementing practical projects. In addition, as indicated by the MOWRAM's policy on sustainable irrigation, community based irrigation approaches such as small reservoirs, small dams and micro-catchment are highly encouraged. The MOWRAM's policy also supports local participation in developing and delivering irrigation water supply services. Although the proposed technologies are well aligned with the government's policies, a number of factors need to be taken into account to enable transfer and diffusion of the technology.

Building social capital and local institutions: It is important to consider building social capital and local institutions as part of a package with the development of infrastructure. Adger (2003) views adaptive capacity as an ability to act collectively, noting that adaptation efforts can be enhanced through building relationships, trust and exchange. Paavola and Adger (2005) indicate that if there is only a small number of members in a group, the group is more effective in terms of maintaining transparency and interactions. They further add that a group with large number of members tends to increase transaction costs and undermine collective actions unless trust has been built firmly. Similarly, if there is strong social capital, the issue of the heterogeneity may be tackled; otherwise conflicts may arise and individual interests may need to be addressed (Paavola and Adger 2005). Having acknowledge the importance of local social capital and local institutions in managing local development it is necessary to include such software development (e.g. formation of functional irrigation water user group and committee) if the infrastructure developed is to be transferred to community for ownership and operation. In practical terms, longer term sustainability can only be ensured if local people are provided meaningful opportunities to participate in key decision making (choice of adaptation technologies, location of infrastructures, rules governing water usage etc.), and if local people are properly trained in how to operate, maintain and manage these infrastructures.

Improving research and consultations: What form of model, community-based or public-private partnership for local investment, will work is an important question in planning for implementation of the technology. As indicated by the literature (Cernea 1987, Pretty et al. 1999), having well-organised groups of local people and local users who are involved in the planning and implementation stages of a project and taking into account their knowledge is very important in sustaining activities after completion of the project. Therefore relevant research providing background information relating to local cultural, and socio-economic dimensions, as well as insights in term of local relation of trust and social bonding of communities is necessary in informing local development.

Financial mechanism: Local resources mobilization is important in sustaining the functioning of the infrastructures and services (for operation and maintenance costs only), and this may be crucial when external funding is limited. The operation of the technologies can be carried out in either forms of community based or public private partnership with local investments (local better-off families who are interested in providing certain services, e.g. investment in constructing sub-cannel connecting from main canal that is generally provided by the government to rice field of farmers). Requirements for co-financing by local communities would limit the provision of infrastructure to well-off households and other local elites. Lease financing by a centralised trust fund or by private sector firms may allow broader participation by poorer households. In these schemes, the cost of infrastructure would be initially be borne by the contractor responsible its construction. Participating households would only be required to make smaller monthly payments towards the reimbursement of the cost of the infrastructure. Nevertheless, seed funding towards capital costs should be provided by government and donors.

Monitoring and evaluation: Over-optimism about a local group and their capacity to deliver economic and environment benefits can jeopardise a situation because change within and between communities can result in damage to services delivered and outcomes (Pretty, 2003). Therefore, to ensure effective implementation, monitoring and evaluation are important to provide feedback and make any necessary adjustments or further innovations to the selected technologies (Linham and Nicholls, 2010; UNFCCC, 2006).

Law enforcement: Cambodian policy on the implementation of sustainable irrigation networks should be reinforced especially in regard to subsidies for implementation of community-based irrigation system because, as indicated by Lebel and Sinh (2005), the gaps between policy and implementation can contribute to increased vulnerabilities.Given the gaps in financing for adaptation in developing countries, this outcome is likely. For instance, the National Adaptation Plan of Action to Climate Change formulated in least developed countries with the support for the UNFCCC, remain to date largely underfunded. The international financial crisis is likely to compound the problem further as donors budgets are being slashed drastically (Climate Funds Update, 2012). Pretty and Ward (2001) also argue that the act of forming a water user group *per se* is not enough; policy reform and implementation also need to be provided. According to MOWRAM's policy on sustainable irrigation (Circular No. 1 released by the RGC in 1999) the government was expected to subsidise 80% of costs in the first year, 60% of costs in the second year, 40% of costs in the third year and 20% of the costs in the fourth year for community-based irrigation. The policy needs to be reinforced and government needs to make a clearer commitment to its implementation.

1.3.4 Recommended Solutions for the Water Sector

Although a number of solutions are proposed, it is important to address the most fundamental, practical and urgent ones. In general, the issues of institutional capacities, relevant information for climate informed-decision and planning, building local capital and institutions for collective assets, and improved cooperation need to be addressed first. Therefore, the proposed solutions basically fall into 1) mainstreaming climate change issues into the existing relevant policies and strategies, 2) institutional capacity building at either national and sub-national levels, 3) demonstration and practical projects, 4) promotion of research and information management, and 5) financial mechanisms for funding support to overcome high rural poverty prevalence in Cambodia.

1.4 Technology Action Plan, Project Ideas, and other Issues in the Water Sector

The proposed technologies for this action plan are under the supervision of different ministries. Wells construction and rainwater harvesting are under the Department of Rural Water Supply of the Ministry of Rural Development (MRD). The development of small scale reservoirs, small dams and micro-catchment is the responsibility of (MWRAM). Mangrove management is under supervision of the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Ministry of Environment (MOE) and the National Coastal Steering Committee. The technology action considers actions for the short term (3 years), the medium term (5 years), and the long term (10 years).

1.4.1 Technology Action Plan for the Transfer and Diffusion of Well and Rainwater Harvesting Technologies

Well construction for domestic water supply has been one of the central activities of the Department of Rural Water Supply, which is part of the Ministry of Rural Development. However, with emerging problems such as high arsenic concentration in groundwater, and increasing climatic vulnerabilities and risks, a sound climate-informed planning and decision-making process is required. In a similar vein, rainwater harvesting has been locally used for decades, though improved systems together with a more climate-informed decision and planning for the technology is needed to better cope with the changing climate. To enable the Department of Rural Water Supply and their development partners to make a more climate-informed decision and planning, as well as deliver climate-proof rural water supply, a number of milestones, ranging from institutional capacity building, to policy implementation and institutional strengthening) are suggested.

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Table 8: Technology Action Plan for Wells and Rainwater Harvesting

Targets	Barriers	TAP Action Plan			Key Stakeholders
		Short Term	Medium Term	Long Term	
To enable for climate-informed decision making and planning, as well as delivery of climate-proof rural water supply infrastructures and services	No climate change impacts and vulnerabilities are considered in the current rural water supply and sanitation policies and strategies	Mainstreaming climate change adaptation into rural water supply policies and strategies			MRD, WATSAN DPs, CCD, RUPP
	Limited institutional capacity at both national and sub-national levels	Capacity building and strengthening for rural water supply officials			MRD and PDRDs, WATSAN DPs, CCD, RUPP
	Limited information for climate informed decision making and planning for rural water supply and services				RUPP, MRD, CCD
	Limited climate change considerations are mainstreamed into design of rural water supply infrastructure and services		Demonstration and implementation of practical projects		MRD, WATSAN Development partners, CCD, RUPP

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Mainstreaming climate change adaptation into rural water supply policy and strategy: The current strategy sees the provision of rural water supply service as a disaster risk reduction intervention rather than considering the impacts of climate change and disaster risks on the delivery of services and infrastructure. Reflecting the inadequacy of climate change considerations in the rural water supply and sanitation policy and strategy, it is important to mainstream climate change adaptation measures into the existing policy and strategy. As such, appropriate water supply options should be well examined to suit local-specific climate conditions and stresses or/and a sound climate-proof infrastructure should be promoted. Shall the policy and strategy be implemented; risks of climate stresses can be expected to be lessened.

Capacity building and strengthening for rural water supply officials: Institutional capacity for climate change adaptation remains limited, especially at sub-national levels. With a firm commitment to provide 50% and 100% of rural population with sustainable access to an improved water supply by 2015 and 2020 respectively, the Royal Government of Cambodia has recently developed a 'National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25', supporting the implementation of the national rural water supply and sanitation policy (2003). To enable the Department of Rural Water Supply (MRD) and its provincial departments to effectively implement the strategy, necessary capacity related to climate-informed decision-making and planning needs to be built and strengthened. Training could cover understanding of basic climate change concepts and science, awareness of current climate vulnerabilities and expected climate impacts, climate vulnerabilities assessment and implementation of climate adaptation measures (including the provision of infrastructures), and technical skills and knowledge in hydrology, water resources planning and management. The Department of Rural Water Supply of the Ministry of Rural Development (MRD) is responsible for supplying water to rural residents. The implementation of Cambodian organic laws entails high capacity at sub-national level. Furthermore, with anticipated risks of climate disasters towards the achievement of the government's targets, it is important to also include climate change impacts, vulnerability and water supply related adaptation measures (appropriate adjustments to the on-going activities or more climate informed decision making and planning) into the capacity building program. It is expected that capacity building will enable MRD and PRD not only to implement the rural water supply strategy effectively, but also to prepare sound climate-informed decision-making and planning processes so that climate vulnerabilities and risks on rural water supply infrastructure and services can be minimized.

Improving research capacity and promoting links between research, policy and practice: Diffusing and transferring this technology requires a sound information basis. Given the fact that the availability of local climate scientific information and climate vulnerability assessments are limited, further studies are of critical importance in enabling a sound climate informed decision-making and planning.

Financing mechanism: Due to high rural poverty prevalence, it may be difficult to deliver the technology at full market price. However, as rainwater harvesting is only suitable to households with sufficient rooftops (the assumption here is that poor people have smaller houses with thatched roofs), a sharing of capital cost as indicated in the rural water supply strategy may be relevant. If the assumption is not proven, an appropriate subsidizing mechanism adapted to different economic classes needs to be developed. This would require co-financing from households only if they can afford it. Although it is difficult to estimate household income

accurately, proxies such as characteristics of the dwelling and land area cultivated may be used as proxy. Until the technologies are firmly established, subsidies at full cost may be required to demonstrate their benefits. In all likelihood, households living below the official poverty line cannot be expected to pay for what is in essence a public good. However, a full subsidy should be given to schools, health care centres, and pagodas. Subsidizing is only possible with financial support. An adaptation fund will make an important contribution to this objective.

1.4.2 Technology Action plan for the Transfer and Diffusion of Wells for Domestic Water Supply

Well construction for domestic water supply has been one of the central activities of the Department of Rural Water Supply, which is part of the Ministry of Rural Development. However, with emerging problems such as high arsenic concentration in groundwater, and increasing climatic vulnerabilities and risks, a sound climate-informed planning and decision-making process as well as climate proofing of infrastructure is necessary. To enable the Department of Rural Water Supply and their development partners in making a more climate-informed decision and planning, the suggested actions plans for diffusing and transferring of rainwater harvesting technology are also valid for diffusing and transferring of wells for domestic water supply. In addition, the following focuses should be underlined for this specific technology:

- Climate-proof well designs that can be more tolerant resistant to climatic stresses should be included in the institutional capacity building and research activities;
- Climate hazards and vulnerabilities should be mapped out and the information be shared widely, especially among key actors to serve as a basis for planning and decision-making in selection of rural water supply options, especially well construction. Overlay mapping between arsenic concentrations in groundwater and climate vulnerabilities may provide detailed information for better informed decisions;
- Local maintenance capacity should be packaged with the development of wells and take into consideration social acceptance and local affordability to ensure that the infrastructure can be operated over the longest duration possible.

1.4.3 Technology Action Plan for the Transfer and Diffusion of Small Dams, Small Reservoirs, and Micro Catchments

Although small dams, small reservoirs and micro-catchment are low cost, low tech adaption options and have been implemented in Cambodia, the implementation of these technologies remains a challenge due to a number of reasons. Investment cost is a significant obstacle if funding is not available, especially when a community based approach is selected. Based on a study done in rural Takeo province (Dany and Vuthy 2011), local investments were available for construction of sub-canals (see Figure 16:) only in selected locations. Operation and maintenance of the system also requires budget and good organization of water user groups. Because these technologies are collective assets, collective action would be required to operate and maintain the systems. To enable the diffusion of these technologies, the following action plan is proposed.

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Table 9: Technology Action Plan for Small Dams, Small Reservoirs and Micro-Catchments

Targets	Barriers	TAP Action Plan			Key Stakeholders
		Short Term	Medium term	Long Term	
To facilitate the MOWRAM and MAFF in deliver a more climate informed small scale irrigation system	Institutional capacities constraint, and lack of climate change considerations in existing relevant policies and strategies	Institutional capacity building			MOWRM, MAFF, water and agriculture DPs, RUA, ITC, RUPP, CCD
		Promote research and education			RUA, ITC, RUPP, CCD
	Limited local engagement and participation in infrastructure development	Establish water user committees and water user groups			MOWRM, MAFF, water and agriculture DPs,
		Building local institutions and their connectedness for operation and maintenance			MOWRM, MAFF, water and agriculture DPs, RUA, RUPP
	Lack of financial resources	Encourage local investments in small scale irrigation infrastructure development			MOWRM, MAFF, water and agriculture DPs,
		Seek for external financial supports			MOWRM, MAFF, water and agriculture DPs,
		Public consultations with local communities in planning for the infrastructure to ensure long life of infrastructure			MOWRM, MAFF, water and agriculture DPs,

Figure 16: Irrigation Canal in Rural Takeo Province

Photographed by Va Vuthy, May 2010

Institutional technical capacity building: As indicated in the Strategy for Agriculture and Water, the lack of technical staff (meteorologists, hydrologists and water chemical engineers) is a critical issue at the provincial level department of Agriculture and Water Resources Management, especially

once the organic laws are implemented. At the provincial level, generally there is only one technician who is also responsible for management, and is usually the director of the provincial department. At the national level, both MAFF and MoWRAM face the same issue and even more so because their qualified workforce is getting older (the strategy for agriculture and water resources 2009-13). In responding to this challenge, it may be necessary to discuss the possibility to increase enrolment in key areas of expertise at the Institute of Technology of Cambodia, the only engineering institute that offers degree programmes in civil engineering, rural engineering and chemical engineering. There is currently no training program on meteorology in Cambodia. This should be established in an existing university in order to meet growing demand. Additionally, overseas training opportunity in the expertise areas should also be searched for. Short course training to fill capacity gaps of MAFF and MoWRAM staff should also be included in human resources management at the ministries.

