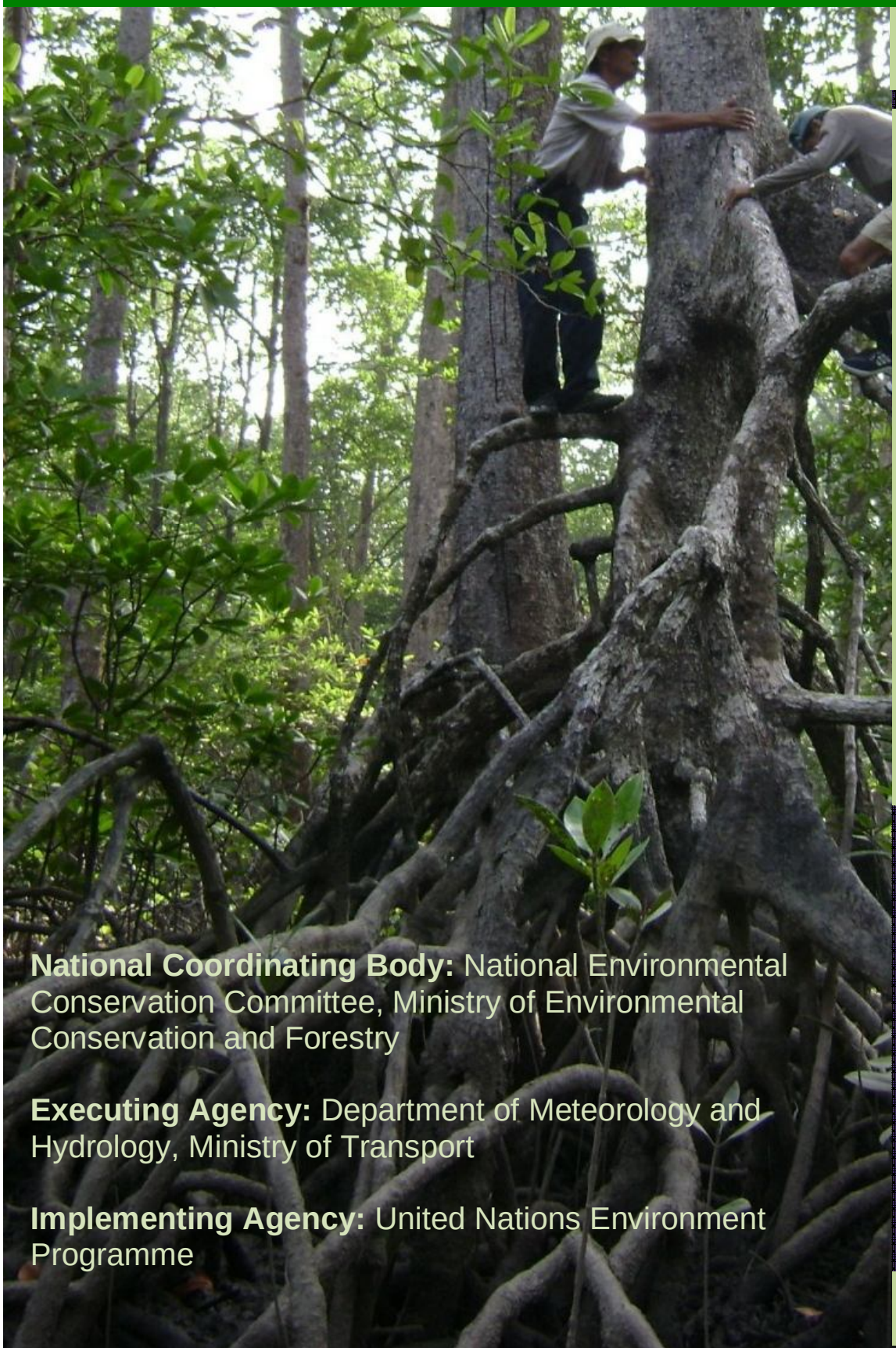
Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change

2012



National Coordinating Body: National Environmental Conservation Committee, Ministry of Environmental Conservation and Forestry

Executing Agency: Department of Meteorology and Hydrology, Ministry of Transport

Implementing Agency: United Nations Environment Programme

The Myanmar National Adaptation Programme of Action (NAPA) Report is prepared in the framework of the LCDF funded project ” Preparation of National Adaptation Programmes of Action ” implemented by UNEP and Executed by the Department of Meteorology and Hydrology, Ministry of Transport of Union of the Republic of Myanmar

National Coordinating Body: National Environmental Conservation Committee, Ministry of Environmental Conservation and Forestry

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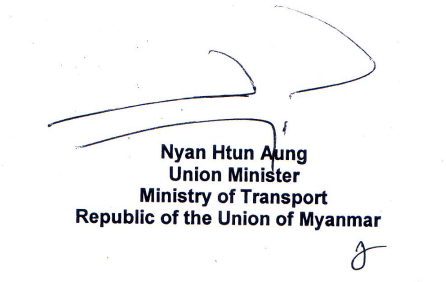
Message from H.E U Nyan Tun Aung, Union Minister for the Ministry of Transport, Republic of the Union of Myanmar

It is my pleasure indeed to make a few remark on the National Adaptation Programmes of Action for climate change -NAPA of Myanmar. Situated in the Southeast Asia, endowed with rich water resources, fertile land, long coastal zone, Myanmar economy is traditionally based on the Agricultural activities on which about 70% of the 53 million population engaged. Therefore favourable climate means successful harvest and good economy, and extreme climate poses hardship to the livelihood of communities involved and it may further hamper the national development activities. Myanmar notices the climate change is taking place in the country such as decreasing southwest monsoon duration, increasing cyclone seasons, increasing cyclone landfall frequency on Myanmar coast, extreme rain spells, etc. The communities in the rural areas are the hardest hit. It is relevant to mention the climate change event of Cyclone Nargis in May 2008. The date of cyclone development was earlier, change of tract from some westward to eastward was too abrupt and latitude of landfall was the record lowest. The Government of Myanmar has put concerted all out effort in collaboration with national/ international organizations to restore the affected areas to normalcy as fast as possible.

Myanmar is exposed to various climate hazards such as cyclone, heavy rain, flood, extreme temperatures, drought and sea level rise. The events may be further complicated by climate change due to global warming. Myanmar has to go along with these changing climate. The government is taking initiatives to implement Myanmar Action Plan on Disaster Risk Reduction. Additionally Myanmar needs to take climate change adaptation measures immediately for sustainable development which also addresses the poverty alleviation of poor communities of the country. In the NAPA preparation process, urgent adaptation needs of the rural communities are assessed through application of Participatory Rural Appraisal PRA in Nyaung Shwe, Kyauk Pa Daung and Bogale townships which respectively represents the hilly region, the dry zone and the coastal area with coordination of local General Administration Offices and UNDP/ICDP.

The adaptation needs are further identified as projects by mainstreaming into national plans by Working Groups on key socio-economic sectors. In the project prioritization, NAPA applied socio-economic criteria mainly based on recommendation suggested by Least Development Countries Expert Group LEG. Myanmar is convinced that implementation of NAPA will be beneficial to the rural communities and the nation by sustainable development.



Nyan Htun Aung
Union Minister
Ministry of Transport
Republic of the Union of Myanmar

Remarks from U SannLwin, Secretary of National Environment Conservation Committee and the Director-General of the Planning and Statistics Department, Ministry of Environmental Conservation and Forestry

By virtue of geographical position and landscape of the country, Myanmar is endowed with natural resources at one hand and being threatened on the other hand by natural disasters/hazards such as cyclones associated with strong winds, storm surges, heavy rains, river floods and flash floods, scanty rain and droughts, untimely rain, extremely warm/cold spells across the country and shorter duration of southwest monsoon season. Due to climate change, the behaviour of the natural hazards have changed general feature of time and space. On top of these there comes the threat of sea level rise in area along 2400 km long coastal line.

Myanmar is highly vulnerable to environmental pressure potentially in the socio-economic sections such as agriculture, forestry, live-stocks, public health, biodiversity, water resources, industry, transport and energy sectors and early warning system. Majority of the national population is engaged in one way or another on agriculture and live-stocks raising, extreme climate event mean unfavourable livelihood to the country. The impact is more severe in the higher population density area in coastal regions and flat plain areas along the Ayeyarwaddy, Chindwin, Thanlwin and Sittaung Rivers system every year. Myanmar needs adaptation measures in various socio-economic sectors and stakeholders.

The NAPA report reveals the four levels of priority for implementation sector with proposed four projects each. In the first level, there stood the agriculture sector, forestry sector, early warning systems. It is very appropriate to the country which is currently trying to implement the Millennium Development Goal for poverty alleviation in Myanmar. Myanmar recommends the project proposals of the NAPA report for urgent implementation through the UNEP guided sponsors from various agencies.

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Secretary
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List of Acronyms

Agricultural Mechanisation Department	AMD
ASEAN Committee on Disaster Management	ACDM
ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries and Forestry towards Food Security	AFCC
Bay of Bengal Large Marine Ecosystem	BOBLME
Behaviour Change Communication	BCC
Biodiversity And Nature Conservation Association	BANCA
Clean Development Mechanism	CDM
Community Development for Remote Townships	CDRT
Community Forest Instruction	CFI
Convention on Biological Diversity	CBD
Convention on International Trade in Endangered Species	CITIES
Department of Development Affairs	DDA
Department of Health	DoH
Department of Meteorology and Hydrology	DMH
Early Warning Systems	EWS
Economically Progressive Ecosystem Development	ECODEV
Ecosystem Conservation and Community Development Initiative	ECCDI
El Niño Southern Oscillation	ENSO
Energy Planning Department	EPD
Energy Services and Income Generating Opportunities for the Poor	ENSIGN
Environmental Sanitation Division	ESD
Fauna and Flora International	FFI
Food and Agriculture Organisation	FAO
Forest Resource Environment Development and Conservation Association	FREDA
Green House Gasses	GHG
Hyogo Framework for Action	HFA
Information, education and communication	IEC
Integrated Coastal Zone Management	ICZM
Integrated Community Development Project	ICDP
Intensive Care Units	ICU
Intergovernmental Panel on Climate Change	IPCC
International Development Enterprise	IDE
International tropical timber organization	ITTO
International Union for Conservation of Nature and Natural Resources	IUCN)
Japan International Cooperation Agency	JICA
Mangrove Environmental Rehabilitation Network	MERN
Marine Protected Area	MPA
Millennium Development Goals	MDG
Ministry of Agriculture and Irrigation	MoAI
Ministry of Environmental Conservation and Forestry	MoECAF
Multi-Criteria Analysis	MCA
Multi-disciplinary Integrated Assessment Team	MIAT
Myanmar Action Plan on Disaster Risk Reduction	MAPDRR
Myanmar Fisheries Federation	MFF

Myanmar Scientific and Technological Research Department	MSTRD
Myanmar Overseas Seafarers Association	MOSA
National Adaptation Programmes of Action	NAPA
National Biodiversity Strategy Action Plan	NBSAP
National Commission for Environmental Affairs	NCEA
National Disaster Prevention Central Committee	NDPCC
National Environmental Conservation Committee	NECC
National Sustainable Development Strategy	NSDS
New Energy and Industrial Technology Development Organization	NEDO
Non Government Organizations	NGOs
Ocean Park Foundation	OPF
Participatory Rural Appraisals	PRA
Project Management Team	PMT
Protected Area	PA
Providing Regional Climates for Impacts Studies	PRECIS
Rapid Rural Appraisal	RRA
Reducing Emission from Deforestation and Degradation	REDD
Regional Integrated Multi-hazard Early Warning Systems	RIMES
Relief and Resettlement Department	RRD
South East Asia System Analysis Research and Training Regional Centre	SEASTAR TRC
UN Framework Convention on Climate Change	UNFCCC
United Nations Convention to Combat Desertification	UNCCD
United Nations Development Programme	UNDP
Waste Water Treatment Plants	WWTP
Water Resources Utilization Department	WRUD
Whale and Dugong Conservation Society	WDCS
Wildlife Conservation Society	WCS
Working Group	WG
World Health Organisation	WHO
World Meteorological Organisation	WMO
Yangon City Development Committee	YCDC

Executive Summary

Myanmar's climate is changing and climate variability already affects communities and socio-economic sectors in the country. Some climate change impacts are already observable and there is broad scientific consensus that further change will occur. Even with significant global climate mitigation (activities and technologies that reduce greenhouse gas emissions), economic sectors, local communities and natural ecosystems in Myanmar will be strongly affected by climate change as a result of the emissions already in the atmosphere. Adaptation is therefore necessary for reducing Myanmar's vulnerability to climate variability and change.