Research: In addition to the selection of appropriate models for development, it is also essential to take into consideration the social and environmental impacts and consequences of technologies in order to ensure that the delivered technologies or newly development models are socially and culturally acceptable. Thus investigations of local specific social cultural and environmental conditions are necessary. For instance, development of small reservoirs in the Tonle Sap area destroyed around 100, 000 ha of flooded forest, a freshwater fish habitat (Johnston, R. et al., 2012). Research and dissemination is important to inform planners and policy-makers in taking knowledge based decisions. In addition, it is important to learn from good practices and scale up successful experiences in other parts of Cambodia or in neighbouring countries. In the Cambodian context, practical and applied research that can provide information to decision makers and to local communities is urgently required to maximise resource utilization and effectiveness. More theoretical research is not appropriate in a context where there exist significant gaps in technical capacity and uncertainties as to the veracity of local data. Applied research based on learning and doing, documentation of lessons learned from field case studies can help clarify success stories to be replicated. It is essential to understand what social conditions are necessary to the successful implementation of small dams, small reservoirs and micro-catchments by local people, as this will ensure longer term sustainability.

The following factors need to be taken into account in designing and implementing the technologies:

Public consultations with local communities: It is important to have thorough consultations with local communities and users to identify and adopt the appropriate technologies. These consultations should be carried out by the entities responsible for the provision and implementation of the technologies, bet they government institutions or donor agencies. This will develop common goals and local ownership, fostering greater local participation and longer term self reliance. MOWRAM and development partners should apply participatory planning with local communities, taking into account local knowledge and perceptions, in planning irrigation infrastructure development because having well-organised groups of people is a key in sustaining activities after completion of projects. Also, collective asset is a public property, it is thus dependent on individual efforts and good will (Lin 1999, 2001).Therefore sufficient consultations and participatory planning are important. The consultations may be able to determine local materials for construction as well as identify local investors who are interested in partnership. It is

also important to understand the determinants of social local capital for the establishment of water user groups.

Building local institutions and their connectedness for operation and maintenance: Strengthening social capital and institutional connectedness, taking into account past experiences is critical in sustaining collective assets. In addition to the technical requirements necessary for work to be completed, institutions are the products of interactions and adaptation wherein values are infused and for this reason, promote stability of work (Scott 1987). Normative, regulative and cultural cognitive aspects are key elements of institutions (Scott 2008) as well as ingredients of social capital (Adger 2003, Pretty 2003, Pretty and Ward 2001). Social capital is self-reinforcing when reciprocity increases connectedness between people, leading to greater trust, confidence and capacity to innovate (Pretty 2003, Pretty and Ward 2001). The operationalisation of these academic concepts need not be overly complex. In effect, water user committee and group should be established and functioned as part of infrastructure development. For example, good practice has been demonstrated for *Water Users Committee* established by the MORAM in Koh Andet district of Takao province in 2002. These simply follow international accepted guidelines and well documented standards that the Cambodia only need to adapt to the local social context (SRP 2011, WHO 2010 & 2012).

Water user committees and water user groups: Common rules, norms and sanctions reflect the social agreement that individuals control their own behaviour in collective actions, thus giving individuals confidence in investing in collective or group actions (Pretty 2003, Pretty and Ward 2001).Administrative procedures are necessary when implementing rules, and it is necessary to have adequate bureaucracy to effectively implement an agreement (Menard 2011). Rules stipulate behaviours with positive and/or negative sanctions (Pretty and Ward 2001). Sanctions are used to ensure that those who do not respect the rules will be punished (Pretty 2003). It is also important to note here that smaller groups tend to be more effective in maintaining transparency. Although, there is no clear cut rules for establishing well-functioning user groups and committees, well grounded understanding of local social and cultural aspects are essential. In addition, established guidelines and lessons learned need to be followed closely and would ensure longer term sustainability of the operation of infrastructures delivered (SRP 2011,WHO 2010 & 2012).

1.4.2 Brief Summary of Project Ideas for International Support (Details in Annex 3)

Since the implementation of the two water supply technologies is under the responsibility of the Department or Rural Water Supply of the Ministry of Rural Development, they are the key players who need to be equipped with appropriate capabilities. To enable effective capacity building on climate-informed planning, it is necessary to mainstream climate change considerations into rural water supply and sanitation development plans, strategies and policies. Moreover, it is important to also promote research and improve groundwater data management to assist a decision making. The following project ideas are suggested in order to diffuse and transfer the technologies.

1. Mainstreaming climate change considerations into the ‘National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25’ and institutional capacity building at national level
2. Climate related capacity building and strengthening for Rural Water Supply officials at sub-national level

3. Pilot climate-informed planning and climate proof well designs in Takeo province
4. Scaling up of flood proof well designs in flood prone areas
5. Provision of rainwater harvesting systems in arsenic prone areas
6. Strengthening research capacity for the Faculties of Sciences of RUPP and ITC.

Development of small dams, small reservoirs and micro-catchment requires appropriate capacities at either national level or provincial level department of Water Resources Management (and the Department of Agriculture). In addition to engineering knowledge, they should also be able to discuss and make climate-informed decisions with regards to the design and location for the system. Experience in community mobilization is another important aspect as the development and sustainability of the technology depend on community participation. In addition, good cooperation with local authorities and communities is required. To enable transfer and diffusion of these technologies effectively, the following project ideas are suggested:

7. Institutional capacity strengthening on climate change impacts, vulnerability and adaptation for MoWRAM and MAFF at national level
8. Institutional capacity strengthening on climate change impacts, vulnerability and adaptation for PDWRAM and PDAFF at sub-national level
9. Development of a graduate programme on climate science and meteorology at the Royal University of Phnom Penh

1.4.3 Other External Barriers

Most of the proposed solutions are 'no-regret' options, thus they will benefit Cambodia as a whole and rural poor in particular. The development and implementation of these proposed projects can only be done if external funding is available, together with the capacity of key stakeholders in absorb funding. The uncertainty of adaptation funds could be a key barrier for this commitment.

1.5 Summary

Three water related adaptation technologies were prioritized by consultative stakeholders, of which two are safe water supply technologies for domestic consumption: rainwater harvesting from rooftop and well construction. The third technology prioritized; small reservoirs, small dams and micro-catchment; is to address water supply for agriculture. The implementation of the two water supply technologies lies on the responsibility of MRD, especially the Department of Rural Water Supply and the Department of Rural Health Care, with it provincial departments. The implementation of second technology requires joint commitment of two ministries – MAFF and MWRAM. There are a number of barriers anticipated for the implementation of these technologies, namely institutional capacities constraint, lack of climate change considerations in existing relevant policies and strategies, and lack of financial resources. A number of projects ideas are suggested, of which some are enabling projects, for example mainstreaming and institutional capacity building, and others are the actual/practical projects implementation, for instance the provision of rainwater harvesting and climate proof-wells.

Chapter 2. Coastal Zone

2.1 Preliminary Targets for Technology Transfer and Diffusion

Based on national stakeholder consultations, mangrove management is a high priority and selected as coastal adaptation to be included in this national adaption technology action plan. Mangroves are endemic to the coastal provinces of Cambodia; with the largest proportion in Koh Kong Province, followed by Kampong Som, Kampot and Kep Procinces. According to FAO (2005), mangroves in Cambodia consist of three types, riverine, basin and fringing mangroves. The riverine mangroves are found in Prek Koh Poa, Prek Piphot, Stung Meteoeuk, Stung Kep, Peam Krasoap, Kampot and Kampong Som Province. Basin mangroves are in Kampong Some, Koh Kong and Kep bays. Fringing mangroves grow in complex ecosystems of Koh Kong province and Koh Kapi. Larger areas of mangroves are found in main estuaries such as Peam Krasop, Sre Ambel, Andong Tuk, Chak Sre Cham, and Prek Kampot (FAO 2005). A number of protected areas such as Ream National Park, Botum Sakor National Park and Peam Krasoap Wildlife Sanctuary protect the most important mangrove forests in Cambodia (FAO 2005). The Peam Krasop Wildlife Sanctuary (a Ramsar site) covers more than 25,000 hectares and is one of Cambodia's most important mangrove areas. In addition totheir importance in buffering floods and windstorms, mangrove forests are significant for biodiversity conservation, for instance, the Peam Krasop wildlife sanctuary serves as habitat for saltwater crocodiles and Irrawaddy dolphins, and stopovers for migrating birds like the Asiatic dowitcher and the spotted greenshank (Kimsreng 2011).

Mangroves forest, however, have been significantly degraded (Table 10, Figure 17) due to large scale harvesting for fuel wood, urbanization, land encroachment, and salt farms and aquaculture development (RGC 2006, FAO 2005). Illegal mangroves harvesting was also observed to occur at Peam Krasop Wildlife Sanctuary (RGC 2006).In a broader context of coastal zone management, Monyneath (n.d.) identifies a wide range of issues as factors contributing to the degradation of coastal and marine resources in Cambodia including mangroves forest: lack of enforcement of the relevant laws (law on fisheries, laws on forestry, and laws on environmental protection and natural resources management), poorly defined roles and responsibilities of relevant organizations together with a lack of coordination, no coastal zone management framework and plan, limited research and monitoring, as well as low public awareness on marine resources and coastal management. In addition, coastal zone, a sensitive area to climate hazard, will be more vulnerable to climate change and sea level rise in addition to a mounting concern of rapid development and population growth (IPCC 2007, UNFCCC 2006). Degrading marine ecosystems and increasing coastal flooding have a strong implication on socio-economic and environmental developments of coastal areas (UNFCCC 2006, Nicholls et al 2007).

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Table 10: Estimated Mangrove Areas in Cambodia

Year	1980	1990	2000	2005
Area (ha)	91,200	82,400	73,600	69,200
% of change from the previous estimated year		- 9.6	-10.68	-5.98

Source: FAO, 2005

Figure 17: Mangroves Destruction

Retrieved from: https://encrypted-tbn1.google.com/images?q=tbn:ANd9GcR-ceP6Ymt4IDkSOsQttJrNOT2t7KUpperw

Retrieved from http://www.travelfish.org/blogs/cambodia/wp-content/uploads/2011/09/IMG_5329.

2.2 Barrier Analysis

2.2.1 Barrier Identification and Analysis for the Transfer and Diffusion of Mangrove Management

Poorly defined institutions and capacity: poorly defined roles and responsibilities of relevant organizations together with a lack of coordination is a main cause of the decline of marine resources and mangroves forest. Key organizations in coastal and marine resources management

include MOE, MAFF, the National Coastal Steering Committee, and the Coastal Coordinating Unit. Representatives of funding agencies and civil society organizations play a role as observers in the committee. Lebel and Sinh (2005) argue that clear and properly defined roles and responsibilities, and rules of engagement are ways of institutionalizing capacities that can build capacities of actors. Nicholls et al., (2007) also observe through lessons from recent extreme events that, strong governance and institutions are drivers for effective disaster preparedness and prevention.

Limited local awareness and participation in mangrove management: Limited local participation is identified as one of the barriers in mangroves forest management in Cambodia. Although mangroves forest traditionally serve as local free sources of food, construction materials, and fuel wood, local participation in mangrove management remains limited and project based. High poverty prevalence in rural Cambodia, limited local livelihoods, and poor public awareness are key constraints in strengthening local participation. Over harvesting of mangroves causes decline of natural fish stock and forest products, threaten local food supply and exacerbate climatic risks and vulnerabilities.

Unclear land use planning and land encroachment: As indicated by the RGC (2006) encroachment on mangroves is among key factors contributing to the rapid depletion of mangrove forests. The literature also points out that uncontrolled development activities and the influence of social elites are key constraints in protecting mangroves forest and marine ecosystems. Clearance of mangroves for shrimp farms and salt production considerably degrades mangrove forests in Cambodia (FAO 2006 and RGC 2005). Following similar unsustainable practices in Thailand, shrimp farming was introduced through Koh Kong Province to Cambodia in the early 1990s. Although existing environmental and pollution controls restrict aquaculture in general and shrimp farming in particular to non-mangrove areas and at least 150 meters from the shoreline, enforcement is weak on the ground. In addition, land grabbing especially in Kampong Som and Kep Provinces was also underlined by the RGC (2006) as one of the reasons for the loss of coastal areas and mangroves forests. As a result, Cambodia has lost almost 40% of its mangroves between 1973 and 2006 (Mangrove Action Project, 2008).

Weak implementation and enforcement of relevant laws and legal instruments: Mangrove forest is primarily protected by the fishery and forestry laws which are under the mandate of MAFF, and the natural resources and environmental protection law which is under the mandate of MOE. The RGC (2006) identifies a lack of technical capacities, uncontrolled development activities and influences of social elites as key constraints in effectively implementing and enforcing legal instruments. Although these issues are critical in implementing sustainable mangrove management, they reflect the broader institutional, political and social setup in Cambodia which may require broader governance reforms.

2.2.4 Linkages of the Barriers Identified

Barriers can be classified into lack of law enforcement, institutional arrangement and implementation capacities, and local awareness and participation in mangrove management (co-management). Against a backdrop of generally weak law enforcement, the enforcement of laws related to mangrove management is limited in Cambodia. Strengthening law implementation and enforcement would require massive political will from the RGC which may not be practical

relevance to this technology action plan. Institutional arrangement and implementation capacities, especially at the local level may be of more practical use. The positive roles of local institutions in coordinating local social capital and protecting natural resources are traditionally appreciated. Strengthening communities' awareness and participation seems the most practical and implementable way to protect mangroves forest, and builds local resilience to climate variability and change as well as protects biodiversity.

2.3 Enabling Framework for Overcoming the Barriers

2.3.1 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Mangrove Management

Building social capital and local institutions for mangroves management: It is important to consider building social capital and local institutions for marine resources including mangrove management in Cambodia. Adger (2003) views adaptive capacity as an ability to act collectively, noting that adaptation efforts can be enhanced through building relationships, trust and exchange. The literature further indicates thatsocial capital plays an important role in collective action for natural resources management. Nooteboom (2007) additionally explains that social capital is a source of reliance. When institutions are weak, the go-betweens inherent in social capital may be critical in fostering reliability. Community participation in mangroves management in Cambodia has been approached by various projects; however sustainability remains a challenge. Pretty (2003) indicates, community will be able to work together collectively if good knowledge about local resources, appropriate institutional, social and economic conditions; and process that encourage careful deliberation is transferred. The Danida funded coastal zone management project from 1997 to 2002 also supported the formation of working group at the provincial level. It may be, therefore, important to learn from past experience and build up on their capacity to effectively participate in mangroves management.

Improving research, education and awareness: Linham and Nicholls (2010) point out that there is no single best coastal adaptation solution, thus selection of technologies should be based on local conditions. In this respect, research is needed in order to better understand local environmental, social and cultural aspects in managing natural resources. The literature further notes, stakeholder engagement, communication and awareness raising are key in the adaptation process.As part of a coastal zone management project funded by Danida in 1997-2002, a number of cases studies were undertaken to inform decisions, and a series of capacity building activities were carried out for relevant staff at provincial level. Nevertheless, research, education and awareness-raising cannot be a one-off action, thus additional efforts are required to improve understanding and participation in mangrove management projects. In addition, it is necessary to produce mangroves maps to assist effective management.

Financial mechanism: Due to high poverty prevalence in rural Cambodia, it may not be feasible to commit for full voluntary participation in collective action for natural resources management and protection. Despite funding for capacity building and awareness raising, operation and management, mangrove management especially in a form of eco-tourism development projects could create jobs for local communities – for instance, as service providers.

Land use management - encroachment in mangrove areas: The commission on monitoring and assessing for suppressing encroachment into mangrove land and coastal reclamation was established in 2005 by the Royal Government of Cambodia under decision number 28 S.S.R. The commission is composed of the Minister of Environment, and Secretaries of State of the Ministry of Interior; Land Management, Urban Planning and Construction; Tourism; Agriculture, Forestry and Fisheries; and governors of coastal provinces and municipalities. The commission is authorized to take measures to stop encroaching activities and replant mangrove trees in historical mangrove areas. Nevertheless, the RGC (2006) indicates no clearly identified results or outcomes from consultations with governors of coastal provinces and municipalities. A review may be necessary to better understand its effectiveness and identify additional mechanisms to empower the commission.

2.3.4 Recommended Solutions for the Coastal Zone

Although a number of solutions are proposed, it is important to address the most fundamental, practical and urgent ones. In general, the issues of institutional arrangement and capacities, research and relevant information for climate informed-decision and planning, building local social capital and institution for resources co-management, and improved cooperation need to be addressed first. Therefore, the proposed solutions basically fall into 1) institutional capacity building at either national and sub-national levels, 2)promotion of research and information management and 3) development of mangrove re-plantation plan, especially in historical mangrove areas, and 4) financial mechanism for funding support together with an exploration of potential eco-tourism benefits.

2.4 Technology Action Plan, Project Ideas, and Other Issues in the Coastal Zone

2.4.1 Technology Action Plan for the Transfer and Diffusion of Mangrove Management

Mangrove forest management requires co-management. The co-management of natural resources cannot be implemented successfully unless local people can derive income from their involvement in the process. This is in part due to the high prevalence of rural poverty in Cambodia, limited livelihood options, and arguably low social capital for working together. Because illegal activities especially land encroachments and logging of mangroves are the prime causes of degradation, law implementation and enforcement are required otherwise the natural resources co-management cannot be implemented successfully. The presence of the State needs to be felt more strongly as the customary rights of local people over communal mangroves are not respected. In addition, research is necessary to provide a strong basis of social, economic and biological information for mangrove co-management. To enable the diffusion of mangrove management in Cambodia, a technology action plan is proposed hereunder. The technology action plan considers actions for the short term (3 years), the medium term (5 years), and the long term (10 years).

Promote eco-tourism as a way for resources co-management: Due to high poverty prevalence in rural Cambodia together with limited local livelihood options, it may not be practical to expect full voluntary participation from local communities. Job creation in local communities could facilitate stronger local participation in mangroves forest management. There is in-depth experience in resource co-management at Peam Krasop (Figure 18) Wildlife Sanctuary and Ream National Park (eco-tourism – mangroves protection).In addition, it is important to strengthen local institutions to better tap social capital in protecting mangrove resources. Public consultations at all stages lead to more engagement and acceptance which in turn, will enable the transfer of technology to local communities for operation and maintenance (UNFCCC, 2006).

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Table 11: Technology Action Plan for Mangrove Management

Targets	Barriers	TAP Action Plan			Key stakeholders
		Short term	Medium term	Long term	
Strengthening mangroves forest management on Cambodia's shoreline	Poorly defined institutional mandates and weak institutional capacity	Institutional capacity building and clarification of institutional mandates, improved coordination of responsible agencies and of donors			Coastal Steering Committee, MAFF, MOE and their respective provincial department in coastal provinces and municipality, relevant NGOs
		Capacity building in applied research to produce policy relevant data (social, economic, biological)			Research Institute and Marine Fisheries Development, RUA, RUPP and Partnered International University/research institute
	Limited local awareness and participation in mangrove management	Promote eco-tourism and sustainable small-scale resource extraction (fisheries, timber and non timber forest products) by local people			Coastal Steering Committee, MAFF, MOE, Ministry of tourism, RUPP, RUA, Fisheries and Marine resource development institute relevant NGOs
		Education and awareness raising of the benefits of mangroves for local communities, in particular with regards to ecosystem services (storm protection, fish habitat etc.)			Coastal Steering Committee, MAFF, MOE, RUPP, RUA, relevant NGOs
	Unclear land use planning and land encroachment	Develop national mangrove management and reforestation plan			Coastal Steering Committee, MAFF, MOE and their respective provincial department in coastal provinces and municipalities
		Delineate mangrove areas, mark boundaries of mangrove protected areas, and assign zones for sustainable development activities such as aquaculture and salt farming			Coastal Steering Committee, MAFF, MOE and their respective provincial department in coastal provinces and municipalities, relevant NGOs

Figure 18: Peam Kasop Wildlife Sanctuary

a).Eco-tourism facilities

b). Peam Krasop mangroves

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Develop mangrove management and re-plantation plan: The Cambodia shoreline strategy (RGC, 2006) suggests replanting mangroves in historical mangrove areas. However, many of the mangroves re-plantation projects were not sustained due to land use change and land encroachment. It may be necessary that shrimp farms and salt production are required to develop mangrove re-plantation plan and implement it accordingly. The strategy also suggests developing regional plans for community mangrove management to thus mangroves forest areas for domestic use and areas for protection will be identified. In addition, environmental and social impact assessment for development activities such as shrimp farms and salt production will assist decision-makers and planners in making rational decisions.

Defining and strengthening roles and responsibilities of key stakeholders: Because mangroves forest is protected by Fisheries and Forestry laws which is under mandates of MAFF and the natural resources protection laws which is under the mandates of MOE, therefore both ministries play important role in managing mangroves forest. Meanwhile, the national coastal steering committee has been established, sitting within the MOE with the Minister of Environment as a chairman. Therefore, roles and responsibilities of these two important government agencies need to be clearly defined and strengthened.

Research, education and awareness raising: As part of a coastal zone management project funded by Danida in 1997-2002, a number of cases studies were undertaken to inform decisions, and series of capacity building activities were carried out for relevant staff at provincial level. However, further research to improve understanding and determine appropriate institutional arrangement and capacities, and roles of social capital in managing mangrove resources, is crucial. Exploring eco-tourism potentials is necessary in creating jobs for local communities, a core of sustainable mangroves management. On the other hand, Linham and Nicholls (2010) indicate the importance of stakeholder engagement, communication and awareness raising in the adaptation process, thus it is essential to understand social, cultural and economic dimensions of local communities.

2.4.2 Brief Summary of Project Ideas for International Support (Details in Annex 3)

The Cambodia shoreline strategy (RGC, 2006) recommends replanting mangroves in historical mangrove areas, and developing regional plans for community mangrove management. Development of eco-tourism is argued as the appropriate path towards mangroves resource co-management in Cambodia with already good examples from previous projects, in particular the development of eco-tourism in Peam Krasop Wildlife Sanctuary. The following project ideas are, thus, suggested:

1. Mangrove reforestation and management in coastal aquaculture farms areas
2. Mangrove reforestation and management in coastal salt farms areas
3. Community-based mangroves management and eco-tourism development
4. Strengthening research capacity (related to coastal resources, especially mangrove management) of the Research Institute and Marine Fisheries Development of MAFF, and
5. Institutional capacity building and awareness raising on climate change impacts and vulnerabilities on mangroves forests and marine ecosystems.

2.4.3 Other External Barriers

Most of the proposed solutions are 'no-regret' options, thus they will benefit Cambodia as a whole and the coastal poor in particular. The development and implementation of these proposed projects can only be done if external funding is available, together with the building of the capacity of key stakeholders to absorb funding. The uncertainty of adaptation funds could be a key barrier for this commitment.

2.5 Summary

Mangroves forest management was prioritized by consultative stakeholders and selected to be included in this technology action plan. The implementation of this technology lies with the responsibilities of MAFF and MOE as well as the Coastal Steering Committee. A number of barriers and challenges for the implementation of the technology include elite capture (mangroves areas encroachment and beach reclamation), weak institutional capacities especially the authority of MAFF, MOE and the steering committee in addressing illegal activities, insufficient local participation, limited research and information for knowledge planning and decision, and lack of financial resources. A number of solutions are proposed, ranging from promoting research and information to the strengthening of the roles and responsibilities of the key ministries. The proposed project ideas aim to address specific urgent activities towards the overall objective of sustainable mangrove management and increased resilience to climate change, including development of ecotourism, mangrove re-plantation, institutional capacity strengthening, and promotion of research and information management.

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Annexes

Annex I. Technology Factsheets

Sector	Coastal Zone
Subsector	Coastal Protection
Technology name	**Mangrove Management**
Scale	Small/medium
Availability	Medium to long term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- Salt water intrusion, coastal erosion by strong wave as a result of increasing wind speed under changing climate, mangrove rehabilitation for buffer zone, etc.; - In areas where the likelihood of strong wind and sea level rise is quite high, we may need to introduce new building codes for climate proofing; - Planting wind breaker in some agriculture areas may also be necessary to reduce negative impacts of strong wind on seasonal crops.
Implementation assumptions	- The Royal Government of Cambodia has planned a number of programs to promote awareness raising and capacity building and livelihood improvement in mangrove management and coastal protection; - Strengthening the management and conservation of wetlands, biosphere, and coastal zones including mangrove management (NSDP Update 2009-2013); - Small scale technologies implementation through program which are applied at sub national or community level and household; - These technologies applied at household or community level are considered small/medium scale technologies.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Climate change will result in sea level rise and have a number of different physical and ecological effects on coastal systems. These include inundation, flood and storm damage, loss of wetlands, erosion, and saltwater intrusion; - Cambodia has identified development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC.
Country development priorities	- The importance of the coastal protection for Cambodia's overall economy, and for the economy of a coastal provinces; - Supporting national economic development and stability.
Country environmental	- Protection and management of natural coastal resources;

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development priorities	- Avoiding polluting coastal water resources in order to protect ecosystems; - Increased adaptation resilience.
Other consideration and priorities such as market potential	- Potential market for coastal protection
Capital costs over 10 years	- The costs are dependent on the extent of the mangrove forests to be managed, their accessibility and their natural state. Heavily degraded areas will require substantially more investment than well preserved forests. Capital costs would include tools, equipment and technical support to local communities.
Operational costs over 10 years	- Community based resources management involving local people can reduce significantly the operational costs, but this depends on local communities interest and on the benefits they may derive from helping managed mangrove forests.
Other costs over 10 years	N/a

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Sector	COASTAL ZONE
Subsector	Coastal Protection
Technology name	**Seawalls, Dikes, Barriers**
Scale	Small/Medium
Availability	Medium to Long Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- Salt water intrusion, coastal erosion by strong wave as a result of increasing wind speed under changing climate, mangrove rehabilitation for buffer zone etc.; - In areas where the likelihood of strong wind and sea level rise is quite high, we may need to introduce new building codes for climate proofing.
Implementation assumptions	- The Royal Government of Cambodia has planned a number of programs to increase awareness raising and capacity building and livelihood improvement in coastal protection include seawalls, dikes; - Maximising the mitigation of flood effects and build capacity to prevent floods from precipitation and sea water; - Providing the public with weather forecast information, advice and education to enhance their understanding on how to prevent and minimise the impact of extreme events caused by nature and climate change: wind storm, lightening storm, tsunami, coastal floods etc. (NSDP Update 2009-2013); - These technologies apply on sub national and community levels and are considered small/medium to scale technologies.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Sea level rise by climate change will have a number of different physical and ecological effects on coastal systems. These include inundation, flood and storm damage, loss of wetlands, erosion, and saltwater intrusion; - Cambodia has identified development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - These adaptation options under SNC (SNC, 2010) could be classified in different ways. One way of classifying adaptation options is as structural and non structural interventions. Seawalls, dikes and barriers fall under structural interventions.
Country development priorities	- The importance of the coastal protection for Cambodia's overall economy, or for the economy of a coastal

	provinces within the country; - Supporting national economic development and stability.
Country environmental development priorities	- Protection and management of natural coastal resources; - Avoid soil pollution including avoided waste disposal and improvement of the soil and improved water quality; - Avoiding polluting coastal water resources in order to protect ecosystems; - Increased adaptation resilience.
Other consideration and priorities such as market potential	- Potential market for coastal protection.
Costs (US$)	
Capital costs over 10 years	N/a
Operational costs over 10 years	N/a
Other costs over 10 years	N/a