National Adaptation Programmes of Action (NAPAs) serve as simplified, rapid and direct channels for Least Developed Countries to identify and communicate priority activities to address their urgent and immediate adaptation needs. NAPAs emerged from the multilateral discussions on adaptation measures within the UN Framework Convention on Climate Change (UNFCCC)[1,2]. Myanmar's NAPA therefore specifies **32 priority activities (referred to as Priority Adaptation Projects)** for effective climate change adaptation for eight main sectors/themes (i.e. four Project Options per sector/theme), namely: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy, and Industry; and viii) Biodiversity(Table 1).

The Myanmar NAPA preparation process followed the guidelines outlined by the United Nations Framework Convention on Climate Change (UNFCCC) Least Developed Countries (LDC) Expert Group[3,4]. Seven main steps were followed: i) establishment of NAPA Project Management and multidisciplinary teams (April 2011); ii) synthesis of available information (May – July 2011); iii) stakeholder and public consultation to establish Myanmar's **adaptation needs** and potential **adaptation projects/options** (July – September 2011); iv) sectoral working group meetings to identify and draft a list of **Adaptation Project Options** (October – November 2011); v) sectoral working group meetings for screening, ranking and prioritising identified Adaptation Project Options (October – November 2011 and March-April 2012). This entailed using a Multi-criteria analyses (a **series of 15 criteria developed by the LDC Expert Group**) to rank and prioritise **Adaptation Project Options** for implementation. Resulting scores for each **Adaptation Project Option** were used to determine the **32 Priority Adaptation Projects**; vi) public Review Process of NAPA draft (February to April 2012); and vii) development of the NAPA project profiles using focus group discussions and meetings with working group members as well as other key stakeholders (March - April 2012).

Priority Adaptation Projects as well as sectors were selected/prioritised using participatory discussions and analyses including expert opinion as well as community and cultural/traditional knowledge (See Chapter 4 and 6 as well as Annex 2). Capacity building, knowledge and monitoring requirements were considered and contrasted across all 32 Priority Adaptation Projects. A detailed project profile is presented for each Priority Adaptation Project in Annex 1. This includes: i) Project Objective; ii) Project Area; iii) Beneficiaries; iv) Period; v) Estimated Budget; vi) Project Framework including Main Components, Outcomes, and Outputs; vii) Agencies Involved; viii) Baseline Information; and ix) Climate Change Adaptation Rationale. Although, project profiles are presented separately for each Priority Adaptation Project, it is important to note that project ideas/activities/elements can be blended across projects and sectors when designing final project concepts for implementation in the country.

Sectors in which Priority Adaptation Projects should be implemented first include: 1) **Agriculture, Early Warning Systems and Forest** (First Priority Level Sectors). This is followed by: 2): Public

1 Decision 5/CP.7 of the 7th Conference of the Parties (COP) acknowledged the specific situation of LDCs and established an LDC work programme. Decision 28/CP.7 adopted the guidelines for NAPAs, and Decision 29/CP.7 set up an LDC Expert Group (LEG) to provide guidance and advice on the preparation and implementation strategy for NAPAs

2 Terminal Evaluation Of The UNEP GEF Projects "Enabling Activities For The Preparation Of A National Adaptation Programme Of Action (NAPA)". 2008. Mauritania, Senegal, Djibouti, Haiti, Comoros, Tanzania, Uganda, Liberia, Lesotho, Rwanda, The Gambia, Central African Republic And Afghanistan. Final Report – Synthesis Of Findings.

3 Least Developed Countries Expert Group. 2002. Annotated guidelines for the preparation of national adaptation programmes of action.

4 Least Developed Countries Expert Group. 2009. National adaptation Programmes of action: Overview of preparation, design of implementation strategies and submission of revised project lists and profiles.

Health and Water Resources (Second Priority Level Sectors); 3) Coastal Zone (Third Priority Level Sector); and 4): Energy and Industry, and Biodiversity (Fourth Priority Level Sectors).

Table 1. Priority Adaptation Projects for implementation in Myanmar to address immediate needs for building climate change resilience of vulnerable communities.

Sector/Theme	Priority Adaptation Project Title	US$ (million)
FIRST PRIORITY LEVEL SECTORS: Agriculture, Early Warning Systems and Forest		
AGRICULTURE	**First priority:** Reduced climate change vulnerability of rural and subsistence farmers through locally relevant technologies, climate-resilient rice varieties, and ex/in-situ conservation of plant genetic resources.	US$ 1.5
	Second priority: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.	US$ 1.5
	Third priority: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.	US$ 1.5
	Fourth priority: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.	US$ 1.5
EARLY WARNING SYSTEMS	**First priority:** Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events.	US$ 3
	Second priority: Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.	US$ 1
	Third priority: Assessing the hydrological impact of climate change on river systems.	US$ 1.5
	Fourth priority: Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.	US$ 1.5
FOREST	**First priority:** Building the resilience of degraded/sensitive forest areas to climate change impacts through reforestation.	US$ 3.5
	Second priority: Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.	US$ 2.5
	Third priority: Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.	US$ 2.5
	Fourth priority: Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.	US$ 2.5
SECOND PRIORITY LEVEL SECTORS: Public Health and Water Resources		
PUBLIC HEALTH	**First priority:** Adaptation to climate change through climate-resilient health facilities in the Rakhine State and Ayeyarwady Region.	(US$ 0.2 per health centre)
	Second priority: Integrating climate change adaptation strategies into the prevention of heat- related disorders in agricultural and industrial workers.	US$ 1.5
	Third priority: Supporting Intensive Care Units (ICU) in hospitals to treat heat-related disorders.	US$ 1
	Fourth priority: Reducing the vulnerability of local communities to climate-induced water-related health hazards through the provision of safe water supplies and sanitary latrines.	US$ 1.5
WATER RESOURCES	**First priority:** Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change.	US$ 1.5
	Second priority: Constructing small-scale water impoundments in Naypyidaw for flood control and increasing water supplies for local communities.	US$ 3.56
	Third priority: Protecting human life and property against climate extremes in the Ayeyarwady river system through channel improvement and adaptation structures.	US$ 0.6
	Fourth priority: Estimating regional rainfall-runoff relationships for supporting the development of flood early warning systems and ensuring sustainable water management.	US$ 1
THIRD PRIORITY LEVEL SECTOR: Coastal Zone		
COASTAL ZONE	**First priority:** Adaptation to climate change through Integrated Coastal Zone Management (ICZM).	US$ 0.8
	Second priority: Community-based mangrove reforestation for building climate-	US$ 3

	resilient ecosystems and rural livelihoods in degraded coastal areas in the Rakhine State.	
	Third priority: Community based eco-friendly aquaculture systems (e.g. mudcrab, clam, shrimp and tilapia) for enhancing the climate change resilience of rural livelihoods and supporting the recovery of mangrove forest ecosystems.	US$ 0.6
	Fourth priority: Small-scale aquaculture and mangrove buffers demonstration sites for transferring adaptation technologies to Mon and Tanintharyi coastal communities.	US$ 0.6
FOURTH PRIORITY LEVEL SECTORS: Energy and Industry, and Biodiversity		
ENERGY AND INDUSTRY	**First priority:** Enhancing the resilience of water supplies in the face of climate change for rural communities through solar powered water purification and irrigation pumping systems.	US$ 3
	Second priority: Enhancing the resilience of sanitation in the Shan Region to climate change impacts through solar powered aerobic septic tanks.	US$ 2
	Third priority: Increasing climate change resilience of rural communities in the Sagaing, Mandalay and Ayeyarwady Regions by increasing livelihood opportunities through renewable solar electricity systems.	US$ 5
	Fourth priority: Increasing climate-resilience of harvested seed/grains through heated-air mechanical drying technologies.	US$ 3
BIODIVERSITY	**First priority:** Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Sister Group Islands of the Myeik Archipelago.	US$ 0.8
	Second priority: Mainstreaming ecosystem-based climate change adaptation for buffering rural communities against climate change impacts into policy, planning and relevant projects.	US$ 1.5
	Third priority: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at Wetthay Chaing (bay) coastal area.	US$ 0.8
	Fourth priority: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Thameehla Island, Ayeyarwady Region.	US $ 0.8

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Introduction and Outline of Myanmar's NAPA

There is an urgent need for Myanmar's communities and economic sectors to adapt to climate change and variability. This is because actual and potential impacts are becoming more evident, including: i) increased temperatures, ii) rainfall variability; and iii) more frequent, intense and widespread extreme weather events such as cyclones, floods, intense rains, droughts and high-temperatures.

According to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report[5], climate change adaptation includes: "initiatives and measures to reduce the vulnerability of human and natural systems to actual and/or expected climate change". Climate change adaptation is necessary in Myanmar as even with significant reductions in carbon emissions (i.e. global climate mitigation) the impacts of climate change will still occur as a result of the lag in the climate system. The need for adaptation is compounded by the growing populations and economies in Myanmar's most vulnerable areas.

National Adaptation Programmes of Action (NAPAs) provide a process for Least Developed Countries (LDCs) to identify and implement priority activities/projects to address urgent and immediate adaptation needs. The concept of NAPAs emerged from multilateral discussions on adaptation within the UN Framework Convention on Climate Change (UNFCCC)[6,7]. Myanmar's NAPA (hereafter referred to as the "NAPA") covers 32 priority activities (hereafter referred to as Priority Adaptation Projects) for implementation in the country. This includes four Priority Adaptation Projects for eight main socio-economic sectors/themes: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy and Industry; and viii) Biodiversity (see Chapter 5 and Annex 1).

Priority Adaptation Projects included in the NAPA target areas where communities are considered most vulnerable to climate change. Priority Adaptation Projects have been identified using existing research on the impacts of climate change as well as in-country Participatory Rural Appraisals (PRA, see Annex 2). Furthermore, they have been prioritised using a set of 15 weighted selection criteria from a list of 77 Adaptation Project Options identified for the country. The NAPA target audience is broad and includes individuals in government institutions, International Agencies, NGOs, and the private sector.

The outline of the NAPA is as follows:

Chapter 1: Introduction and Setting introduces background information that is relevant to the NAPA process such as Myanmar's main environmental stresses including climate variability/climate change and the effects on socio-economic sectors.

Chapter 2: Myanmar's Framework for Climate Change Adaptation summarises the main impacts of climate variability/climate change on socio-economic sectors and communities in Myanmar. This is based on previous studies, expert opinion and traditional/cultural knowledge. The chapter also focuses on the NAPA's overall goal, objectives and strategies including how the NAPA fits into Myanmar's economic/political/social development goals, current institutional frameworks and national/multi-lateral environmental agreements. Lastly, this chapter describes the potential barriers for achieving the NAPA's goals and thus implementing climate change adaptation in the country.

Chapter 3: Identification of Adaptation Needs and Project Options describes Myanmar's current coping mechanisms for managing climate change and presents a list of 77 Adaptation Options for addressing specific climate change impacts and associated vulnerabilities. Approximately eight to ten Adaptation Options are presented and ranked per socio-economic sector/theme, namely: i)

[5] (IPCC WG II, 2007)

[6] Decision 5/CP.7 of the 7th Conference of the Parties (COP) acknowledged the specific situation of LDCs and established an LDC work programme. Decision 28/CP.7 adopted the guidelines for NAPAs, and Decision 29/CP.7 set up an LDC Expert Group (LEG) to provide guidance and advice on the preparation and implementation strategy for NAPAs

[7] Terminal Evaluation Of The UNEP GEF Projects "Enabling Activities For The Preparation Of A National Adaptation Programme Of Action (NAPA)". 2008. Mauritania, Senegal, Djibouti, Haiti, Comoros, Tanzania, Uganda, Liberia, Lesotho, Rwanda, The Gambia, Central African Republic And Afghanistan. Final Report – Synthesis Of Findings.

Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water resources; vi) Coastal Zone; vii) Energy, and Industry; and viii) Biodiversity.

Chapter 4: Criteria for Selecting Priority Adaptation Projects describes the weighted selection criteria that were used by local communities and experts for selecting and ranking the 77 Adaptation Project Options respectively.

Chapter 5: List of Priority Adaptation Projects for implementation in Myanmar presents a table of 32 Priority Adaptation Projects that address Myanmar's urgent and immediate adaptation needs. The table includes: i) Project Title; ii) Project Objective; iv) Project Area; and v) Executing Agency for each Adaptation Project. Detailed information per project is presented as ~1-2 page project profiles in Annex 1. Project profiles include: i) Project Objective; ii) Project Area; iii) Beneficiaries; iv) Period; v) Estimated Budget; vi) Project Framework including Main Components, Outcomes, and Outputs; vii) Agencies involved; viii) Baseline information; and ix) Climate Change Adaptation Rationale.

Chapter 6: NAPA Preparation Process describes the methodologies and development processes used for the compilation of Myanmar's NAPA. This includes the process of consultation, project selection and prioritisation techniques, methods for evaluation and monitoring processes.

1. Introduction and Setting

Background and Context

Location

The Republic of the Union of Myanmar (Myanmar) is situated on the western end of Southeast Asia (between 9º 55', 28º15' N and 92º 10', 101º 10' E). It is bordered by the Andaman Sea and the Bay of Bengal (2,330 km), Thailand (2,325 km), Laos (235 km), China (2,185 km), India (1,454 km) and Bangladesh (258 km) (Figure 1a). Myanmar is the largest country in Southeast Asia, covering ~ 676,578 km^2, extending 800 km east to west and 1,300 km north to south.

Administrative Units

Myanmar is divided into 14 administrative units comprising seven States (Kachin, Kayah, Kayin, Chin, Mon, Shan and Rakhine) and seven Regions (formerly called divisions) (Magway, Mandalay, Sagaing, Bago, Tanintharyi, Ayeyarwady and Yangon) (Figure 1 b). Yangon is the largest city in the country. However, the smaller but more central Naypyitaw serves as the capital[8]. States and Regions are subdivided into districts, which are further subdivided into townships, sub-townships, wards, village tracts and villages.

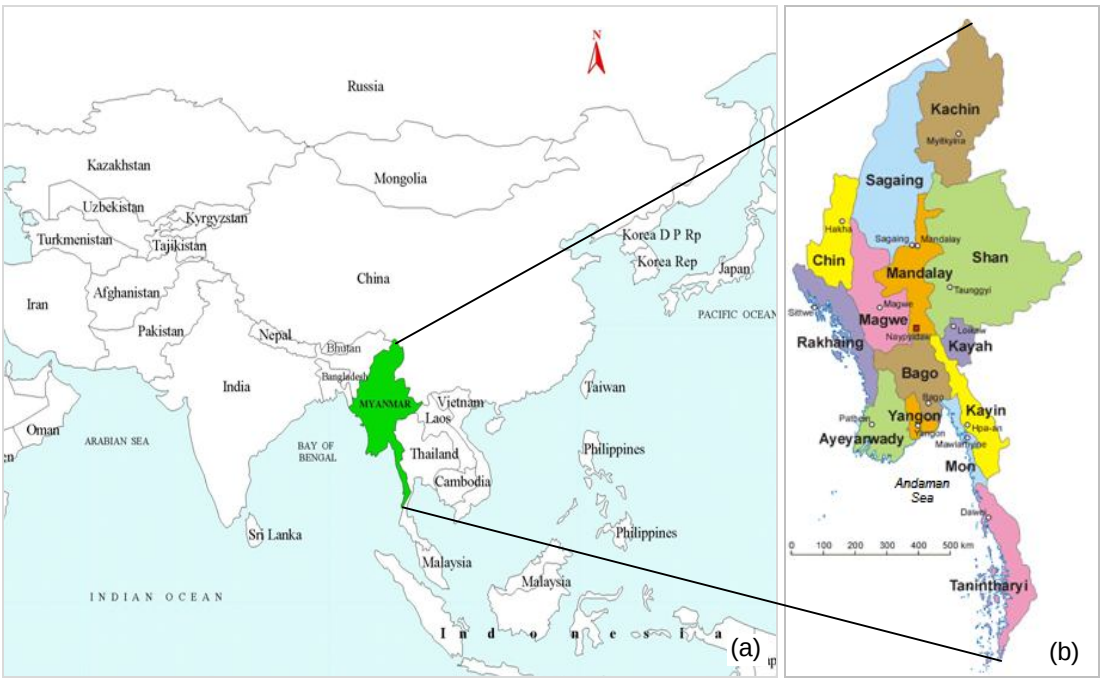

Figure 1. (a) Location map of Myanmar and; (b) administrative units including location of the capital Naypyitaw and the largest city Yangon[9].

Population

Myanmar has an estimated population of 54.6 million (73 people per km^2)[10,11]. Approximately 66% of the population live in rural areas with 33% living in urban areas[12]. The majority of the population is concentrated in the Ayeyarwaddy basin, situated in between the Rakhine Yoma and the Shan Plateau. This includes the areas in the Central Belt (Sagaing, Magway and Mandalay Regions), the

[8] Egashira, K., and A. T. Aye. 2006. Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. Journal of the Faculty of Agriculture, Kyushu University 51:373-387.
[9] http://en.wikipedia.org/wiki/Burma
[10] World Bank. Myanmar country data. http://data.worldbank.org/country/myanmar.
[11] The last reliable census was conducted in 1931 and estimates of the present population are based on models which used parameters derived from reproductive and fertility health surveys (Central Intelligence Agency [CIA]. 2012. The World Fact Book: Burma. https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html)
[12] World Bank. Myanmar country data. http://data.worldbank.org/country/myanmar.

Ayeyarwady Delta, Yangon Deltaic region and parts of the Shan Plateau (Figure 2a). Regions are predominantly inhabited by the dominant ethnic group Bamar. States are essentially Regions that are inhabited by other ethnic groups (Figure 2b)[13].

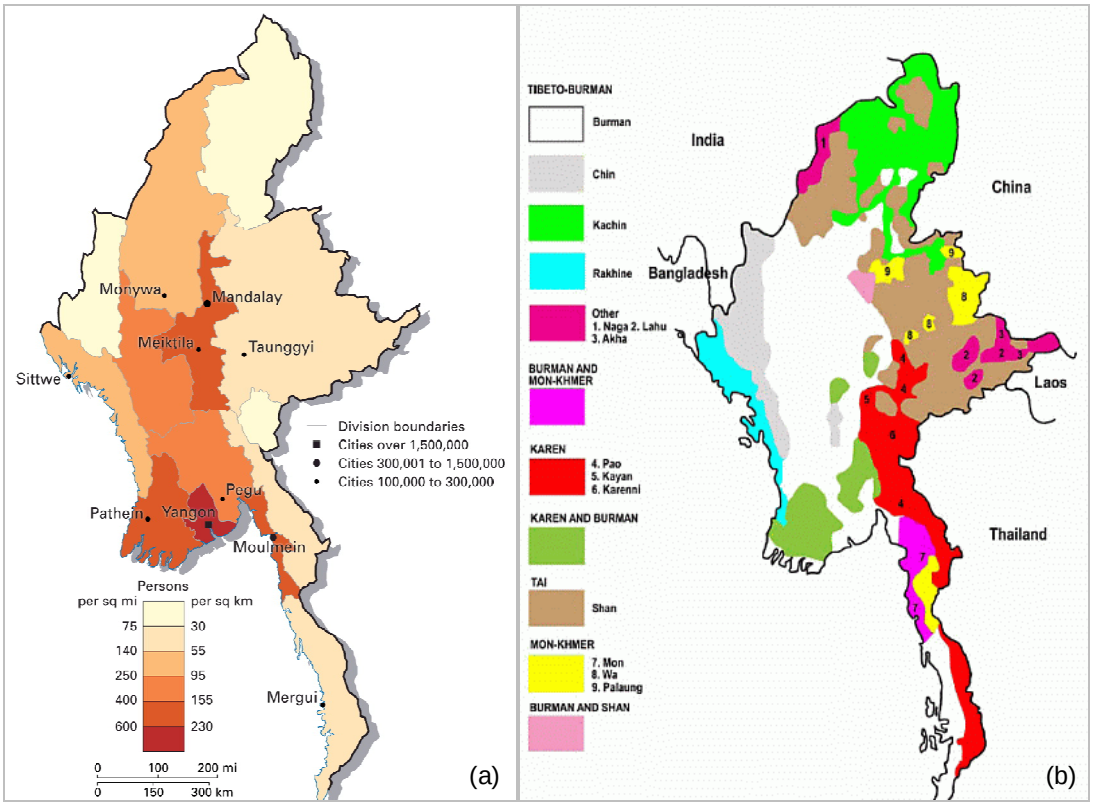

Figure 2. (a) Myanmar's estimated population density[14]; and (b) major and other ethnic groups[15].

Economy

Myanmar's economy is one of the least developed in the world. In the past, GDP growth has been relatively slow averaging ~2.9% annually. A change of government in 2011, however, induced a number of policy reforms that increased GDP growth to 10% per annum. In 2011, Agriculture contributed ~43% to GDP, services ~36.6% and industry ~20.5%[16]. Agriculture, forestry, and fisheries constitute the largest contribution to the economy. Approximately 75% of the rural population rely on the agriculture, livestock and fisheries sectors for their livelihoods. Other major livelihood activities in Myanmar utilise the following major products: i) wood and wood products; ii) copper; iii) tin; iv) tungsten; v) iron; vi) cement; vii) construction materials; viii) pharmaceuticals; ix) fertilizer; x) natural gas; xi) garments; xii) jade; and xiii) gems[17].

Physical Features and Topography

Myanmar slopes from an elevation of 5,881 m in the extreme north at Mount Hkakabo (the country's highest peak) to the Ayeyarwady (Irrawaddy) and Sittang (Sittoung) river deltas at sea-level in the south. There are three main mountain ranges, namely the i) Rakhine Yoma (western range 400 km including the Patkai, Naga, Mizo, Chin and Arakan hills/mountains), ii) Bago Yoma/Pegu Mountains (south-central range 435 km), and ii) the Shan Plateau (eastern range) (Figure 3a). The mountain ranges divide the country into three river systems, the: i) Ayeyarwady, which is the longest river

[13] Hadden, R. L. 2008. The geology of Burma (Myanmar): an annotated bibliography of Burma's geology and earth science. Topographical Engineering Center, US Army Corps of Engineers, Virginia.
[14] http://www.britannica.com/EBchecked/media/137732/Population-density-of-Myanmar
[15] Martin Smith: Burma, Insurgency and the Politics of ethnicity, http://bippaw.wordpress.com/2012/03/02/a-history-of-the-burmese-conflict-why-people-flee-burma/
[16] Central Intelligence Agency (CIA). 2011. World Fact Book: Burma. https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html
[17] Hadden, R. L. 2008. The geology of Burma (Myanmar): an annotated bibliography of Burma's geology and earth science. Topographical Engineering Center, US Army Corps of Engineers, Virginia.

system in Myanmar (Irrawaddy), ii) Sittoung; and ii) Salween (Thanlwin) (Figure 3b). The Ayeyarwady (2,170 km long), with its major tributary the Chindwin (960 km) has a vast drainage area (~255,081 km²) (Figure 3c) that supports a range of socio-economic sectors and livelihoods in the country. As the Ayeyarwady enters the sea it forms a delta of ~50,400 km^2.

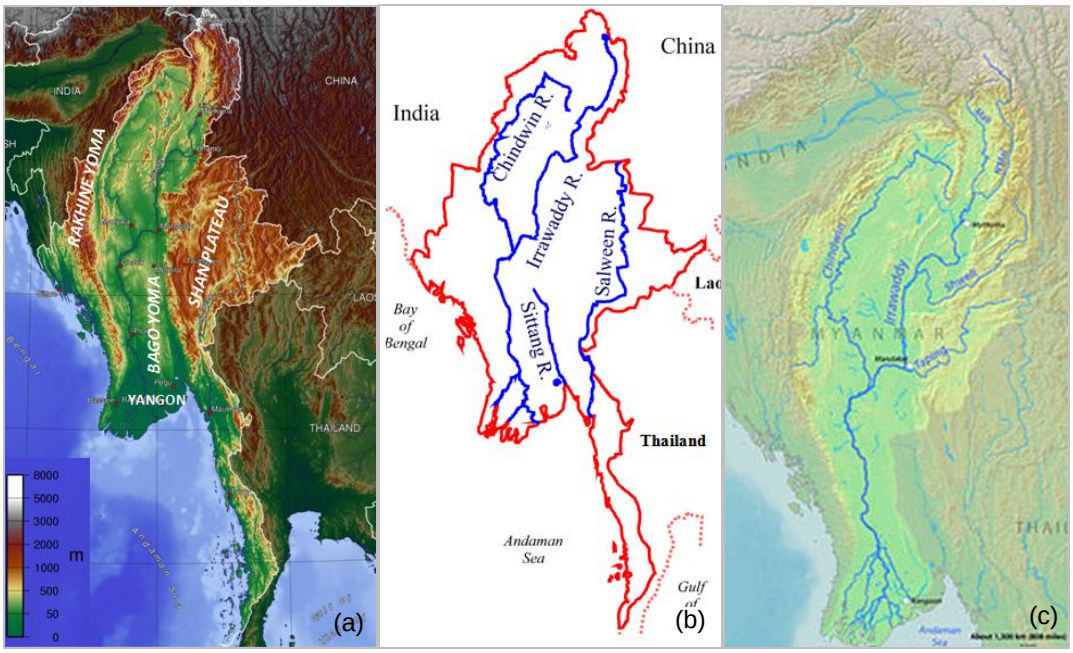

Figure 3. (a) Elevation above sea-level and mountain ranges in Myanmar[18]; (b) major rivers in Myanmar and (c) the Ayeyarwaddy River Basin[19].