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Sector	WATER RESOURCES
Subsector	Domestic water supply
Technology name	**Rainwater Harvesting from Rooftops**
Scale	Small
Availability	Short Term, Medium Term and Long Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- Cambodia's key strengths are the availability of land, soil and water that at presently are not used or are used inefficiently. The strategy includes, for example, promoting improved farm water management through water harvesting/storage, gravity-fed irrigation systems, and technology such as drip irrigation of crops; promoting rice-field fisheries and aquaculture; promoting settlement of cultivable land and securing land ownership against land theft (MAFF and MoWRAM, 2007).
Implementation assumptions	- National Water Resources Policy, several laws and sub-decrees recently approved in the agriculture and water sector; - Small scale technologies implementation through programs which are applied at sub national or community/household level; - Short term technologies have been applied commercially with proven reliability in a comparable market context.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Cambodia has identified development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - The capacity of water reservoirs has expanded and the ability to provide water for cultivation has increased; - The Royal Government has established water user communities with increasing participation from farmers.
Country development priorities	- Establishing and supporting farmer development community, Farmer Water User Communities, assisting farmers to establish agriculture cooperatives and other organizations to market agricultural products and purchase inputs; - Providing safe and clean water to rural households.
Country environmental development priorities	- Promoting soil fertility management, protecting water resources from pollution and degradation so that they continue to be available for human consumption, fisheries, ecosystem maintenance, etc.
Other consideration and priorities such as market	- The technology is small-scale, proven and less capital-intensive. It has market potential nationwide.

potential	
Costs (US$)	
Capital costs over 10 years	- The initial investment costs depend on the size of the buildings or houses to be equipped as wells as the storage capacity required. For a typical household, a one-time capital cost of US $500 to $1000 is required.
Operational costs over 10 years	- Operational costs are minimum aside from regularly cleaning for debris and sediments, and repairs of potential leaks.
Other costs over 10 years	N/a

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Sector	WATER RESOURCES
Subsector	Domestic water supply
Technology name	**Household Water Treatment and Safe Storage**
Scale	Small/medium
Availability	Short Term, Medium Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- Rural water supply for domestic need, primary health care and rural sanitation, community development, and development of rural economy; - Developing drinking water supply for rural households; - Improvement of accessibility to safe-drinking water and sanitation in particular in rural communities residing in water-scarce areas as well as water to be used in households and for irrigation purposes (NSDP Update, 2009-2013); - In addition, NAPA has identified and prioritized many water related projects in specific locations (SNC-V&A Assessment, 2010).
Implementation assumptions	- The attempt here is to support the implementation of NAPA water infrastructure related projects; - Construct, repair and maintain all types of existing wells; provide ponds; and produce jumbo cement water jars in order to provide safe drinking water and water for household use as well as build small-scale irrigation system.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Cambodia has identified development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - The Royal Government has established water user communities with increasing participation from farmers; - The Royal Government of the Fourth Legislature will continue to accord priority to the rehabilitation, construction, maintenance and efficient management of water reservoirs, canals, pipes, drainages and water pumping (NSDP Update 2009-2013).
Country development priorities	- Developing drinking water supply and sanitation expansion projects for poor communities; - Examining the drinking water production costs set by public water works except for the autonomous agencies.
Country environmental development priorities	- Strengthening environmental protection and sanitation to preserve unpolluted water and clean environment; - Avoiding polluting water resources in order to protect

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	ecosystems
Other consideration and priorities such as market potential	- Improving quality, business efficiency, and governance of water works
Costs (US$)	
Capital costs over 10 years	N/a
Operational costs over 10 years	N/a
Other costs over 10 years	N/a

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Sector	WATER RESOURCES
Subsector	Domestic water supply
Technology name	**Wells for Domestic Water Supply**
Scale	Small
Availability	Short Term, Medium Term and Long Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- Constructing, repairing and maintaining all types of existing wells; provide ponds; and produce jumbo cement water jars in order to provide safe drinking water and water for household use (NSDP update 2009-2013); - The RGC's Strategic Framework for Decentralization and Deconcentration Reform promotes a transfer of responsibilities and resources to sub-national and local levels; - The Strategy includes promoting improved farm water management through water harvesting/storage (MAFF and MoWRAM, 2007).
Implementation assumptions	- National Water Resources Policy, several laws and sub-decrees recently approved in the agriculture and water sector; - Accessibility to safe-drinking water and sanitation in particular in rural communities residing in water-scarce areas; - Small scale technologies implementation through programs which are applied at sub national or community level as well as at household level; - These technologies apply at the household or community level are considered small scale technologies; - Short term technologies have been applied commercially with proven reliability in a comparable market context.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Cambodia has identified development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - The capacity of water reservoirs has expanded and the ability to provide water for cultivation has increased; - The Royal Government has established water user communities with increasing participation from farmers.
Country development priorities	- Establishing and supporting farmer development community, Farmer Water User Communities, assisting farmers to establish agriculture cooperatives and other organizations to market of agricultural products and purchase inputs.

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Country environmental development priorities	- Protecting water resources from pollution and degradation so that they continue to be available for human consumption, fisheries, ecosystem maintenance, etc.
Other consideration and priorities such as market potential	- The technology is small-scale, proven and less capital-intensive. It has market potential nationwide.
Costs (US$)	
Capital costs over 10 years	- Costs are dependent on the type of technology to be used (open wells, semi-open wells, bore wells), and the depth of the water table. An initial investment cost of about US $1000 per well is required. Open wells are expected to last 20 years with minimum maintenance other than removing sediments during the dry season.
Operational costs over 10 years	- Bore wells with hand pumps are the least costly but require spare parts and regular maintenance, whilst open wells can be maintained by local communities at lower cost.
Other costs over 10 years	N/a

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Sector	WATER RESOURCES
Subsector	Water Supply for Agriculture
Technology name	**Small Reservoirs, Small Dams and Micro-Catchments**
Scale	Small/medium
Availability	Short Term, Medium Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- The Royal Government has prioritized the rehabilitation, construction, maintenance and efficient management of irrigation infrastructure, water reservoirs, canals, pipes and water pumping stations to increase irrigated areas and boost agricultural production (NSDP Update, 2009-2013); - In addition, NAPA has identified and prioritized many water related projects in specific locations (SNC-V&A Assessment, 2010).
Implementation assumptions	- The attempt here is to support the implementation of NAPA water infrastructure related projects; - Construct, repair and maintain all types of existing small reservoirs, small dams and micro-catchments, produce jumbo cement water jars for household use as well as build small-scale irrigation system.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Cambodia has been identifying development priorities as part of NAPAs, NSDP Update 2009-2013, Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - The Royal Government priority to the rehabilitation, construction, maintenance and efficient management of water reservoirs, canals, pipes, drainages and water pumping (NSDP Update 2009-2013);
Country development priorities	- Prioritising rehabilitation and construction for economic purpose of reservoirs, ponds, canals and drainage system to ensure the water supply for cultivated land areas, aquaculture, daily use and animals.
Country environmental development priorities	- Strengthening environmental protection and sanitation to preserve unpolluted water and clean environment; - Maximising the mitigation of flood effects and build capacity to prevent floods from rain; - Avoid polluting water resources in order to protect ecosystems
Other consideration and priorities such as market potential	- Improving quality, business efficiency, and governance of water works
Capital costs over 10 years	- The capital investment for community water

	infrastructures is usually beyond the resources available to a village or even a cluster of villages. A multiple use reservoirs that can meet the needs 2-3 villages will cost a minimum of US $15,000 to construct.
Operational costs over 10 years	- Villagers are expected to contribute labour towards the maintenance of the reservoirs, which should bring down operational costs significantly.
Other costs over 10 years	N/a

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Sector	WATER RESOURCES
Subsector	Water Supply for Agriculture
Technology name	**Community Irrigation Systems**
Scale	Small/medium
Availability	Short Term, Medium and Long Term
Technology to be included in prioritisation	- Assessing technologies through multi criteria analysis (based on TNA team assumption through assessment criteria, and TNA Tool).
Background/notes	- The Royal Government priority to the rehabilitation, construction, maintenance and efficient management of irrigation infrastructure, water reservoirs, canals, pipes, drainages to increase irrigated areas and boost agricultural production (NSDP Update, 2009-2013); - In addition, NAPA has identified and prioritized many water related projects with location specific (SNC-V&A Assessment, 2010).
Implementation assumptions	- The attempt here is to support the implementation of NAPA water infrastructure related projects; - Build small-scale irrigation system; - Prioritise the rehabilitation and construction of irrigation system and drainage system in the areas where the poor reside; - Farmers, stakeholders, and private sector involved in irrigation and drainage system development
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	- Cambodia has been identifying development priorities as part of NAPAs, NSDP Update (2009-2013), Poverty Reduction Strategy, Policies, National Communications (INC and SNC) to the UNFCCC; - The Royal Government priority to water resources management and development, and implementation of a hegemonic irrigation system (NSDP Update 2009-2013).
Country development priorities	- Rehabilitating and constructing the existing irrigation system as development priority to meet the urgent needs of water supply for agriculture; - Generating incomes through irrigated agriculture and continued investments.
Country environmental development priorities	- Strengthening environmental protection and sanitation to preserve an unpolluted water and clean environment; - Avoiding polluting water resources in order to protect the ecosystem.
Other consideration and priorities such as market potential	- Encouraging investments from international development partners and the private sector to support the development, maintenance, and management of the irrigation system.

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Capital costs over 10 years	N/a
Operational costs over 10 years	N/a
Other costs over 10 years	N/a

Annex II. Market Maps for Technologies and Problem Trees

Technology	Category	Description	Market characteristics
Rainwater Harvesting from Rooftops and Wells for Domestic Water Supply	Consumer goods	Goods specifically intended for the small market; households, businesses and institutions	- High number of potential consumers - Interaction with existing markets, maintenance and installer networks in the supply chain - Small and complicated supply chains with many actors, including producers, assemblers, wholesalers, retailers and end consumers - Demand depends on consumer awareness and preferences
Small Reservoirs, Small Dams and Micro-Catchments	Capital goods	Equipment used in the production of goods, e.g., water for agricultural crops	- A limited number of potential sites/consumers - Relatively high capital investment - Simple market chain - Demand is profit-driven and depends on demand for the products the capital goods are used
Mangrove Management (Conservation, Restoration, Sustainable Use)	Public goods / nonmarket goods	Contributes to the provision of public benefits and services; Transferred and diffused under nonmarket, governments, public or nonprofit institutions, international donors or NGOs	- Public ownership or joint management with local communities - Serves overall political development objectives, such as poverty alleviation, contribution to the Cambodian Millennium Development Goal (CMDG) - Donor or government funding

	Barriers to implementation of technology	Cause of barriers
Rainwater Harvesting from Rooftops	a. Installation cost	- High price of materials, land and labor cost - Lack of financial incentives - Limited contribution fund and participation - Accessibility and remoteness
	b. Limited standard requirements	- High price of materials - Not enough rainfall - No clean roof construction - Lack of roof surface requirement - Insufficient legal and regulatory framework - Insufficient standards - Lack of knowledge and dissemination - Lack of experts and extension officers
	c. Local knowledge and people behavior (low acceptance of the technology)	- Unstable market access - Limited rural roads and infrastructure - High transaction costs - Limited feasibility studies - Lack of local consultants - High price of materials - Lack of financial incentives - Lack of knowledge for communication - Not enough rural extension officers
	d. Lack of incentives	- High price of materials - Lack of subsidy on materials - Lack of financial incentives - Limited financial resources and funds

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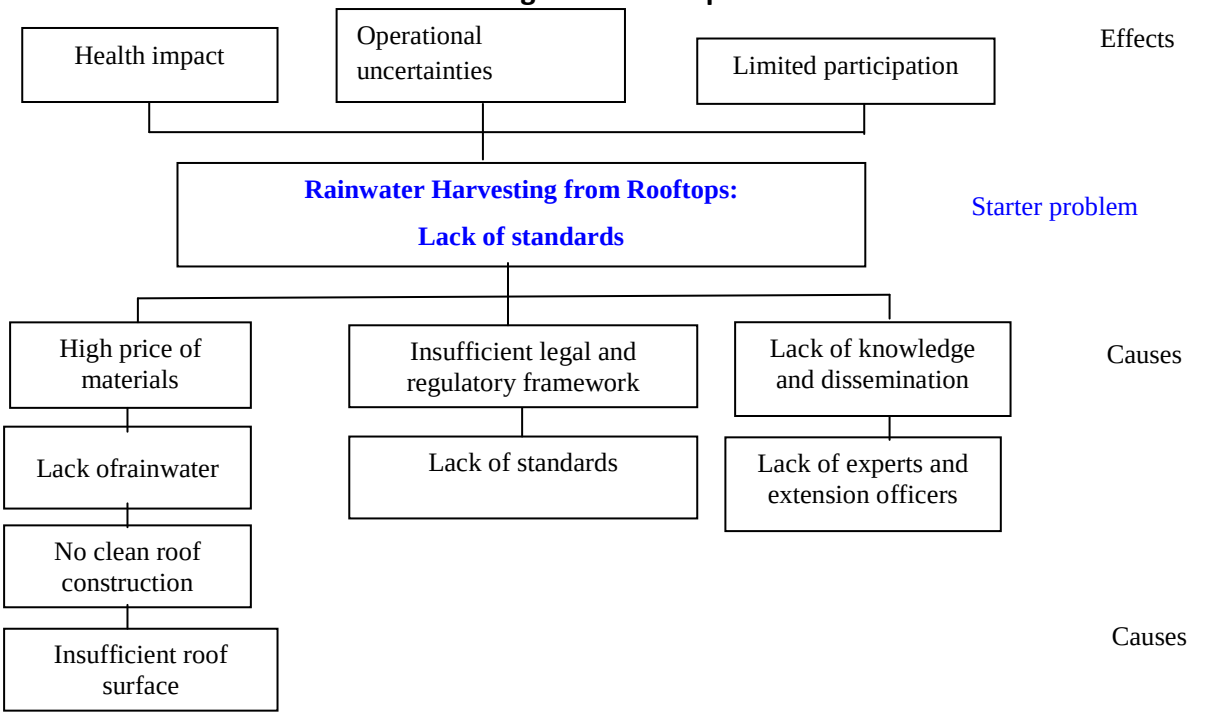
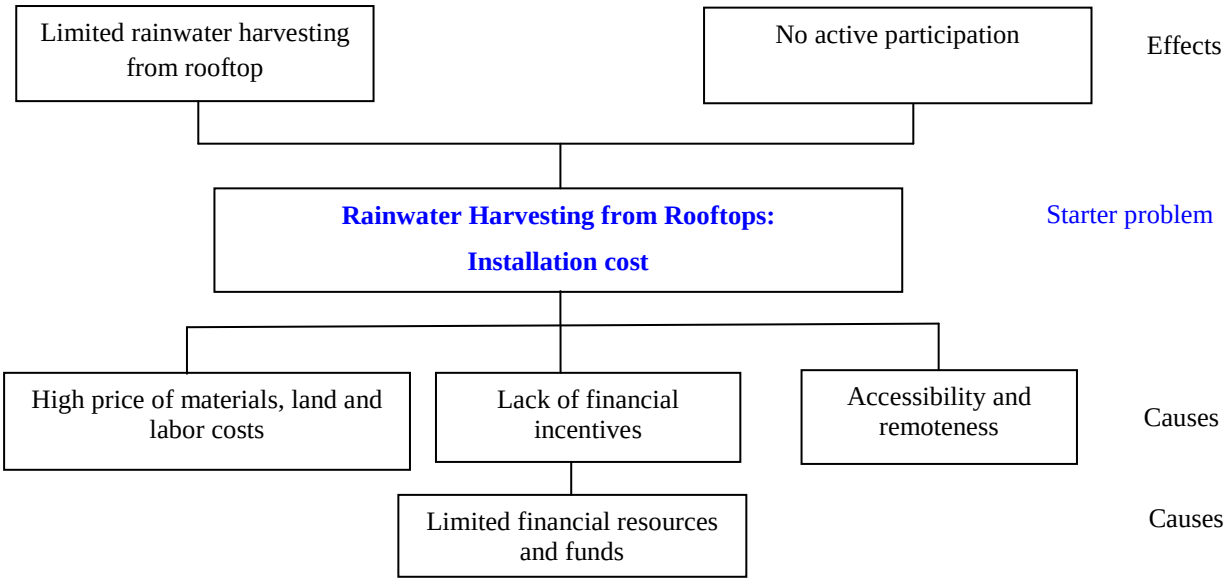
Problem Trees for Rainwater Harvesting from Rooftops