The country as a whole can be divided into three main agro-ecological zones: i) Central Dry; ii) Coastal; and iii) Hilly (Figure 4a). These zones can be further subdivided in eight physiographic regions: i) Northern Hilly; ii) Central Dry; iii) Rakhine Coastal; iv) Western Hilly; v) Eastern Hilly (Shan Plateau); vi) Ayeyarwaddy Delta; vii) Yangon Deltaic; and viii) Southern Coastal (including Tanintharyi coastal strip) (Figure 4b)[20].

Climate

Myanmar has a tropical to subtropical monsoon climate with three seasons: i) hot, dry inter-monsoonal (mid-February to mid-May); ii) rainy southwest monsoon (mid-May to late October); and iii) cool relatively dry northeast monsoon (late October to mid-February). Mean annual rainfall is the lowest in the Central Dry Zone (500-1000 mm per year), increases in the Eastern and Northern Hilly regions, and is the highest in the Southern and Rakhine Coastal regions (2,500 – 5,500 mm)[21] (Figure 5a). Mean temperature ranges from 32°C in the coastal and delta areas to 21°C in the northern lowlands[22] (Figure 5b). Seasonal temperatures generally vary greatly throughout most of Myanmar. In the Central Dry Zone temperatures range from a maximum of 40-43^{o}C in the hot/dry season to10-15^{o}C in the cool/relatively dry season and decrease to -1ºC or 0ºC at times in the highlands. Seasonal temperatures do not vary much in the southern parts of the country[23]. Myanmar's west coast is subject to frequent tropical storms and cyclones during October to December with a secondary peak in April to May[24,25].

[18] http://en.wikipedia.org/wiki/Burma
[19] http://en.wikipedia.org/wiki/Irrawaddy_River
[20] http://www.roadtomandalay.com/business/myanmar_burma.htm
[21] Egashira, K., and A. T. Aye. 2006. Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. Journal of the Faculty of Agriculture, Kyushu University 51:373.
[22] http://www.roadtomandalay.com/business/myanmar_burma.htm
[23] Egashira, K., and A. T. Aye. 2006. Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. Journal of the Faculty of Agriculture, Kyushu University 51:373.
[24] McPhaden, M. J., G. R. Foltz, T. Lee, V. S. N. Murty, M. Ravichandran, G. A. Vecchi, J. Vialard, J. D. Wiggert, and L. Yu. 2009. Ocean-atmosphere interactions during Cyclone Nargis. Transactions - American Geophysical Union 90:53-60.
[25] Hadden, R. L. 2008. The geology of Burma (Myanmar): an annotated bibliography of Burma's geology and earth science. Topographical Engineering Center, US Army Corps of Engineers, Virginia.

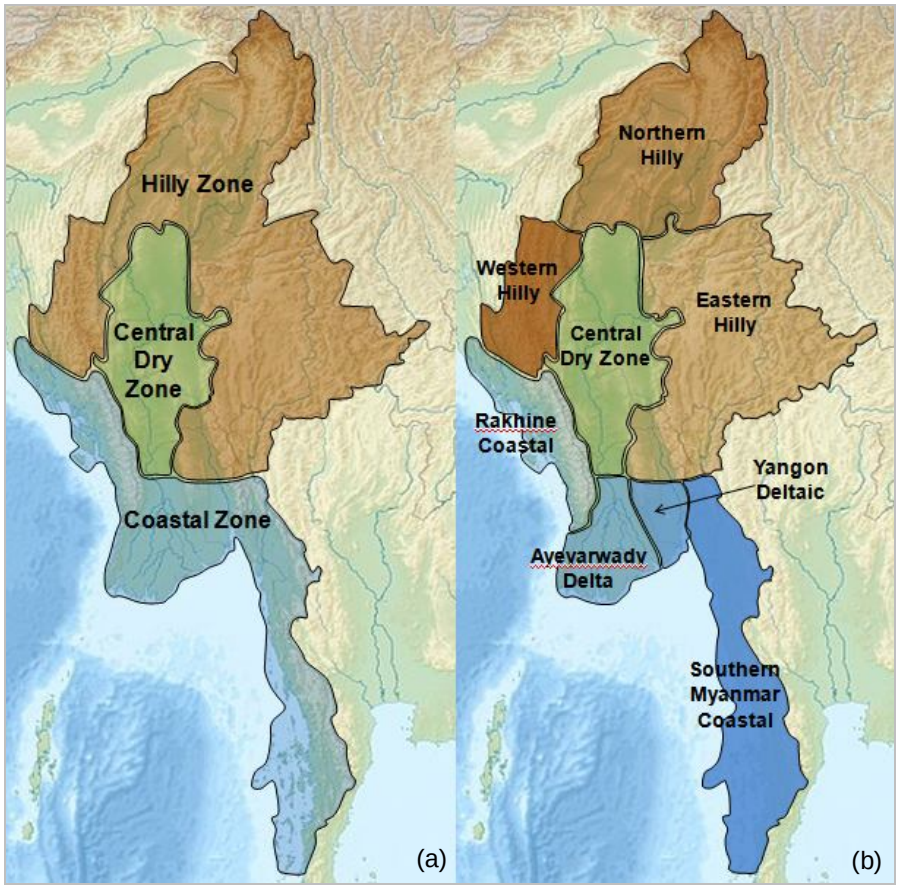

Figure 4. (a) Myanmar's three agro-ecological zones; and (b) eight physiogeographic regions[26].

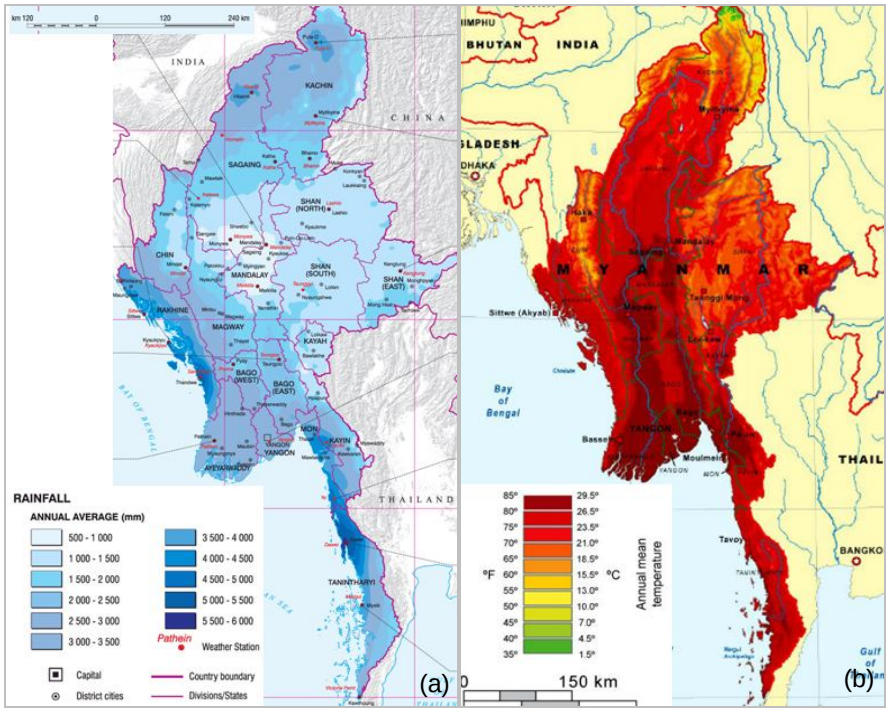

Figure 5. (a) Annual average rainfall[27]; and (b) annual average temperatures over Myanmar.

[26] Base topographic maps: http://en.wikipedia.org/wiki/Hlawga_National_Park

Water Resources
Myanmar has abundant water resources comprising four principle river basins (Ayeyarwady, Chindwin, Sittaung and Thanlwin/Salween) with a catchment area of ~737,800 km^2. This provides renewable water resources of ~880 km^3 to 1082 km^3 per year (surface water resources volume)[28]. Water availability, however, is highly variable between wet and dry seasons. Out of total fresh water utilised, approximately 70% is consumed by the agriculture sector. This is followed by 7% for domestic use and 3% for industrial purposes[29].

Agriculture
Agriculture is the predominant sector in Myanmar[30]. The wide variety of agro-ecological tracts lead to farmers growing more than 60 different crops including both tropical and temperate varieties. The predominant food crop is rice, which is cultivated across ~50% of Myanmar's agricultural land[31]. Other cereal crops include wheat, maize and millet. Furthermore, crops commonly cultivated for domestic use include onions, potatoes, garlic, cassava, sweet potatoes, oilseed (groundnut, sesame, sunflower), and pulses and beans (black gram, chickpea, soybean, pigeon pea)[32]. Cotton, sugarcane, jute and rubber are cultivated as industrial crops for both domestic use and for export. Maize is grown predominantly for export and livestock feed[33]. The majority of the farmers are small-scale landholders with an average lot size of 2.27 ha[34]. At a national level, Myanmar produces a food surplus. However, as a result of geographical differences there are many areas/villages suffering from inadequate food supplies[35]. Agriculture and crop production in Myanmar are strongly affected by rainfall as crop cultivation is mostly rain-fed[36]. The irrigated area of agricultural land in Myanmar increased from 12.5% in 1987/88, to 18% in 2006/7.

Forest Resources
Myanmar is rich in natural forests and approximately half (49% or ~317,730 km^2) of the total land area is forested (Figure 6a)[37]. Forest type and distribution is mostly dependent upon the landscape of the country (Figure 6b):

- the delta and coastal regions comprise mangrove and estuarine forests;
- the arid and semi-arid regions comprise deciduous and dipterocarpus forests;
- the low rainfall areas (particularly the Central Dry Zone and surrounding areas) comprise dry thorn and scrubland forests;
- the high rainfall regions comprise evergreen forests, and
- the subtropical high altitudinal areas comprise hill evergreen and sub-alpine forests.

The forests in Myanmar underpin the development of a range of socio-economic sectors and local livelihoods. Forests provide revenue from the supply of forest products and services. They also provide a number of ecological supporting functions such as sequestering carbon, regulating micro-

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[27] http://dwms.fao.org/atlases/myanmar/downs/atlas/p030_rainfall_table.pdf
[28] Ministry of Agriculture and Irrigation, Government of the Union of Myanmar, Ti, L. H. and Facon, T. Report on the formulation of a national water vision to action in the Union of Myanmar**.** Last Accessed 17/02/2012**.** http://www.fao.org/docrep/008/ae546e/ae546e04.htm
[29] Association of Southeast Asian Nations (ASEAN). 2000. Second ASEAN State of the Environment Report. ISBN: 979-8080-83-1.
[30] Central Intelligence Agency (CIA). 2011. World Fact Book: Burma. https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html
[31] Hadden, R. L. 2008. The geology of Burma (Myanmar): an annotated bibliography of Burma's geology and earth science. Topographical Engineering Center, US Army Corps of Engineers, Virginia.
[32] United Nations Economic and Social Commission for Asia and the Pacific. 2011. Food Security and Natural Disasters: Country Status Paper.
[33] Egashira, K., and A. T. Aye. 2006. Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. Journal of the Faculty of Agriculture, Kyushu University 51:373.
[34] Climate Change Management in Myanmar. Last Accessed 16/02/2012 http://www.google.co.za/url?sa=t&rct=j&q=climate%20change%20management%20in%20myanmar%201.%20national%20circumstances&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.gwpsea.org%2Findex.php%3Foption%3Dcom_docman%26task%3Ddoc_download%26gid%3D54%26Itemid%3D135&ei=8_U8T9WyFYWm0QW5nbHOBw&usg=AFQjCNGiAuf8e6EAhJhZQungDr2j786Zxg
[35] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2011. Food Security and Natural Disasters: Country Status Paper.
[36] Egashira, K., and A. T. Aye. 2006. Cropping characteristics in Myanmar with some case studies in Shan State and Mandalay Division. Journal of the Faculty of Agriculture, Kyushu University 51:373.
[37] World Bank. Myanmar country data. http://data.worldbank.org/country/myanmar.

climates, protecting top soils from rain and sun, stabilising soils and providing habitats for globally important animal/plant species[38] e.g. Bengal tigers and Asian elephants[39].

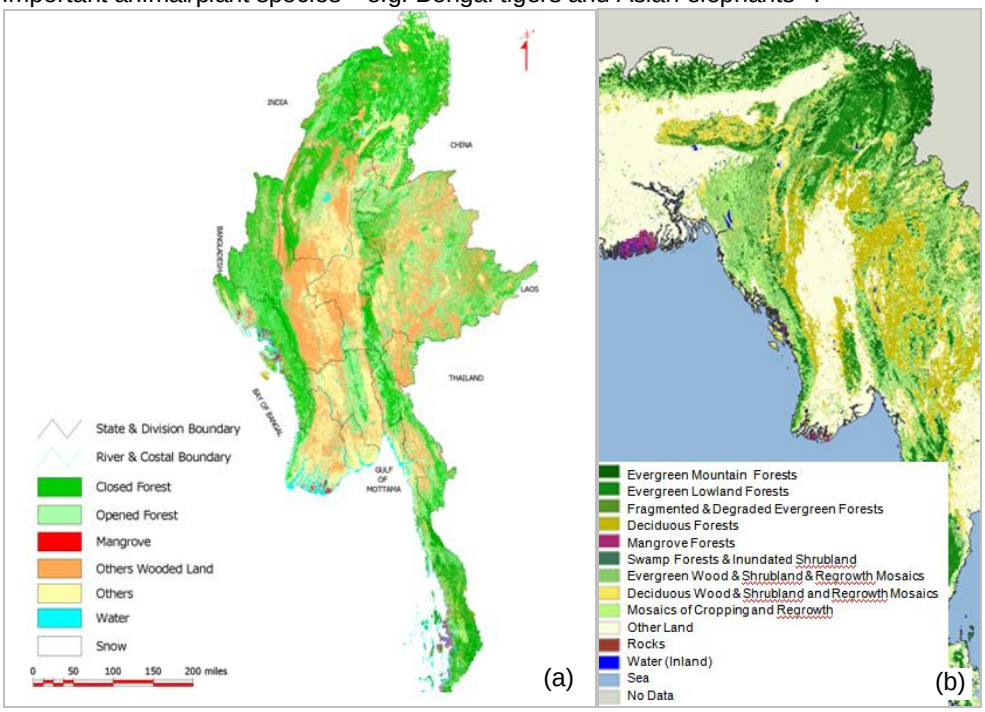

Figure 6. (a) Forest cover status (2006); and (b) Forest types in Myanmar.

Public health

Main health risks in Myanmar include limited clean drinking water and poor sanitation services. Furthermore, food insecurity is widespread. Many communities, in particular pregnant women and children, face sub-standard diets. As a result, ~40% of children below the age of five have stunted growth and ~30% are underweight. In addition, pregnancy related deaths represent the leading cause of mortality with 230 to 580 maternal deaths per 100,000 live births[40]. The poor living standards in the country assist the spread of vector borne diseases (e.g. diarrhoea, cholera, influenza, malaria, dengue fever, yellow fever, tuberculosis) which are a major cause of morbidity and mortality. Diarrhoea is common throughout the year affecting particularly children and elderly[41].

Environmental Stresses and Impacts on Socio-Economic Sectors

Three main environmental stresses affect Myanmar: i) climate related hazards/extreme weather events;; ii) deforestation; and iv) diminishing water resources. The root causes of these environmental stresses include both anthropogenic and natural pressures (including climate variability). However, anthropogenic pressures directly and/or indirectly are associated with as well as aggravate natural pressures including climate change/variability. These environmental stresses affect biophysical processes that underpin a range of socio-economic sectors e.g. agriculture, water, energy, public health and natural resources.

Climate hazards/extreme weather events

Myanmar experiences the following climate hazards/extreme weather events: i) cyclones/ strong winds; ii) flood/storm surge; iii) intense rains; iii) extreme high temperatures; and v) drought. Drought is the most severe weather event in the country, followed by extreme day temperatures,

[38] Leimgruber, P., D. S. Kelly, M. K. Steininger, J. Brunner, T. MÃller, and M. Songer. 2005. Forest cover change patterns in Myanmar (Burma) 1990-2000. Environmental Conservation 32:356.
[39] Leimgruber, P., D. S. Kelly, M. K. Steininger, J. Brunner, T. MÃller, and M. Songer. 2005. Forest cover change patterns in Myanmar (Burma) 1990-2000. Environmental Conservation 32:356.
[40] Lateef, F. 2009. Cyclone Nargis and Myanmar: a wakeup call. Journal of Emergencies, Trauma and Shock 2:106-113.
[41] Medical Advice Myanmar. 2009. Last Accessed 16/02/12 http://www.rangun.diplo.de/contentblob/2507870/Daten/602459/Medical_Advice.pdf

cyclones/strong winds, intense rain and flood/storm surge. This is based on the overall impact of drought events on local communities, including health impacts, damage to property and assets as well as loss of income and livelihoods. See Table 2 below for a description of the highest impact sectors, areas and main impacts for climate hazards/extreme weather events in Myanmar.

Table 2 Description of climate hazards/extreme weather events that affect Myanmar including the highest impact sectors, areas and direct/indirect impacts.

Climate hazard	Highest impact sectors	Highest impact areas	Direct & indirect impacts
Drought	agriculture, water, energy and public health	• Rain-shadow (arid to semi-arid) central belt of the country. • Central Dry Zone	**Direct** • Agricultural yields decrease and crops fail. • Limited consumable water. • Severe water shortages during El Niño Southern Oscillation years. • Decreased river flows. • Worker productivity declines. **Indirect** • Reduced potential for harnessing energy for electricity and power. • Dehydration and other health complications • Increased wildfires and associated haze pollution cause health risks. • Limited access for local communities to food, drinking water and other basic services. • Poverty, morbidity and mortality increases.
Cyclone/ strong winds	agriculture (crops and livestock), fisheries (marine), water, energy and public health	• Coastal areas, mainly the Rakhine Coastal State, Ayeyarwady Delta and Mon State.	**Direct** • Storm surges (higher than 3m), heavy rains (>127mm in 24 hours), and strong winds (as high as 120mph)[42]. • Damage to agricultural land and crops, and windthrow of trees. • Damage to vulnerable ecosystems e.g. coral reefs and mangrove/coastal forests. • Local rice/crop landraces (germplasm) damaged and/or lost. • Loss of lives and livelihoods. • Displaced ground and surface freshwater supplies by saline water. **Indirect** • Limited drinking-water and irrigation water supply[43]. • Outbreak of food- and water-borne diseases. • Post-traumatic stress disorders.
Intense rains	agriculture, water, and public health,	• Catchment areas of major rivers in the Northern Hilly region and Central Dry Zone • Mountainous and hilly areas in Kayin, Kachin, Shan, Mon and Chin States. • Ayeryarwady River basin areas. • Coastal areas.	**Direct** • Flash floods in lowland areas[44]. • Top soil runoff and erosion resulting in severe soil degradation and loss of fertile soils. • Damage to crops. • Enhanced problems during La Niña periods when the country experiences excessive water levels[45]. **Indirect** • Death of livestock. • Health risks such as skin diseases and the outbreak of diarrheal diseases. • Erosion gullies in agricultural areas. • Loss of valuable farming areas. • Degradation of natural vegetation resulting in an increase in erosion. • Landslides resulting in extensive damage to human

[42] Union of Myanmar et al. 2009. Hazard Profile of Myanmar.
[43] Swe, K. L. Review of adaptations in socio-economical sectors in Myanmar. Yezin Agricultural University.
[44] Department of Meteorology and Hydrology, United Nations Environment Programme. 2009. Towards Myanmar's National Strategy for Adaptation to Climate Change, Participatory Rural Appraisal Synthesis Report. Preparation of National Adaptation Programmes of Action (NAPA Project).
[45] Swe, K. L. Review of adaptations in socio-economical sectors in Myanmar. Yezin Agricultural University.

			settlements and agricultural land.
Flood/storm surge	agriculture (crop and livestock), water, infrastructure, energy and public health.	• Upper reaches of river systems. • Coastal areas. • Low-lying areas along major river systems (such as the Ayeyarwady Delta).	**Direct** • Storm surge flooding as a result of cyclones and storms in coastal areas. • River floods in delta areas. • Flash floods. • Localized floods in urban areas as a result of *inter alia* cloudburst, poor infiltration rates, saturated soils, and inadequate infrastructure. • Damage to coastal areas e.g. mangroves and river ecosystems. • Severely flooded or inundated land (every 2 years ~2 million hectares of land is flooded and 3.25 million hectares is moderately inundated). **Indirect** • Intense runoff and soil erosion (particularly during La Niña periods). • Damage to riverbanks and irrigation systems. • Landslides triggered. • Entire villages lost including loss of lives and livelihoods.
Extreme high temperatures	agriculture (livestock and crops), fisheries, water, energy and industry, and public health	• Arid to semi-arid central belt of the country. • Central Dry Zone	**Direct** • Heat waves • Reduced water availability. **Indirect** • Aggravated drought events. • Decreased agricultural production. • Pest and disease outbreaks e.g. foot and mouth disease. • Health problems such as diarrhoea, heat stroke, dehydration, and brain haemorrhaging particularly among elderly, infants, and agricultural and industrial workers.

Deforestation

Myanmar's forests have been affected by degradation, shifting cultivation, and conversion to commercial oil palm plantations (the latter is particularly relevant in the lowland forests of the Tanintharyi Region). Deforestation pressures include: i) fuelwood consumption (the principle source of energy); ii) unplanned and unrestricted agricultural expansion; iii) aquaculture (e.g. shrimp farming in the Delta region); iv) infrastructure development; and v) commercial clear cutting[46]. Over the period 1989-1998, the annual deforestation rate in Myanmar has been estimated at 466,420 ha/annum. Furthermore, over the past two decades, Myanmar has lost >3% of its forest ecosystems[47]. Deforestation, however, varies considerably among the regions. The central and/or more populated States and Regions show the highest losses of forest resources. The most notable being the mangrove forests in the Ayeyarwady Delta and the remaining dry forests at the northern edge of the Central Dry Zone[48]. For example, it has been estimated that ~83% of mangroves in the Ayeyarwady Delta have been destroyed between 1924 and 1999[49].

The root cause of deforestation in Myanmar is over-exploitation of natural resources and unsustainable land management practices. For example, illegal and uncontrolled logging has caused substantial damage to Myanmar's forests, particularly in upland areas. Over-exploitation results in soil degradation and erosion. This is further aggravated by traditional farming practices used by local farmers e.g. slash-and-burn cultivation. Poor farming practices which deplete essential minerals from soils (e.g. potassium, nitrogen, and phosphorous) has reduced land productivity[50]. Decreased productivity and limited vegetation cover has destabilised soils and caused erosion resulting in gullies,

[46] Leimgruber, P., B. Senior, Uga, M. Aung, M. A. Songer, T. Mueller, C. Wemmer, and J. D. Ballou. 2008. Modeling population viability of captive elephants in Myanmar (Burma): Implications for wild populations. Animal Conservation 11:198.
[47] Moe, W. 2009. Burma taking severe hit from climate change: Watchdog. http://reliefweb.int/node/336464
[48] Leimgruber, P., D. S. Kelly, M. K. Steininger, J. Brunner, T. MÃller, and M. Songer. 2005. Forest cover change patterns in Myanmar (Burma) 1990-2000. Environmental Conservation 32:356.
[49] World Vision. 2008. Disaster Monitor, Myanmar.
[50] Kabir, H. Adaptation and adoption of the system of rice intensification (SRI) in Myanmar using the farmer field school (FFS) approach.

soil loss and decreased infiltration rates. In coastal areas large-scale destruction of coastal ecosystems (e.g. mangroves and other coastal ecosystems) has occurred as a result of increasing human populations, infrastructural developments (e.g. shrimp farming), over exploitation (timber and fuelwood), and pollution.