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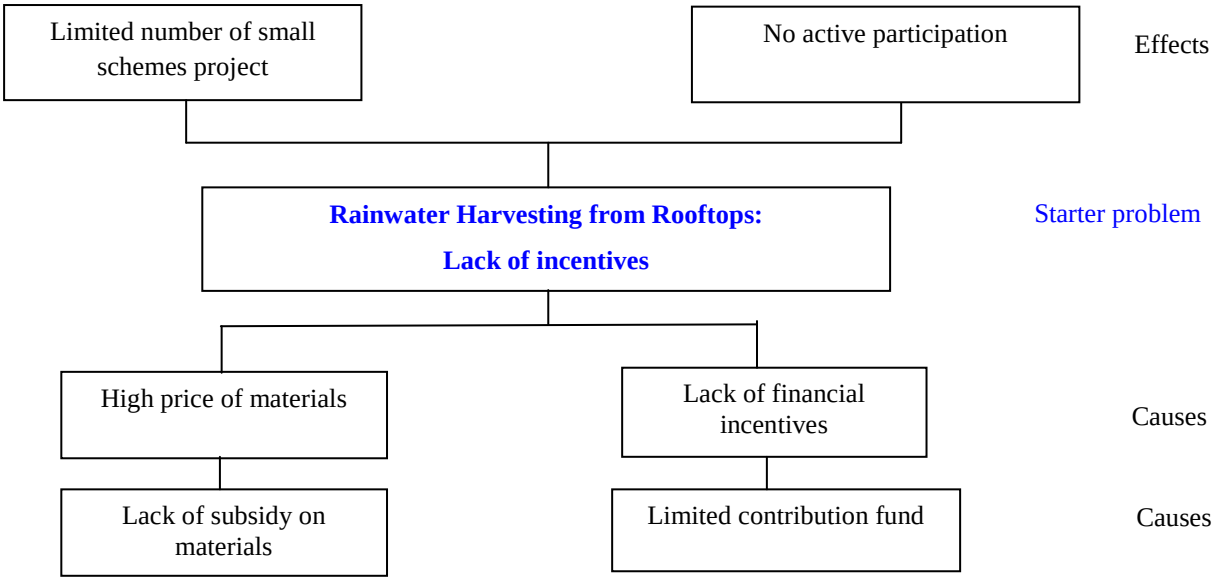

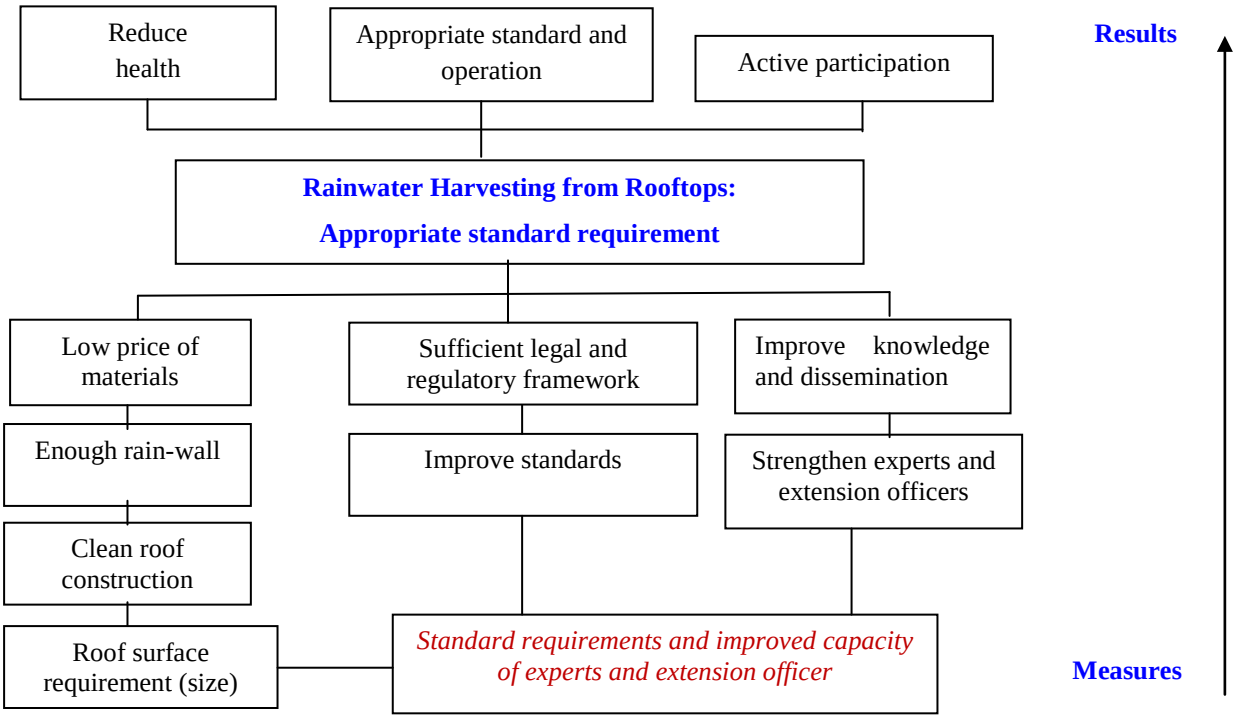

Annex III. Project Ideas

PROJECT IDEA NOTE 1

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Rainwater harvesting and wells
Project name	Mainstreaming climate change considerations into the 'National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25' and institutional capacity building at national level
Background	Climate variability and change threaten water supply in many ways especially through climate stress on water availability and quality as well as climate change impacts on water supply infrastructure. The potential for climate causing vulnerabilities would add pressure to the current government commitment in halving the population with no access to safe water supply and improved sanitation by 2015, and providing a full coverage of rural water supply and sanitation by 2025. The current national strategy for rural water supply, sanitation and hygiene has very limited climate change considerations. The existing institutional capacity in undertaking climate change adaptation efforts is inadequate.
Purpose and objectives	This project aims to assist the Ministry of Rural Development in mainstreaming climate change considerations into its current policy and strategy documents, together with institutional capacity strengthening at national level to enable the implementation of the policies and strategies. The project covers the following specific objectives: 1. Strengthen the capacity of relevant MRD officials on climate change, impacts, vulnerability and adaptation in water sector, 2. Strengthen the capacity of relevant MRD officials on climate-informed planning and decision-making , 3. Integrate climate change impacts on water availability and quality into the current rural water supply strategy, 4. Integrate climate change vulnerabilities and risks on rural water supply infrastructure into the current rural water supply strategy, and 5. Identify climate resistant/climate proof water supply technologies that are suitable for rural Cambodia.
Relationship to national sustainable development objectives	The project will facilitate government commitment in halving population without access to improved water supply by 2015 and provide full coverage of improved access to water supply by 2025.
Project deliverables	As suggested by the World Bank Institute, institutional

	capacity building should be designed on the basis of capacity gaps in implementing policy and strategy, thus capacity needs assessment must be undertaken to identify the gaps, motivators and incentives in improving efficiency of the capacity strengthening. The project is expected to produce an updated version of the rural water supply, sanitation and hygiene strategy that integrates climate change impacts and vulnerabilities, together with capacity in place in MRD to implement it.
Project scope	The Ministry of Rural Development is responsible for rural water supply and sanitation, and implementing the government's policy and strategy on rural water supply, sanitation and hygiene. This project, thus, works directly with the Ministry. Two key departments of the Ministry, the Department of Rural Water Supply and the Department of Rural Health Care are the specific units responsible for implementing the policy and strategy. Therefore, they are the main beneficiaries of the project, receiving capacity building and closely working on mainstreaming climate change considerations into policy and strategy.
Timeline	18 months
Budget/resource requirements	The project would require about US$ 200,000 to cover administration costs, experts and logistics of the training. Funds should be allocated separately for the Ministry (for administration and logistics) and universities (training fees and technical support).
Measurement/Evaluation	The project outputs can be measured by the quality of an updated version of the policy and strategy document, the number of trainings and trainees participating in the trainings as well as their improved understanding. The project impacts can be demonstrated through the implementation of the new version of the policy and strategy.
Challenges	The main anticipated challenge of this project is to select experienced motivators of staff and to provide incentives to turn knowledge into practical action.
Responsibilities and Coordination	The project should be implemented by the MRD itself in cooperation with local universities with expertise in climate change and experience in capacity building. Technically, it may be more appropriate that MRD takes a coordination role, while the universities provide training and conducts capacity needs assessments and technical backup during mainstreaming process. It is important that MRD key policy-makers and technical staff are actively involved not only in the mainstreaming process, but also in the capacity building activities.

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PROJECT IDEA NOTE 2

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Rainwater harvesting and wells
Project name	Climate related capacity building and strengthening for Rural Water Supply officials at sub-national level
Background	The provincial department of rural development (PDRD) plays an important role in implementing rural water supply, sanitation and hygiene strategy and will have significantly more responsibilities when the organic laws are put in place. The capacity of sub-national level institutions is limited in many areas and even more so for climate change adaptation knowledge. As climate change is a cross cutting issue and requires field work, it is necessary to build capacity of local institutions, at least at the provincial level if not at the lower ones. Experiences in many countries in the world also highlight the central roles of local institutions in addressing climate vulnerability and risks.
Purpose and objectives	The overall purpose of the project is to improve the understanding of government officials at the provincial department of rural development in climate change and variability and associated impacts; and available climate change adaptation technologies in water supply and sanitation, especially on household water supply and sanitation technologies. The specific objectives of the project include: 1. Strengthen the capacity of relevant PDRD officials in climate change, impacts, vulnerabilities and adaptation in the water sector, 2. Strengthen the capacity of relevant PDRD officials in climate-informed planning and decision-making process, 3. Identify climate resistant/climate proof water supply technologies that are suitable for specific rural areas given proper consideration to local climate conditions, 4. Strengthen the relationship between PDRD officials of different provinces and facilitating the sharing experiences and lessons learned.
Relationship to national sustainable development objectives	The project will facilitate government commitment in halving population without access to improved water supply by 2015 and provide full coverage of improved access to water supply by 2025.
Project deliverables	This institutional capacity building project is expected to enable provincial departments of rural development to prepare more climate informed planning through mainstreaming climate change considerations in their respective development plans; thus appropriate adaptation

	measures, especially climate-proof water supply and sanitation technologies will be chosen.
Project scope	Relevant officials of PDRD nationwide are the target beneficiaries of this capacity building project.
Timeline	2 years
Budget/resource requirements	The project would require about US$ 200,000 to cover administration costs, experts and logistics of the training.
Measurement/Evaluation	Quantitative indicators to measure outcomes of the project include: number of trainers, number of training manuals, number of trainings organized, number of training days, number of training participants, and number of demonstration projects. Throughout the training process, trainers should assess and provide feedback to participants to ensure that they have duly assimilated knowledge and know-how from the training. Long term impacts of the project can be measured by examining development plans of the provincial departments of rural development on what climatic factors were considered in selecting water supply and sanitation technologies.
Challenges	The main anticipated challenge of this project is to select experienced motivators of staff and to provide incentives to turn knowledge into practical action.
Responsibilities and Coordination	The project should be implemented by local universities with expertise and experience in climate change capacity building in cooperation with the Ministry of Rural Development. A steering committee composed of representatives from MRD, the Climate Change Department and local universities should be established to direct the implementation of the project as well as to synergize available resources.