Diminishing Water Resources

The compounding effects of land degradation, overutilization and unfavourable agricultural practices in Myanmar are diminishing water supplies for domestic, agricultural and industrial use. Degradation of vegetation cover and poor land management around Inle Lake (Myanmar's largest Lake) for example has caused severe soil erosion and sedimentation resulting in the Lake becoming shallower. This has reduced the quantity of water available for use by local communities and jeopardised agricultural practices (floating gardens, fishing activities), tourism and recreational activities[51]. The demand for water in Myanmar significantly increases during the hotter and drier parts of the year. It is expected that this demand will increase as socio-economic sectors expand, the climate gets hotter and drier and rainfall becomes more unpredictable. Under a changing climate, losses in agriculture productivity are expected as most of Myanmar's food production relies on rain-fed agriculture. Water related impacts are likely to undermine future development and economic growth in Myanmar.

Myanmar's Status under the United Nations Framework Convention on Climate Change (UNFCCC) and Institutional Arrangements for Climate Change Adaptation

The Government of Myanmar signed the United Nations Framework Convention on Climate Change on 11 June 1992 and ratified the UNFCCC on 25 November 1994. In order to fulfil its commitments and obligations as required by Articles 4.1 and 12.1 of the UNFCCC, apart from developing its NAPA, Myanmar is currently completing the preparation of its Initial National Communication (INC)[52] for submission to the UNFCCC. As highlighted in Decision 2/CP.7 of the COP 7, through the INC process Myanmar is gradually building its institutional, scientific, technical, informational and human capacity at all levels. This will ensure the country's effective implementation of the Convention in a sustainable manner. The current INC project focuses on analysing levels of greenhouse gas emission, climate change scenarios, associated risks and vulnerabilities, potential measures and technology transfer for mitigating climate change and the degree of public awareness on climate change issues.

The National Environmental Conservation Committee (NECC) (formerly known as the National Commission for Environmental Affairs [NCEA]) is the focal point for various international environmental conventions including the UNFCCC in Myanmar. The NCEA was established in 1990 to: i) advise the government on environmental policies; ii) act as a coordinating body for environmental affairs; and iii) promote environmentally sound sustainable development. The NCEA was reorganised into the Planning and Statistics Department, under the Ministry of Environmental Conservation and Forestry, with a new identity of the National Environmental Conservation Committee (NECC) in April 2011. The NECC (located within the Ministry of Environmental Conservation and Forestry) is responsible for guiding national activities to address climate change-related problems. Furthermore, the NECC manages and coordinates all climate change-related activities in Myanmar including developing climate change related policies and strategies as well as programmes of action.

Although the government has taken several steps towards sustainable development, conservation of natural resources and disaster risk reduction, such as drafting of Disaster Risk Reduction Law, there are still needs for laws or regulatory mechanisms directly focussed on building the resilience and adaptive capacity of communities and ecosystems (and thus socio-economic sectors) to climate change impacts. There are some laws that directly relate to climate change mitigation, in particular, the emissions of Green House Gasses (GHG) and pollutants. Other laws that are in some way promoting adaptation to climate change include the Forest Law Act (1992), Wildlife Act (1994) and

[51] UNEP Project Document. 2009. Myanmar: Preparation of National Adaptation Programme of Action (NAPA).

[52] INC preparation is being based on Guidelines for the preparation of National Communications from non-Annex I Parties to the UNFCCC adopted at COP 8 (decision 17/CP.8) in 2002 and the format recommended by the Operational Procedures for the Expedited Financing of National Communications from non-Annex I Parties provided by the GEF in 2003.

Protected Area and Forest Policy Statement (1995). As climate change impacts could severely undermine economic growth in Myanmar, the formulation and implementation of policies on climate change adaptation is vital for sustainable development.

2. Myanmar's Framework for Climate Change Adaptation

Observed Climate Variability/Change in Myanmar

The observed climate variability and change in Myanmar over the last ~six decades includes the following:

- a general increase in temperatures across the whole country (~0.08°C per decade), most notably in the northern and central regions;
- a general increase in total rainfall over most regions, however, with notable decreases occurring in certain areas (e.g. Bago Region);
- a decrease in the duration of the south-west monsoon season as a result of a late onset and early departure times; and
- increases in the occurrence and severity of extreme weather events, including; cyclones/strong winds, flood/storm surges, intense rains, extreme high temperatures and drought.

Observed Changes in Temperature (Annex 3)

Over the last six decades (1951 to 2007), the temperature in Myanmar has increased on average by ~0.08°C per decade. This has been reflected by fewer cold days and more frequent hot days (Figure 7)[53]. Despite overall trends of increasing temperatures, five Regions have experienced decreases. Appreciable decreases include Magway (-0.23°C per decade) and Bago (-0.16°C per decade). The highest warming (~0.32°C per decade) has been experienced in the Kayin State. From 1951 to 2000, ~15 heat waves occurred per year. The most extensive heat wave (covering up to 60% of the country) occurred in 1998 during a El Niño Southern Oscillation (ENSO) year.

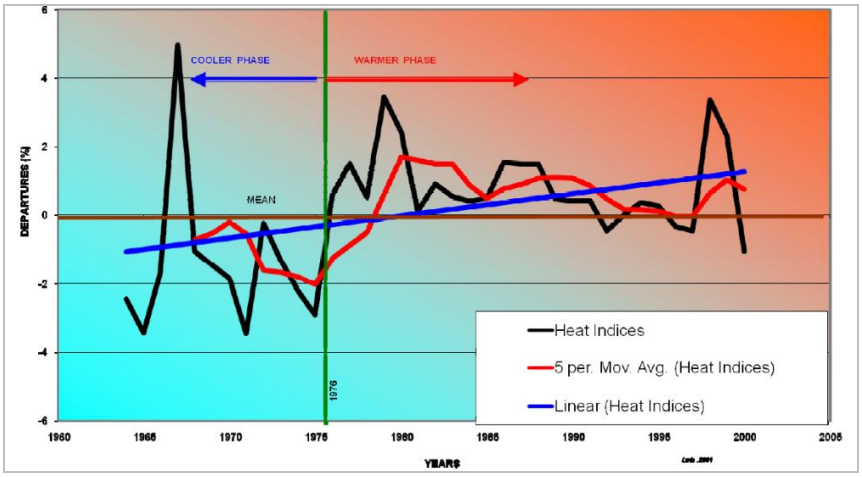

Figure 7. Departure from the mean temperature over the period 1960 to 2005 (Heat Index-black line) indicating: i) more frequent hot years since 1976; and ii) a linear increase in temperature over the time period (Linear–Blueline)[54].

Observed Changes in Rainfall (Annex 3)

Over the last six decades (1951-2007), the rainfall in Myanmar has increased on average by 29 mm per decade. Rainfall trends have however been variable over the period. The majority of regions have experienced an increase in rainfall with the Upper Sagaing Region experiencing the greatest increases (~215 mm per decade). However, six regions experienced a decrease in annual rainfall. The greatest being the Bago Region (81 mm per decade). Changes in rainfall have also influenced the duration of the monsoon season. The southwest monsoon onset has become later in the year and

[53] Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K., and Heuer, S. 2009. Regional Vulnerability of Climate Change Impacts on Asian Rice Production and Scope for Adaptation. Advances in Agronomy 102:91-133.

[54] Department of Meteorology and Hydrology, Myanmar. 2010.

withdrawal earlier in the year (see Figure 8). Over the period 1991-2004, 32 extreme rainfalls have occurred across 16 stations in the country.

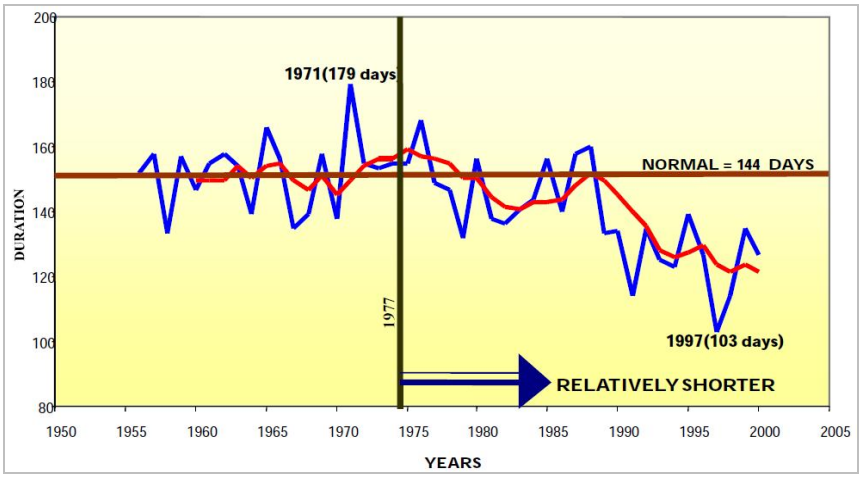

Figure 8. Departure from the mean normal monsoon duration (144 days) over the period 1950-2005 (Blue line) indicating a relative shorter annual monsoon season since 1975[55].

Observed Changes in Climate Related Hazards/Extreme Weather Events

The observed changes in climate related hazards in Myanmar include:

- **An increase in the prevalence of drought events -** Drought years with moderate intensity were frequent in the 1980s and the 1990s. Extended dry seasons and increased temperatures have however caused an increase in the prevalence of drought. Severe droughts have increased in frequency from 1990 to 2002. In 2010, severe drought diminished village water sources across the country and destroyed agricultural yields of peas, sugar cane, tomato, and rice.
- **An increase in intensity and frequency of cyclone/strong winds -** In the past (before 2000), cyclones made landfall (i.e. centre of the storm moved across the coast) along Myanmar's coast once every three years. Since the turn of the century, cyclones have made landfall along Myanmar's coastline every year[56]. From 1887 to 2005, 1,248 tropical storms formed in the Bay of Bengal. Eighty of these storms (6.4% of the total) reached Myanmar's coastline. Recent cyclones of note include Cyclone Mala (2006), Nargis (2008) and Giri (2010)[57]. Cyclone Nargis hit the coast in May 2008 and was the most devastating cyclone that Myanmar has ever experienced. The Ayeyarwady Delta and the eastern part of Yangon were most affected experiencing wind speeds >258 km/h. The main impacts included: i) extensive damage to mangroves, agricultural land, houses and utility infrastructures; ii) salt-water intrusion into agricultural lands and freshwater sources causing economic, social and environmental damage; iii) loss of livelihoods and homes (3.2 million people affected), including 138,373 deaths; and iv) damages of ~US $4.1 billion[58]. Cyclone Giri hit the coast in October 2010 resulting in a maximum storm surge of approximately 3.7 m and winds speeds in excess of 120 km/h. The Cyclone caused damage and loss of government buildings, households, schools and farm assets. The death toll was significantly less than that of Cyclone Nargis (45 people). However, the cyclone resulted in 70,000 people left without homes.
- **Rainfall variability including erratic and record-breaking intense rainfall events -** Rainfall patterns in Myanmar have become unpredictable with regular reports of record-breaking rainfall:
  - Over the period 1960-2009, shorter rainfall seasons in combination with erratic and intense rainfall resulted in numerous flooding events[59].
  - In 1999, heavy rainfall triggered a landslide along the western slope of the Tanintharyi Ranges, causing damages to several villages as a result of fallen material[60].

[55] Department of Meteorology and Hydrology, Myanmar. 2010
[56] Union of Myanmar *et al.* 2009. Hazard Profile of Myanmar.
[57] Swe, K. L. Review of adaptations in socio-economical sectors in Myanmar. Yezin Agricultural University.
[58] Tripartite Core Group. 2009.Post Nargis Joint Assessment (PONJA) "Post Nargis Periodic Review II".
59 Swe, K. L. Review of adaptations in socio-economical sectors in Myanmar. Yezin Agricultural University.
[60] Union of Myanmar et al. 2009. Hazard Profile of Myanmar.

- In July 2009, 434 mm of rainfall fell in a single day in Launglon breaking the highest 24-hour rainfall record in the country.
- In August 2009, the Bago Division experienced its highest 24-hour rainfall in 45 years, resulting in severe flooding throughout the town.
- From July to October in 2011, heavy rain and flooding in the Ayeyarwady, Bago, Mon and Rakhine Regions/States resulted in losses of ~1.7 million tons of rice.