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PROJECT IDEA NOTE 3

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Rainwater harvesting and wells
Project name	Pilot climate-informed planning and climate proof well designs in Takeo province
Background	Supplying safe drinking water and sanitation to rural residents are key development priorities of the Royal Government of Cambodia (RGC). As indicated in the Cambodian Millennium Development Goals, the RGC is committed to providing half of rural residents with safe water supply and improved sanitation by 2015. According to the Ministry of Planning (2011), progress has been slow and it is unlikely the set targets will be met. Climate change impacts were underlined as one of the key constraints in achieving the CMDG. Similarly, climate variability and change, as projected by the Intergovernmental Panel on Climate Change (IPCC) and in the scientific literature, will soon have significant impact on the water sector in Asia: unequal distribution of the hydrological cycle which in turn will result in extreme climatic events especially flood and drought. Either open or tube wells suffer from climate stresses especially flood and drought. In some areas in Cambodia, wells suffer from the shortage of groundwater, while in other places they were damaged or contaminated by floods.
Purpose and objectives	The project aims to pilot and demonstrate climate-informed planning in water supply especially in flood proof well designs in flood prone areas of Takeo Province. The specific objectives include: 1. Train provincial officials of rural development in climate impacts and vulnerabilities on water supply and sanitation, 2. Facilitate and stimulate climate-proof decision making and map out climate stresses and vulnerabilities in the province, 3. Design climate resistant/ climate proof water supply technologies that are suitable for different flood prone areas of Takeo and integrate them into the provincial rural water supply development plans, 4. Pilot 20 flood-proof wells in selected flood prone locations of Takeo, and 5. Compile and disseminate lessons learnt and good practices.
Relationship to national sustainable development objectives	Successful completion of this project would demonstrate a growing institutional culture of climate informed planning and decision-making among rural water supply officials.

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	Flood-proof water supply and sanitation technologies can significantly contribute to sustainable rural water development and poverty reduction.
Project deliverables	Successful completion of the project is expected to strengthen capacity of Takeo PDRD in planning climate change adaptation project for rural water supply. It is also expected that the project can be scaled up nationwide, to thus achieve the government's commitment in providing full coverage of rural water supply and sanitation by 2025. Twenty climate-proof wells constructed would be an infrastructure outcome of the project. Another project deliverable is a list of identified suitable climate change adaptation measures for different localities according to the climate stresses and vulnerabilities mapped out. Moreover, capacity building and their improved understanding in climate change adaptation for the rural water supply sub-sector is another project deliverable with long lasting influence on the implementation of the rural water supply and sanitation policy and strategy.
Project scope	Takeo is one of the highly flood prone provinces, thus flood-proof water supply and sanitation technologies can significantly contribute to rural development and poverty reduction. The implementation of this project is to pilot an updated version of the rural water supply, sanitation, and hygiene that integrates climate change considerations.
Timeline	2 years
Budget/resource requirements	The project would require about US$ 200,000 to cover the costs of infrastructure, technical experts, and administration.
Measurement/Evaluation	Capacity building can be measured by the number of training and trainees, and their improved understanding in climate change adaptation for the rural water supply sub-sector.
Challenges	Shortage of climatic data and projections, and groundwater information poses a significant hurdle to the implementation of the project.
Responsibilities and Coordination	It is suggested that the project be implemented by Takeo PDRD with coordination support from MRD. A technical expert should be included in the project to provide technical backup to the implementing unit and to compile good practices and lessons learned. Development partners should also be involved to ensure that they also receive consistent messages from PDRD, which would ensure effective communication and promote cooperation.

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PROJECT IDEA NOTE 4

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Wells
Project name	Scaling up of flood proof well designs in flood prone areas,
Background	This project consists of the actual implementation of the rural water supply and sanitation strategies, scaling up from the pilot project in Takeo (Project Idea Note 3). As identified in the Cambodian NAPA, the provinces that are highly vulnerable to flood include Prey Veng, Takao, Kampong Thom, Battambang, Banteay Meanchhey and Kampong Cham
Purpose and objectives	Specific objectives of this project are: 1. Map out climate stresses and vulnerabilities in each province, and use it for rural water supply planning, 2. Map out available water supply sources of the selected provinces, 3. Design climate-proof wells or suitable water supply technologies for specific locations according to the identified climate stresses, vulnerabilities, and availability of water sources, 4. Construct climate-proof wells design in high risk flood areas, and 5. Monitor and evaluate the constructed wells and compile lessons learned accordingly.
Relationship to national sustainable development objectives	The project will facilitate government commitment in halving population without access to improved water supply by 2015 and provide full coverage of improved access to water supply by 2025.
Project deliverables	Successful completion of the project is expected to strengthen capacity of PDRDs in the selected provinces in planning climate change adaptation projects for rural water supply. The project will not only demonstrate the implementation of an updated version of the rural water supply and sanitation strategy, but also facilitate the implementation of the government organic laws that are in transitional stage. Moreover, the project will build capacity of MRD and PDRDs and promote a culture in climate-informed planning. The climate-proof wells constructed would be an infrastructure output of the project. The project will also produce maps of climate stresses and vulnerabilities of the provinces together with lists of identified suitable climate change adaptations for different localities.
Project scope	The project will be implemented in Prey Veng, Takeo, Kampong Thom, Battambang, Banteay Meanchhey and Kampong Cham, high flood prone provinces.

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Timeline	3 years
Budget/resource requirements	The project would require about US $3 million to cover the costs of infrastructure, technical expertise, and administration. Co-funding or/and additional projects from development partners will further contribute to the government's target.
Measurement/Evaluation	Infrastructure inventory can be used as a quantitative indicator, measuring number of wells constructed, while design criteria including construction materials can be used to evaluate whether or not the infrastructure is soundly climate-proof. The longer average life of wells could be a good indicator of good climate proof designs.
Challenges	Shortage of climatic data and projections, and groundwater information poses a significant hurdle to the implementation of the project. There are also limited local investments and shared capital in construction due to high rural poverty prevalence.
Responsibilities and Coordination	The project should be coordinated by MRD, and implemented by PDRDs with technical support from selected local universities and technical specialists. Rural water supply development partners should closely be involved, so that the implementation of the rural water supply and sanitation strategy is widely disseminated. The involvement of a wider range of stakeholders will also enhance cooperation, a key challenge in development efforts in Cambodia.

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PROJECT IDEA NOTE 5

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Rainwater harvesting
Project name	Provision of rainwater harvesting systems in arsenic prone areas
Background	Rainwater in Cambodia is considered as a safer source for water supply. In rural areas, the technology has been used traditionally, though an improved technology needs to be introduced for safer water quality and larger storage volume, to cover dry season period. Rainwater harvesting systems should be introduced to locations that have reasonable levels of rainfall or areas where rainfall is projected to increase. The technology becomes more important in arsenic prone areas where groundwater is not safe and/or only few water sources are available. Arsenic high risk areas are located in 49 districts of 6 provinces: Kandal, Prey Veng, Kampong Cham, Kampong Chhnang, Kampong Thom and Kratie.
Purpose and objectives	The overall objective of this project is to provide households and communities improved rainwater harvesting systems, with the following specific objectives: 1. Identify specific locations for provision of rainwater technology through overlay mapping of arsenic prone areas and climatic stresses maps, 2. Strengthen capacity of PDRD in designing improved rainwater harvesting systems, and operation and maintenance (O&M) skills, and 3. Provide rainwater harvesting systems to community, along with awareness raising and capacity building on O&M.
Relationship to national sustainable development objectives	Successful completion of the project is expected to strengthen capacity of PDRDs in the selected provinces in planning climate change adaptation project for rural water supply. The project will not only demonstrate the implementation of an updated version of the rural water supply and sanitation strategy, but also facilitate the implementation of the government organic laws that are in transitional stage.
Project deliverables	The project will build capacity of MRD and PDRDs and promote a culture in climate-informed planning. The rainwater harvesting systems constructed would be an infrastructure output of the project. The project would also produce climate stresses and arsenic maps of the provinces.
Project scope	It is suggested that the project be implemented in Kandal, Prey Veng, Kampong Cham, Kampong Chhnang, Kampong Thom and Kratie, high arsenic prone provinces.

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Timeline	2 years
Budget/resource requirements	The project would require about US$ 1 million to cover the costs of infrastructure, experts, and administration. Co-funding or/and additional projects from development partners will further contribute to the government's target.
Measurement/Evaluation	Infrastructure constructed can be used as quantitative indicators, measuring the number of rainwater harvesting systems constructed. Other important indicators include: maps produced and how they are used in decision making at the provincial level; improved understanding of PDRDs on rainwater harvesting systems (designs and O&M).
Challenges	Shortage of climatic data and projections, and groundwater information poses a significant hurdle to the implementation of the project. There are also limited local investments and shared capital in construction due to high rural poverty prevalence.
Responsibilities and Coordination	The project should be coordinated by MRD, and implemented by PDRD with technical support from experienced organisations such as RainWater Cambodia, and RDI who have experience in implementing similar projects. In addition, the project should also involve local universities in some of the activities such as overlay mapping between arsenic prone areas and climate stresses and vulnerabilities. The project should also work closely with local authorities and water user groups to ensure that knowledge and awareness are encouraged at the community level, in particular with regards to O&M issues.

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PROJECT IDEA NOTE 6

Sector	WATER RESOURCES
Subsector	Water supply for households
Technology name	Rainwater harvesting and wells
Project name	Strengthening research capacity for the Faculties of Sciences of Royal University of Phnom Penh(RUPP) and Institut de Technologie du Cambodge (ITC)
Background	Limited research capacities of local universities and higher education institutions especially in science and technology are one of the constraints in facilitating a sound knowledge or information based decision-making and planning in Cambodia. With anticipated risks of climate change, it becomes more important to develop a culture of informed planning, thus may be able to minimize future climatic vulnerabilities and risks and promote a sound sustainable development of the country. The development of this project idea is undertaken in consultation with the national policy in strengthening higher education, and the human development road map of the country as well as to respond to the needs for the development of water supply sector that confronts emerging problems, especially an increasing climate disasters and risks, and elevated arsenic concentration in groundwater.
Purpose and objectives	The proposed project/program aims to strengthen research capacities of two key scientific bodies: the Faculty of Sciences of Royal University of Phnom Penh (Department of Environmental Sciences, and Department of Chemistry) and the Department of Chemical and Food Engineering of the Cambodian Institute of Technology. Specific objectives of the project should include: 1. Review and develop institutional policy and mechanism, and funding mechanism for promoting science and technology research, 2. Develop institutional capacities, addressing the current barriers and challenges, by evaluating existing research capacities of the institutions (human resources, water quality laboratory equipments and existing cooperation/partnerships), 3. Support at least 10 water supply related research projects of the institutions that highly prioritized by WATSAN working groups, and 4. Participate and regularly disseminate research findings to WATSAN working groups and interested stakeholders.
Relationship to national sustainable development	The target academic institutions may be the largest sources of young scientists and engineers in the fields of water supply

objectives	and sanitation, food processing, and pollution controls. As indicated in the National Human Development Roadmap, lack of scientists and engineers are critical for the development of the country.
Project deliverables	Successful completion of this project will enable the target academic institutions to conduct scientific and technological research projects, especially in the area of water supply and sanitation.
Project scope	As suggested by Kian-Woon et. al, (2010) local universities who have developed their research foundations should be strengthened. The RUPP's Faculty of Sciences and ITC are the leading local academic institutions in sciences and engineering. Therefore, it is important to strengthen their existing capacities. The proposed project is in line with and complementary to the World Bank's support to strengthen higher education, and fund research projects in Cambodia. Strengthening research capacities of the institutions should be built upon the existing capacities in term of human resources, facilities, and institutional mechanism and policies, aligning with the Cambodian human development roadmap and the national policy to strengthen higher education.
Timeline	5 years
Budget/resource requirements	The project would require US$ 1 million to cover the period of five years and fund at least 10 research projects (with individual funding of up to US$ 50,000 for each project). This budget also covers consumables and minimum laboratory equipment.
Measurement/Evaluation	The success of the project can be measured against the following indicators: number of professionals trained, number of research proposal submitted and selected for implementation, laboratory equipment purchased, applications of research findings by WATSAN working groups and institutional, and financial mechanisms established.
Challenges	The main challenges of this project consist of assigning additional responsibilities to individual lecturers and researchers given the fact that existing government incentives are limited. In addition, limited facilities and technical expertise to conduct research work is also a challenge.
Responsibilities and Coordination	The RUPP and ITC are public academic institutions under the Ministry of Education, Youth and Sport (MEYS); however, the project should be implemented by the respective management of the universities taking into account existing policies, institutional mechanisms and capacities. The project should be designed into two stages. Stage 1 consists of the development of institutional policies, mechanisms and

	capacities. In Stage 2, research coaching, and dissemination of findings will be carried out.