- **An increase in the occurrence of flooding and storm surge -** From 1910 to 2000 12 major floods occurred in the country[61]. In recent years, however, there has been an increase in the occurrence of flooding events. Flooding disasters during the last decade include:
  - In June 2001, a severe flash flood occurred in the Wuntwin Township in central Myanmar, which swept away a number of villages.
  - In October 2006, two-week floods from the Zawgyi River caused extensive crop damage.
  - In 2007, extensive record-breaking flooding resulted in ~809,284 ha of crop land inundated and >50% crops damaged.
  - In June 2010, intense rains resulted in excessive sedimentation of paddy fields in the Rakhine State, which damaged rice seedlings and reduced harvests resulting in total damages of ~ US $1.64 million.
- **An increase in extreme high temperatures -** There has been a general increase in temperatures across Myanmar over the last six decades. This has resulted in an increase in extreme high temperature days and thus the prevalence of heat-related disorders. During summer 2010, 1,482 heat-related disorders were reported and 260 heat-related deaths occurred across Myanmar.

Projected Climate Change and Vulnerability for Myanmar (2001-2100) [62]

Climate change projections for Myanmar predict:

- a general increase in temperature across the whole country, particularly from December – May with the Central and Northern regions experiencing the greatest increases;
- a increase in clear sky days exacerbating drought periods;
- an increase in rainfall variability during the rainy season including an increase across the whole country from March – November (particularly in Northern Myanmar), and decrease between December and February;
- an increase in the risk of flooding resulting from a late onset and early withdrawal of monsoon events;
- an increase in the occurrence and intensity of extreme weather events, including cyclones/strong winds, flood/storm surge, intense rains, extreme high temperatures and drought.

Figure 5 and 6 below indicate temperature and rainfall changes over Myanmar for the next 80 years. Table details climate change predictions over Myanmar for the time periods of 2001-2020, 2021-2050 and 2051-2100 (PRECIS model, see Annex 4 for a detailed description of results as well as the seven weather stations used to represent changes for seven physiogeographic regions in Myanmar).

[61] United Nations Economic and Social Commission for Asia and the Pacific. 2011. Food Security and Natural Disasters: Country Status Paper.

[62] Future changes of temperature and precipitation have been estimated for Myanmar using a number of global and regional climate models. For the purpose of this NAPA, the predictions from the model 'Providing Regional Climates for Impacts Studies' (PRECIS) are reported. The model was conducted using 20 km x 20 km resolution, and operated by the South East Asia System Analysis Research and Training Regional Centre (SEA START RC) using A2 emissions scenario. The baseline information uses modelled data for the period 1971-2000. The model used data collected at seven stations, assumed to be representative of seven physiographic regions in Myanmar (Annex 4).

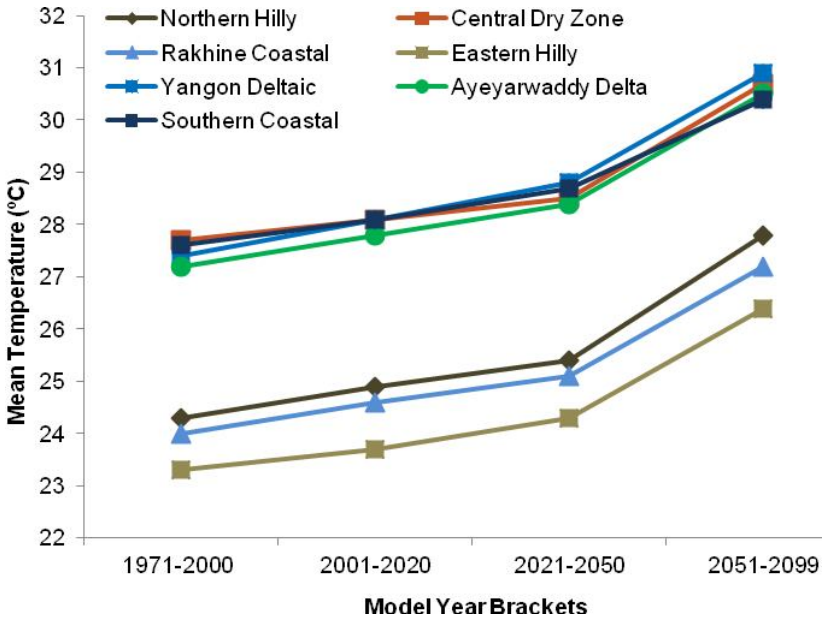

Figure 9. Predicted temperature trends for the seven physiographic regions in Myanmar (PRECIS model – Annex 4).

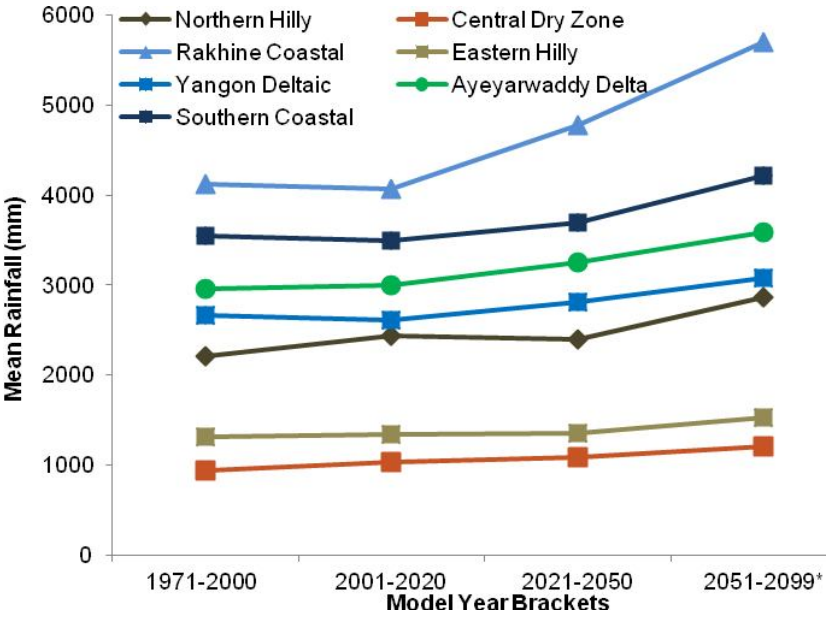

Figure 10. Predicted rainfall trends for the seven physiographic regions in Myanmar (PRECIS model-Annex 4).

Table 3. Detailed projected climate change trends across Myanmar for 2001-2100. Climate change predictions for annual rainfall indicate increases in annual average rainfall over the relevant time period (i.e. non-cumulative). For example an increase of ~228mm per annum over the time period 2001-2020 (see below) specifies that the annual average rainfall across 2001-2020 will increase by 228mm relative to the baseline modelled annual average rainfall (See Annex 4 for baseline modelled averages and relevant comparisons).

Climate change predictions for 2001-2020 include:	Climate change predictions for 2021-2050 include:	Climate change predictions for 2051-2100 include:
• an increase in temperature of ~ 0.4 °C to 0.7 °C across Myanmar with the Yangon Deltaic region experiencing the greatest	• an increase in temperature of 0.8 ºC to 1.4 ºC across Myanmar with the Yangon Deltaic (1.4 ºC) and Rakhine Coastal region	• an increase in temperature of 2.8 ºC to 3.5 ºC across Myanmar with the highest increases in the Rakhine Coastal and Yangon

increase (~0.7 °C); • an increase in clear sky days in Northern and Central Myanmar exacerbating drought events; • highly variable rainfall changes throughout the country including large increases in the Northern Hilly region (~228 mm per annum) as well as decreases in the Rakhine Coastal, Yangon Deltaic, and Southern Coastal region (~58 mm per annum); and • an increase in floods and droughts resulting from variable rainfall conditions.	(1.2°C) experiencing the greatest increases; • an increase in rainfall across the country with the Rakhine Coastal region experiencing the greatest increases (~661 mm per annum) and the Eastern Hilly region experiencing the smallest increase (~36 mm per annum); • periods of heavier rains; and • longer dry spells.	Deltaic regions (3.5°C); • a weakened monsoon climate supported by decreased cloud coverage; • an increase in drought periods across most of Myanmar; and • an increase in precipitation with highest increases in the Rakhine Coastal region (~1582 mm per annum) and smallest increases in the Eastern Hilly region (~209 mm per annum).

Note* ~228mm, 661mm, 1582 mm are standard deviation values from respective base years.

Climate Change Vulnerable Regions, Socio-Economic Sectors and Communities

Myanmar is very vulnerable to climate change as a result of the following compounding factors[63]:

- employment and the national income is dependent on climate-sensitive sectors such as agriculture, forestry and natural resources;
- human populations and economic activities are concentrated in the coastal zone as well as in low-lying lands and are therefore exposed to long-term climatic impacts such as sea-level rise[64] as well as an increase in cyclones and storm surge/flooding;
- exposure to both geological and meteorological hazards (e.g. earthquakes, floods, cyclones and tsunamis) as a result of the country's southwest location within the Bay of Bengal as well as its long and low-lying coastal zone which stretches across the Arabian and Indo-Chineses Tectonic Plates;
- high poverty levels which affect the capacity of the country to respond to climate change related impacts[65]; and
- limited technological capacity to prepare for the impacts of climate change or the consequences of climate change related events.

Predicted climate change in Myanmar is expected to have negative impacts on the entire socio-economic functioning of the country. However, certain regions/states (**Error! Reference source not found.** and Figure 11a) as well as socio-economic sectors (see Figure 11b) are most vulnerable to climate change impacts. Overall, the Coastal, Central Dry and Northern Hilly areas of the country are most vulnerable to climate change impacts (Figure 12a). The Public Health socio-economic sector is most at risk (Vulnerability Index [VI] = 3.4) followed by Biodiversity (VI=2.5), Water Resources (VI=2.4), Forest (VI=1.7), Coastal Zone (VI=1) and Agriculture (VI=0.9)[66]. Considering population density, vulnerability is relatively high in Ayeyarwady and Yangon Regions followed by Mandalay, Mon and Bago Region/States (Figure 12b).

Vulnerability varies significantly between different groups of people in Myanmar depending on their specific reliance on climate-sensitive income or livelihood sources. For example according to the PRA conducted in townships representative of the three agro-ecological zones (see Annex 2 PRA results)[67]:

- **farmers** in Myanmar will be greatly affected by an increase in intensity and severity of droughts and floods;
- **fisher folk** will be affected by the impacts of extreme weather events (e.g. cyclones) on fish stocks;
- **retail businesses** will suffer as consumer goods and food crops increase in price as productivity decreases;

[63] Lian, K. K. and Bhullar, L. 2010. Adaptation to Climate Change in the ASEAN Region.
[64] World Vision. 2008. Disaster Monitor, Myanmar.
[65] Yohe, G. and Tol, R. S. J. 2002. Indicators for social and economic coping capacity: moving toward a working definition of adaptive capacity. Global Environmental Change 12:25-40.
[66] Vulnerability Assessment. Initial National Communication. Myanmar
[67] Department of Meteorology and Hydrology, United Nations Environment Programme. 2009. Towards Myanmar's National Strategy for Adaptation to Climate Change, Participatory Rural Appraisal Synthesis Report. Preparation of National Adaptation Programmes of Action (NAPA Project).

- **poor households** with limited access to health care will be increasingly vulnerable as the availability of work on farms decreases and the occurrence of infectious diseases increases; and
- **women and children** will be particularly vulnerable as they have been found to be more susceptible to the economic/livelihood losses as well as risk of abuse/violence/exploitation after extreme weather events and poor households will struggle to send their children to school[68].

Vulnerability is a set of prevailing or consequential conditions, which adversely affect a community's ability to prevent, mitigate, prepare for or respond to climate change. These long-term factors, weaknesses or constraints affect a household's, community's or society's ability (or inability) to absorb losses and to recover from the damage[69]. The level of vulnerability of local communities in Myanmar is characterised by the above features, including geographical area, community group, livelihood type, and/or economic sector. The most vulnerable communities in Myanmar occur in all three agro-ecological zones namely the Hilly, Dry and Coastal Zones and are made up of mainly community group members situated in high risk areas (Table 4) and participating in vulnerable livelihood strategies e.g. farmers, woodcutters, fisher folk, grocery merchants, casual workers, homemakers, NTFPs collectors and retailers. Furthermore, women and children situated in high impact areas (vulnerable areas and regions/states e.g. Table 4) e.g. hilly, coastal, river/lake side areas, as well as urban areas will be negatively affected (see Chapter 3 for more details on vulnerable communities in Myanmar as well as Annex 2).