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PROJECT IDEA NOTE 7

Sector	WATER RESOURCES
Subsector	Water for agriculture
Technology name	Small dams, small reservoirs and micro-catchments
Project name	Institutional capacity strengthening on climate change impacts, vulnerability and adaptation for MoWRAM and MAFF at national level
Background	Climate stresses – flood, drought, and windstorms have considerable impacts on the water and agriculture sectors, but climate change related concerns are only briefly mentioned in national water and agriculture policy documents. Moreover, as indicated in the Strategy for Agriculture and Water, the lack of technical staff (meteorologists, hydrologists and water chemical engineers) is another challenge for the ministries in charge. With additional pressure from climate change impacts, inadequacies in institutional capacity and policy will only worsen if not urgently and properly addressed.
Purpose and objectives	The purpose of this project is to strengthen the capacities of MAFF and MOWRAM on climate change impacts, vulnerability and adaptation within the water and agriculture sectors, and mainstream climate considerations into water and agriculture policies and strategies, thus facilitating more climate-informed decisions-making and planning. Specific objectives of the project are: 1. Strengthen the capacity of relevant MAFF and MOWRAM officials on climate change, impacts, vulnerability and adaptation in water and agriculture sectors, 2. Strengthen the capacity of relevant MAFF and MOWRAM officials on climate-informed planning and decision-making, and 3. Integrate climate change impacts and vulnerabilities, and appropriate adaptation options into water and agriculture policies and strategies.
Relationship to national sustainable development objectives	Agriculture remains the heart of Cambodian livelihoods and is significant in the country's economy, especially in rural areas. For these reasons, the Royal Government of Cambodia pays greater attention in developing agriculture as indicated in the highest level government policy, the Rectangular Strategy for growth, employment, equity and efficiency.
Project deliverables	Institutional capacity building should be designed on the basis of capacity gaps in implementing policy and strategy, thus capacity needs assessment must be undertaken to identify the gaps, motivators and incentives in improving efficiency of the capacity strengthening. In addition to

	building capacity of the relevant officials of the target ministries, the project is expected to produce an additional annex to the current harmonized water and agriculture strategy 2009-13, discussing climate change impacts and vulnerabilities and appropriate adaptation options for this specific sector.
Project scope	MAFF and MOWRAM are the ministries in charge of implementing the harmonized water and agriculture strategy in addition to mandate specific policies and strategies. This project, thus, works directly with the Ministries (at national level) so that they are the main beneficiaries, receiving capacity building and closely working on mainstreaming climate change considerations.
Timeline	2 years
Budget/resource requirements	The project would require about US$ 500,000 to cover administration costs, experts and logistics of the training. Funds should be allocated separately for the Ministry (for administration and logistics) and universities (training fees and technical support).
Measurement/Evaluation	The project outputs can be measured by the number of trainings and trainees participating in the trainings as well as their improved understanding. The quality of an additional annex to the current water and agriculture strategy is another indicator. The longer term project impacts can be demonstrated through the implementation of the new version of the strategy that includes climate change adaptation.
Challenges	The main anticipated challenge of this project is to select experienced motivators of staff and to provide incentives to turn knowledge into practical action for government institutions.
Responsibilities and Coordination	The project should be implemented by MAFF and MOWRAM themselves in cooperation with local universities with expertise in climate change and experience in capacity building. Technically, it may be more appropriate that the ministries take a coordination role, while the universities provide training and conduct capacity needs assessment and provide technical backup during the mainstreaming process. It is important that MAFF and MOWRAM key policy-makers and technical staff are actively involved not only in the mainstreaming process, but also in the capacity building activities.

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PROJECT IDEA NOTE 8

Sector	WATER RESOURCES
Subsector	Water for agriculture
Technology name	Small dams, small reservoirs and micro-catchments
Project name	Institutional capacity strengthening on climate change impacts, vulnerability and adaptation for PDWRAM and PDAFF at sub-national level
Background	As indicated in the Strategy for Agriculture and Water, the lack of technical capacity is one of the critical issues at the provincial level department of the ministries of Agriculture and Water Resources. With additional pressure from climate change this institutional capacity constraint worsen if not urgently and properly be addressed. More importantly, the Royal Government of Cambodia organic laws on decentralisation require good institutional capacity at sub-national level.
Purpose and objectives	The overall purpose of the project is to improve the understanding of government officials at the provincial departments of agriculture and water resources in climate change and variability and associated impacts; and available climate change adaptation technologies within their respective sectors. The specific objectives of the project include: 1. Strengthen the capacity of relevant PDAFF and PDWRAM officials in climate change, impacts, vulnerabilities and adaptation in their respective sectors, 2. Strengthen the capacity of relevant PDAFF and PDWRM officials in climate-informed planning and decision-making process, 3. Identify appropriate adaptation technologies based on local climate conditions, and 4. Strengthen the relationships between PDAFF and PDWRAM officials, and PDAFF and PDWRAM officials of different provinces to facilitate the sharing experiences and lessons learned.
Relationship to national sustainable development objectives	Agriculture remains the heart of Cambodian livelihoods and is significant in the country's economy, especially in rural areas. For these reasons, the Royal Government of Cambodia pays greater attention in developing agriculture as indicated in the highest level government policy, the Rectangular Strategy for growth, employment, equity and efficiency.
Project deliverables	This institutional capacity building project is expected to enable PDAFF and PDWRM officials to prepare more climate - informed new plans through mainstreaming climate change considerations in their respective development plans; thus

	appropriate climate change adaptation measures will be chosen according to local climate conditions and stresses.
Project scope	Relevant officials of PDAFF and PDWRM nationwide are the target beneficiaries of this capacity building project.
Timeline	3 years
Budget/resource requirements	The project would require about US $500,000 to cover administration costs, experts and logistics of the training.
Measurement/Evaluation	Quantitative indicators to measure outcomes of the project include: number of trainers, number of training manuals, number of trainings organized, number of training days, number of training participants, and number of demonstration projects. Throughout the training process, trainers should assess and provide feedback to participants to ensure that they have duly assimilated knowledge and know-how from the training. Long term impacts of the project can be measured by examining development plans of PDAFF and PDWRAM on what climatic factors were considered in planning for local agriculture and water resources development, as well as what climate change adaptation options were identified in addition to the business as usual proposals in order to cope with climate variability and change.
Challenges	The main anticipated challenge of this project is to select experienced motivators of staff and to provide incentives to turn knowledge into practical action.
Responsibilities and Coordination	The project should be implemented by local universities with expertise and experience in climate change capacity building in cooperation with the MAFF and MOWRAM. A steering committee composed of representatives from the ministries, the Climate Change Department and local universities should be established to direct the implementation of the project as well as to synergize available resources.

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PROJECT IDEA NOTE 9

Sector	WATER RESOURCES
Subsector	Water for agriculture
Technology name	Small dams, small reservoirs and micro-catchments
Project name	Development of a graduate programme on climate science and meteorology at the Royal University of Phnom Penh
Background	As indicated in the Strategy for Agriculture and Water, the lack of technical staff (meteorologists, hydrologists and water chemical engineers) is a critical issue at both the national and at the provincial levels of the ministries of Agriculture and Water Resources. At the provincial level, generally there is only one technician who is also responsible for management, and who is usually the director of the provincial department. At the national level, both MAFF and MoWRAM qualified workforce is getting older (the strategy for agriculture and water resources 2009-13). In responding to this challenge, it may be necessary to increase enrolment in key areas of expertise. The Institute of Technology of Cambodia (ITC) is the only engineering institute that offers degree programmes in civil engineering, rural engineering and chemical engineering. There is currently no training program on meteorology in Cambodia.
Purpose and objectives	This project aims to develop human resources in climate science and meteorology to fulfil the growing demand for qualified staff. Specific objectives of the project include: 1. Assess and collate local available resources relating to climate sciences and meteorology, 2. Develop graduate curriculum and program, 3. Enrol at least 15 students in the program, and 4. Develop strategic and financial plans, including partnership proposals for securing the continuation of the program
Relationship to national sustainable development objectives	Lack of scientists and engineers is one of key constraints in developing institutional capacities for implementing government development plans and policies. Lack of meteorologists and atmospheric scientists specifically underlines the inadequacy of basis climate change adaptive capacity, which needs to be urgently addressed.
Project deliverables	It is expected that successful completion of this project will produce a quality curriculum for graduate degree in atmospheric science and meteorology, basic air and weather monitoring stations. A total of 15 graduates that can serve as resource persons to further assist in development of the programme, in cooperation with the Department of Meteorology, and the Climate Change Department.
Project scope	The project consists of the development of a 2 year graduate

	programme in atmospheric chemistry and meteorology with a target of 15 students enrolled.
Timeline	4 years
Budget/resource requirements	The project would require US$ 800,000 to cover curriculum development and implementation with international academic institutions. This budget also covers consumables and minimum laboratory equipment.
Measurement/Evaluation	The success of the project can be measured against the following indicators: the curriculum produced, the number of graduates, strategic plans to secure cooperation and funding to continue delivering of the curriculum.
Challenges	The main challenge of this project lies on whether or not cooperation (technical and financial) at national, regional and global levels can be identified.
Responsibilities and Coordination	The faculty of Sciences of the Royal University of Phnom Penh consists of a number of relevant departments – chemistry, environment, physics and geography that can contribute to the development of this new program. It is proposed that the program sits within the department of environment, given their comprehensive experiences in managing projects, partnerships and networking in additions to the physical resources. It is important to seek and assess local available resources – human, facilities, and on-going cooperation and mobilize these resources to assist in the development of this program. Regional and international support, either technical or financial, is crucial to the successful completion of this project.

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PROJECT IDEA NOTE 10

Sector	COASTAL ZONE
Subsector	Mangrove protection
Technology name	Mangroves forest management
Project name	Mangrove reforestation and management in coastal aquaculture areas
Background	Aquaculture, especially shrimp farms development in coastal areas, is one of the key drivers contributing to the rapid decline of mangroves forest in Cambodia. As indicated by the Forestry Administration (forestry statistic 2004), forest restoration/re-plantation in coastal areas is limited. On the one hand, mangroves forest planted were destroyed by land encroachment, and land use change especially the development of aquaculture and shrimp farms and salt production. On the other hand, development of marine aquaculture is encouraged under a number of fisheries related laws and policies (Fisheries Laws 2001, Agriculture Development Plan 2000-2005, and Second Five Year Fisheries Sector Development Plan 2001-2005). In addition, according to the laws on environmental protection and natural resources, specifically the sub-decree on environmental impacts assessment (EIA), aquaculture does not require EIA.
Purpose and objectives	The overall aim of the project is to protect mangroves especially in the historical mangroves areas that have been converted to marine aquaculture farms. Specific objectives are to: 1. Map out existing marine aquaculture farms, and identify and estimate historical mangroves areas in for each individual farm, 2. Develop and implement mangrove reforestation plans, 3. Develop a monitoring and evaluation system to ensure successful implementation of mangroves management plans, and 4. Assess whether aquaculture development (both marine and freshwater) should be required to conduct EIA prior to implementation, given its considerable impacts on the environment in general and mangroves in particular.
Relationship to national sustainable development objectives	The project will contribute to sustainable resources use and environmental protection – a foundation of sustainable development of Cambodia. The project also addresses root causes of coastal poverty by protecting local environment and natural resources; and mitigates climatic risks and vulnerabilities to coastal communities.
Project deliverables	The project is expected to generate information on marine

	aquaculture farms in coastal zones of Cambodia as well as historical mangroves areas within the farms areas, a basis for environment and mangroves management and protection. The second output of the project would be mangroves management plans for individual farms, underling how mangroves forests within their aquaculture areas can be restored and protected. The third outcome of the project is a practical implementation of the plans by individual farms. The final expected output of the project is the feasibility to include aquaculture farms into the list of development activities that are required to conduct EIA prior to implementation.
Project scope	The project should cover Koh Kong, Kampong Som, and Kampot Provinces.
Timeline	4 years
Budget/resource requirements	US$ 0.5 Million
Measurement/Evaluation	The project outputs are tangible and can be measured against the following indicators: - The research reports (quantity and quality) produced, - The mangroves forest management plans produced, and number of plans that were implemented, - The monitoring and evaluation system developed, and - Decisions made in term of inclusion of aquaculture development into the EIA laws. Project outcomes and impacts, especially the implementation of mangroves forest management plans by individual farms need to be strictly and regularly monitored and evaluated over decades. Therefore, the success of this project lies on how well the monitoring and evaluation system are developed and implemented after completion of the project.
Challenges	A number of challenges can be expected in implementing this project: cooperation of aquaculture farm developers; fragmentations of government laws, for instance mangroves are protected by a the laws on forest and natural resources protection, yet may be undermined by laws on fisheries and land concession; and weak institutional capacities including unclear mandates, roles and responsibilities of concern government agencies including the Coastal Steering Committee.
Responsibilities and Coordination	The project should be implemented by the Coastal Steering Committee (chaired by the Minister of Environment) in partnership with the Fisheries Administration who is mandated to oversea marine aquaculture development. Local universities (Department of environment of RUPP, Faculty of Fisheries and Faculty of Forestry of RUA) should be involved

	in designing and conducting relevant studies to ensure the integrity of the research.

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PROJECT IDEA NOTE 11

Sector	COASTAL ZONE
Subsector	Mangrove protection
Technology name	Mangrove forest management
Project name	Mangrove reforestation and management in coastal salt farm areas
Background	Salt production is located along coastal line from Kep reach from Thmey village, Boeung Touk Commune, Kampot District to Loke village, Ruessy Sroke Commune, Kampong Trarch District, which is next to the Vietnamese border. Salt production is one of the drivers contributing to the rapid decline of mangroves forest in Cambodia, particularly in Kampot and Kep Provinces. There are nearly 200 salt producers in Cambodia covering an area of about 4,500 ha, located along the coastline from Thmey Village in Boeung Touk Commune of Kep Province to Loke Village of Ruessy Sroke Commune in Kampong Trach District of Kampot Province. An increase in salt production to meet market demand requires expanding salt farm areas, invading mangrove forests.
Purpose and objectives	The overall aim of the project is to protect mangroves forest especially in the historical mangroves areas that have been and will be converted to salt production sites. Specific objectives are to: 1. Map out existing salt farms, and identify and estimate historical mangroves areas in for each individual farm, 2. Develop and implement mangrove reforestation plans, 3. Develop a monitoring and evaluation system to ensure successful implementation of mangroves management plans.
Relationship to national sustainable development objectives	The project will contribute to sustainable resources use and environmental protection – a foundation of sustainable development of Cambodia. The project also addresses root causes of coastal poverty by protecting local environment and natural resources; and mitigates climatic risks and vulnerabilities to coastal communities.
Project deliverables	The project is expected to generate information on salt production farms in the coastal zone of Cambodia as well as historical mangroves areas within the salt farm areas, a basis for mangroves management and protection. The second output of the project would be mangroves management plans of individual farms, outlining how mangroves forests within their farm area will be restored and protected. The third outcome of the project is the practical implementation of the plans by individual farms.

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Project scope	The project should cover Kampot and Kep Provinces
Timeline	3 years
Budget/resource requirements	US $200,000
Measurement/Evaluation	The project outputs are tangible and can be measured against the following indicators: - The research reports (quantity and quality) produced, - The mangroves forest management plans produced, and number of plans that were implemented, - The monitoring and evaluation system developed, and - Decisions made in term of inclusion of aquaculture development into the EIA laws. Project outcomes and impacts, especially the implementation of mangroves forest management plans by individual farms need to be strictly and regularly monitored and evaluated over decades. Therefore, the success of this project lies on how well the monitoring and evaluation system are developed and implemented after completion of the project.
Challenges	The anticipated challenges of this project include: cooperation of salt producers especially social elites, insufficiency of legal instruments and procedures such as EIA to address concerns arising from this industry, and weak institutional capacities including unclear mandates, roles and responsibilities of concern government agencies.
Responsibilities and Coordination	The project should be implemented by the Coastal Steering Committee (chaired by the Minister of Environment) in partnership with local authorities. Local universities and research institutes especially the Marine Fisheries DevelopmentInstitute of the Fisheries Administration should be involved.

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PROJECT IDEA NOTE 12

Sector	COASTAL ZONE
Subsector	Mangrove protection
Technology name	Mangrove forest management
Project name	Community-based mangroves forest management and eco-tourism development at Botum Sakor National Park
Background	Botum Sakor National Park in Koh Kong Province covers an area of 1,834 square kilometers, and is encircled by mangrove forests and gorgeous beaches. The park is a biodiversity rich area including many endangered species. Therefore it is significant to protect this area from rapid and unmanageable development activities. Although there is an increasing recognition of community based resources management, due to high poverty prevalence in rural Cambodia together with limited local livelihood options, it may not be practical to expect full voluntary participation from local communities. Job creation in local communities could facilitate stronger local participation in mangrove forest management. There is in-depth experience in resource co-management at Peam Krasop Wildlife Sanctuary and Ream National Park (eco-tourism – mangroves protection) and elsewhere regionally.
Purpose and objectives	The overall aim of the project is to facilitate effective management of the national park by enhancing community participation in natural resources management through eco-tourism (payment ecosystem services). The project covers the following specific objectives: 1. Conduct feasibility study, identifying potential and appropriate locations for eco-tourism, 2. Develop eco-tourism plan(s) in consultation with local authorities and communities, 3. Develop monitoring and evaluation system in order to provide feedback to the communities, and 4. Implement the eco-tourism plan(s).
Relationship to national sustainable development objectives	The project will contribute to sustainable resources use and environmental protection – a foundation of sustainable development of Cambodia. The project also addresses root causes of coastal poverty by diversifying local livelihoods through ecosystem based approaches.
Project deliverables	The project will produce the following outputs: 1) a feasibility study report, mapping potential locations and analysing feasibilities in developing eco-tourism; 2) an eco-tourism development plan with sufficient inputs from local authorities and communities; and 3) the practical implementation of the plan(s).
Project scope	Botum Sakor National Park, Koh Kong Province

Timeline	5 years
Budget/resource requirements	US$ 1 Million
Measurement/Evaluation	The project outputs can be measured against the following indicators: - The feasibility study reports (quantity and quality) , - The eco-tourism development plan(s), - The monitoring and evaluation system developed, and - The implementation of the plan(s). Project outcomes and impacts, especially the implementation of eco-tourism development plan(s) need to be strictly and regularly monitored and evaluated over decades. Therefore, the success of this project relies on how well the monitoring and evaluation system will be implemented after completion of the project.
Challenges	The main challenges of the project consist of the ability to mobilize local social capital, to strengthen local institutions, and the ability to attract tourists.
Responsibilities and Coordination	The project should be executed by the management of the national park with coordination support from the Protected Areas Administration of the MOE. Partnership should also be made with relevant departments of the Ministry of Tourism. Technical support can be expected from the Department of Tourism of RUPP, the Community-Based Natural Resources Management – Learning Institute, and relevant organizations that have experience in similar projects.

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PROJECT IDEA NOTE 13

Sector	COASTAL ZONE
Subsector	Mangrove protection
Technology name	Mangrove forest management
Project name	Strengthening research capacity (related to coastal resources, especially mangrove management) of the Research Institute and Marine Fisheries Development of MAFF
Background	Climate stresses – flood, drought, and windstorms add considerable impacts on marine resources and mangrove forests due to increasing oceanic acidity, increasing frequency and intensity of climatic catastrophes and rising sea level. To date, there is limited understanding of the impacts of climate change on the Cambodian coastline and marine resources. Gaps in research activities on marine resources poses significant difficulty to sound informed planning and decisions, challenging effective management of the resources. MAFF has recently established a Research Institute and Marine Fisheries Development, however the capacity of the institute remains weak.
Purpose and objectives	The proposed project aims to strengthen research capacities of the Research Institute and Marine Fisheries Development of the Fisheries Administration in undertaking relevant research to inform policies, strategies and plans. The specific objectives of the project include: 1. Review existing gaps in capacities and develop appropriate management mechanisms, 2. Provide capacity building to relevant staff according to the gaps identified, 3. Support at least 5coastal resources management related research projects in the context of climate change with priority on planning and strategies development, 4. Review and develop institutional policy, and funding mechanism for sustaining the functioning of the institute, and 5. Disseminate research findings to relevant stakeholders through climate change forums, research development forums and others.
Relationship to national sustainable development objectives	The lack of scientific information on marine ecosystems and management is a significant barrier in developing sound knowledge planning and decisions and thus prevents effective management of the resources.
Project deliverables	The successful completion of this project will enable the research institute to conduct scientific research including modeling and impact assessment, especially in the context of climate change.

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Project scope	Strengthening research capacities of the institute should be built upon its existing current capacities in terms of human resources, facilities, and institutional mechanism and policies, aligning with the Cambodian human development roadmap.
Timeline	4 years
Budget/resource requirements	The project would require US $0.5 million to cover the period of four years and fund at least 5 research projects (with individual funding of up to US $50,000 for each project). This budget also covers consumables and minimum laboratory equipment if required.
Measurement/Evaluation	The success of the project can be measured against the following indicators: number of professionals trained, number of research proposals submitted and selected for implementation, laboratory equipment purchased, application of research findings, and institutional and financial mechanisms developed.
Challenges	The key challenge of this project consists of assigning additional responsibilities to individual researchers and officials of the institute given the fact that existing government incentives are limited. In addition, low research capacities and limited research partnerships of the institute would demand more time, resources and commitment in order to successfully capacitate them.
Responsibilities and Coordination	The research institute is the only target organization in this project; therefore the project should be implemented by the institute itself with management support from FiA. Local expertise from RUA, RUPP (biology, chemistry, environment, and biodiversity conservation programs) and CCD should be mobilized. The project should be designed in two stages. Stage 1 consists of the development of institutional policies, mechanisms and capacities. In Stage 2, research coaching, and dissemination of findings will be carried out.

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PROJECT IDEA NOTE 14

Sector	COASTAL ZONE
Subsector	Mangroves forest protection
Technology name	Mangrove forest management
Project name	Institutional capacity building and awareness raising on climate change impacts and vulnerabilities on mangroves forests and marine ecosystems
Background	Climate stresses – flood, drought, and windstorms add considerable impacts on marine resources and mangrove forests due to increasing oceanic acidity, increasing frequency and intensity of climatic catastrophes and rising sea level. The development and strengthening of institutional capacities is critical due to a number of reasons – lack of human, technical, financial resources; weak institutional framework; and poor law implementation and enforcement.
Purpose and objectives	The purpose of this project is to strengthen capacity of MAFF and MOE, including the Coastal Steering Committee on climate change impacts, vulnerability and adaptation within coastal ecosystems, and to mainstream climate considerations into shoreline strategy, thus facilitating more climate – informed decisions-making and planning. Specific objectives of the project include: 1. Strengthen capacity of relevant officials of MAFF and MOE including the Coastal Steering Committee on climate change, impacts, vulnerability and adaptation in water and agriculture sectors, 2. Strengthen capacity of relevant officials of MAFF and MOE including the Coastal Steering Committee on climate-informed planning and decision-making, and 3. Integrate climate change impacts and vulnerabilities, and appropriate adaptation options into shoreline strategy.
Relationship to national sustainable development objectives	Marine ecosystem provides many benefits to economic development and rural livelihoods, as well as ecosystem services such as biodiversity and natural disaster. The project is in line with national sustainable development objectives and sustainable management of natural resources.
Project deliverables	Institutional capacity building should be designed on the basis of capacity gaps in implementing policy and strategy, thus capacity needs assessment must be undertaken to identify the gaps, motivators and incentives in improving efficiency of the capacity strengthening. In addition to building capacity of the relevant officials of the target ministries, the project is expected to mainstream climate change considerations into the current shoreline strategy, discussing climate change impacts and vulnerabilities and

	appropriate adaptation options for this specific sector.
Project scope	MAFF and MOE including the Coastal Steering Committee are the ministries in charge of coastal resources management. This project, thus, works directly with the Ministries (at national level) and relevant officials of the four coastal provinces. Therefore, these are the main beneficiaries of the project, receiving capacity building and closely working on mainstreaming climate change considerations.
Timeline	2 years
Budget/resource requirements	The project would require about US$ 200,000 to cover administration costs, experts and logistics for the training. Funds should be allocated separately for the Ministry (for administration and logistics) and universities (training fees and technical support).
Measurement/Evaluation	The project outputs can be measured against the number of trainings and trainees participating in the trainings as well as their improved understanding on the subject. The quality of an updated version of the shoreline strategy is another indicator of this project. The project impacts can be demonstrated through the implementation of the new version of the strategy.
Challenges	The main anticipated challenge of this project is to select experienced motivators of staff and to provide incentives to turn knowledge into practical action.
Responsibilities and Coordination	The project should be implemented by the Coastal Steering Committee with technical support from relevant university such as RUA and the Research Institute and Marine Fisheries Development and CCD. The Committee may take a coordination role, while the RUA, the research institute and CCD provide training and conduct capacity needs assessment, and provide technical backup during mainstreaming process. It is important that MAFF and MOE key policy-makers and technical staff are actively involved not only in the mainstreaming process, but also in the capacity building activities. Lessons learned and experience from past and on-going projects (Danida funded project from 1997-2002, on-going PEMSEA funded program in Kompong Som Province, and the on-going coastal adaption project funded by UNEP and CCCA) should be drawn upon to guide this capacity building project more effectively and efficiently.

Annex IV. List of Stakeholders Involved and their Contacts

No.	Name of Institutions	Contact Details
1.	Department of Climate Change, MoE	#48, Samdech Preah Sihanouk Blvd, Tonle Bassac, Chamkarmon, Phnom Penh, Cambodia
2.	Department of International Conventions and Biodiversity, MoE	#48, Samdech Preah Sihanouk Blvd, Tonle Bassac, Chamkarmon, Phnom Penh, Cambodia
3.	Department of Wetlands and Coastal Zone Management, MoE	#48, Samdech Preah Sihanouk Blvd, Tonle Bassac, Chamkarmon, Phnom Penh, Cambodia
4.	Department of Agricultural Extension, MAFF	#200, Preah Norodom Blvd, Sangkat Tonle Bassac, Khan Chamkarmon, Phnom Penh, Cambodia
5.	Department of Planning, Statistics and International Cooperation, MAFF	#200, Preah Norodom Blvd, Sangkat Tonle Bassac, Khan Chamkarmon, Phnom Penh, Cambodia
6.	Department of Rice Planting, MAFF	#200, Preah Norodom Blvd, Sangkat Tonle Bassac, Khan Chamkarmon, Phnom Penh, Cambodia
7.	Forest Administration, MAFF	#40, Preah Norodom Blvd, Phnom Penh, Cambodia
8.	Fisheries Administration, MAFF	# 186, Norodom Blvd., Sangkat Tonle Bassac KhanChamkar Mon, Phnom Penh, Cambodia
9.	Department of Meteorology, MoWRAM	#364, Monivong Blvd, Kham Chamkarmon, Phnom Penh, Cambodia
10.	Department of Water Resources and River Works, MoWRAM	#364, Preah Monivong Blvd, Sangkat Phsar Daesm Thkov, Khan Chamkarmon, Phnom Penh, Cambodia
11.	Ministry of Economy and Finance	Nº. 60, Daun Penh (St. 92), corner Street Preah Ang Eng & Preah Kosamak
12.	Ministry of Planning	Nº. 386, Preah Monivong Blvd, Phnom Penh
13.	Ministry of Rural Development	Corner of Rd#169, Russian Confederation Blvd, Phnom Penh
14.	Council for the Development of Cambodia	St. Sisowath, Government Palace, Phnom Penh
15.	Royal University of Phnom Penh	Confederation of Russia Blvd, Phnom Penh, Cambodia
16.	Royal University of Agriculture	P.O. Box 2696, Dangkor District, Phnom Penh Cambodia
17.	Cambodian Agricultural Research Development Institute	National Road No. 3 Prateah Lang Commune Dangkor, Phnom Penh, Cambodia
18.	Council for Agricultural and Rural Development	41 Confederation of Russia Blvd, Phnom Penh, Cambodia, P.O. 2470
19.	National Committee for Disaster Management	Street 516, New Building, near Toul Kork TV tower, Phnom Penh 12105, Cambodia
20.	Cambodia Red Cross, Disaster Management Department	16 A, Street # 652@271, Phnom Penh, Cambodia
21.	Cambodian Center for Study and	#119, Street 257, Sangkat Teuk Laak I, Khan Toul

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No.	Name of Institutions	Contact Details
	Development in Agriculture	Kok Phnom Penh, P.O. Box 1118
22.	Save Cambodia's Wildlife	#31Eo, St 388, Toul Svay Prey I, Chamkarmon, Phnom Penh 3, Cambodia
23.	WWF Cambodia Country Programme	House #54, Street 352,Boeung Keng Kang I, PO Box 2467, Phnom Penh, Cambodia
24.	Fauna & Flora International Cambodia	#8B, Street 398, Phnom Penh, Cambodia
25.	Mlop Baitang	#37B, St.113, Sangkat Boeung KengkongII, Khan Chamkarmon, P.O. Box 2510 Phnom Penh
26.	International Union for Conservation of Nature	#19, Street 312, Sangkat Tonle Basac, Khan Chamkamon, Phnom Penh, Cambodia P.O. Box 1504
27.	Plan International Cambodia	#99-100, Street Preah Sothearos, Sangkat Tonle Bassac, Khna Chamkarmon, Phnom Penh, Cambodia
28.	The NGO Forum on Cambodia	#9-11, St.476, Toul Tompoung I, P.O.Box 2295, Phnom Penh
29.	Cambodia Development Resource Institute, CDRI	#56, St. 315, Toul Kork, Phnom Penh, Cambodia