Table 4 The areas and Regions/States that are most vulnerable to sea-level rise as well as climate change-related increases in occurrence and severity of extreme weather events [70]

Extreme weather event	Vulnerable areas and Regions/States
Drought	Central Dry Zone - Sagaing, Mandalay and Magway Regions[71] particularly agricultural land occurring in these areas.
Cyclone/strong winds	Coastal regions - Rakhine, Ayeyarwady and Yangon Regions/States.
Intense rain	Tanintharyi, Yangon, Rakhine, Ayeyarwady and Mon State/Region. These areas have the longest exposure to the south west monsoon flow. Lower Myanmar as well as north-western areas will also be affected.
Flood/storm surge	All low-land and flat Regions as well as rivers and associated valleys and basins. Areas in close proximity to the Ayeyarwady, Chindwin, Sittaung and Thanlwin river systems and coastal areas are particularly at risk to storm surges, hydrological floods, flash floods and river bank overflow associated with snow-melt.
Extreme high temperature	Relatively flat regions in the Central Dry Zone e.g. Mandalay and Magway.
Sea-level rise	Coastal zones, especially areas interspersed with tidal waterways e.g. the Ayeyarwady Delta. In certain areas, it is thought that low-lying coastal areas may face permanent inundation.

[68] Department of Meteorology and Hydrology, United Nations Environment Programme. 2009. Towards Myanmar's National Strategy for Adaptation to Climate Change, Participatory Rural Appraisal Synthesis Report. Preparation of National Adaptation Programmes of Action (NAPA Project).

[69] Global Crisis Solutions –Training Unit – Support to Program Quality Project. Promoting Rights through Practise and Policy. Understanding Vulnerability. Ensuring Appropriate and Effective Response.

[70] National Commission for Environmental Affairs. Report on Possibility of application of\A0\A0 Assessment of Vulnerability Index and adaptations due to Climate Change in Myanmar.

[71] National Commission for Environmental Affairs. Report on Possibility of application of\A0\A0 Assessment of Vulnerability Index and adaptations due to Climate Change in Myanmar.

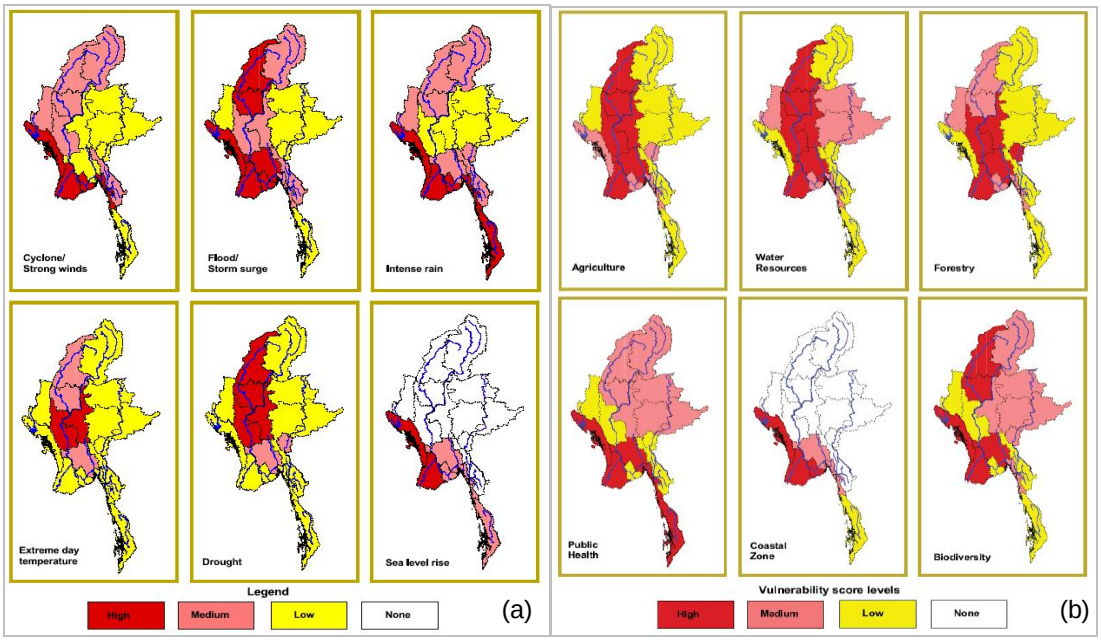

Figure 11. (a) Vulnerability of areas and Regions/States to climate change-related increases in intensity and severity of extreme weather events; and (b) the vulnerability of the main socio-economic sectors in Myanmar to extreme weather events as well as a range of other predicted climate change impacts[72].

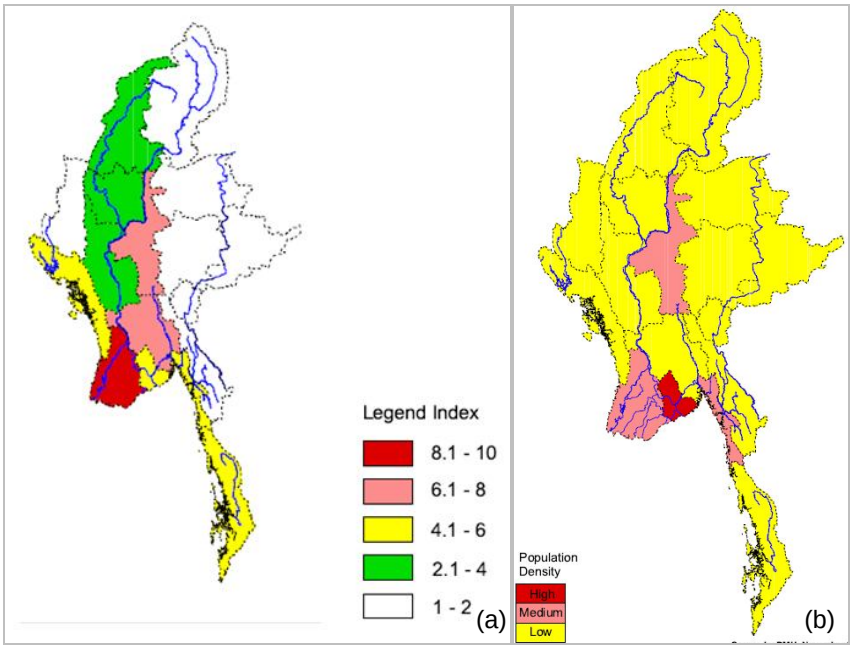

Figure 12. (a) Myanmar's overall climate change vulnerability index (taking into account areas and socio-economic sectors most at risk); and (b) climate change vulnerability index for Myanmar considering population density.

Climate Change Impacts on Socio-Economic Sectors

Agriculture

Agriculture in Myanmar is extremely vulnerable to climate change.The predicted rise in temperature in Myanmar is expected to have major negative impacts on agricultural production and food security[73].

[72] Department of Meteorology and Hydrology, 2009.

Higher temperatures will reduce yields of desirable crops (e.g. rice, wheat, maize, soybean and groundnut) and encourage weed and pest proliferation. Changes in precipitation patterns will increase the likelihood of short-term crop failures as well as long-term production declines. According to the IPCC 4th Assessment Report, climate change is expected to affect agriculture in South East Asia in several ways: i) irrigation systems will be affected by changes in rainfall and runoff, and subsequently, water quality and supply; ii) temperature increases of ~2-4°C will threaten agricultural productivity, stressing crops and reducing yields; iii) changes in temperature, moisture and carbon dioxide concentrations will negatively affect major cereal (e.g. rice, wheat, maize and millet) and tree crops; and iv) increases in rice and wheat production associated with CO_2 fertilization will be offset by reductions in yields resulting from temperature and/or moisture changes. In particular, the increases in occurrence of droughts will result in crop failure in rain-fed agricultural areas and will increase the demand for irrigation. Conversely, increases in the occurrence of intense rains and resulting extreme floods will result in higher yield losses from crop damage[74]. A rise of 1-2°C combined with lower solar radiation has the potential to cause rice spikelet sterility (i.e. infertile rice seeds). Rice becomes sterile if exposed to temperatures above 35 °C for more than one hour during flowering and consequently produces no grain. This will limit rice production[75]. Furthermore, higher temperatures will increase the incidence of crop diseases, insect pests and rodents[76,77].

The highly productive deltaic and low-lying coastal rice/local crop cultivation areas in Myanmar will not only be exposed to increased temperatures, erratic rainfall, droughts, floods and intense rains, but will also be exposed to increased salinity, coastal erosion, and inundation as a result of sea-level rise[78]. The extensive, low-lying Ayeyarwady/Yangon Deltaic regions are particularly vulnerable to sea-level rise. By 2100, global sea level could rise by >0.2-0.6 m. A 0.5 m sea level rise would result in the shoreline along the Ayeyarwady Delta advancing by 10 km. This would have a significant impact on local communities and the Agriculture sector.

Agricultural impacts will particularly affect low-income rural populations that depend on traditional agricultural systems or on marginal lands. According to detailed modelling of crop growth under climate change using global agriculture models[79], climate change will result in the following impacts for South Asian countries: i) severe declines in important crops including rice, wheat, maize, soybeans and groundnuts; and ii) large declines for irrigated crops. This will result in: i) additional price increases for important agricultural crops (rice, wheat, maize, soybeans and groundnut); ii) higher livestock feed prices which will result in higher meat prices; v) a reduction in meat consumption; vi) a substantial fall in cereal consumption; and vii) a decline in calorie availability which will increase child malnutrition by 20%.

Forest

Climate change is likely to affect both the distribution and composition of forests in Myanmar. In certain areas, climate-induced succession will result in forest conversion to less productive grasslands[80]. The predicted increase in intense rain events in combination with a reduction in vegetation cover will result in decreased rainfall infiltration. This will increase runoff, erosion and sedimentation of streams/rivers and lakes. The predicted increase in droughts and extreme day temperatures will increase evapotranspiration from the canopy of trees, causing increased moisture stress. This will in turn increase the vulnerability of forests to fires[81]. Changing climates will also favour the encroachment of invasive plant/animal species including insect pests. Furthermore, structural and

73 Wassmann, R., Jagadish, S. V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K., and Heuer, S. 2009. Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. Advances in Agronomy 102:91-133.

74 Swe, K. L. Review of adaptations in socio-economical sectors in Myanmar. Yezin Agricultural University.

75 Karim, Z., 1996. Agricultural Vulnerability and Poverty Alleviation in Bangladesh. In Climate Change and World Food Security, T.E. Downing (Ed.), NATO ASI Series, 137. Springer-Verlag, Berlin, Hiedelberg, 1996. pp. 307-346.

76 Karim, Z., 1996. Agricultural Vulnerability and Poverty Alleviation in Bangladesh. In Climate Change and World Food Security, T.E. Downing (Ed.), NATO ASI Series, 137. Springer-Verlag, Berlin, Hiedelberg, 1996. pp. 307-346.

77 Singleton G.R., S.R. Belmain, P.R. Brown and B. Hardy. 2010. Rodent Outbreaks: Ecology and Impacts. Los Baños (Philippines): International Rice Research Institute.

78 World Vision. 2008. Disaster Monitor, Myanmar.

79 Gerald C. Nelson. 2009. Climate Change, Impact on Agriculture and Costs of Adaptation, International Food Policy Research Institute. Washington, D.C.

80 Tun, Tin, 2006. Biodiversity: Status of Forest Biodiversity in Myanmar. Paper presented at the 5th Annual Meeting of the Academy of Forestry Science. (5th Annual Meeting of the Myanmar Academy of Agricultural, Forestry, Livestock and Fishery Sciences.

81 Union of Myanmar et al. 2009. Hazard Profile of Myanmar.

functional changes of Myanmar's forests will have a cyclical impact on the climate system through effects on biogeochemical cycles e.g. nitrogen and carbon[82,83].

Public Health

Increasing temperatures and erratic precipitation patterns will create favourable conditions for the spread of infectious diseases. Additional effects of increasing temperatures on human health, including *inter alia* heat stress, heat exhaustion and dehydration. Additionally, extreme temperatures will aggravate the effects of individuals suffering with cardio-respiratory diseases. Air pollution-related health problems will also be affected as air pollution levels increase from a combination of high emissions and unfavourable weather[84]. Higher temperatures will also reduce the development time for pathogens and thereby increase transmission rates e.g. mosquito-borne diseases such as malaria and dengue will increase[85]. Furthermore, pathogen distribution will increase in range as vectors harbouring parasites infest highland areas (e.g. Shan State) which at present are too cold for vector insects. Fluctuating insect, bat and rodent populations in response to climatic conditions are predicted to have negative effects on the spread of a range of diseases[86,87].

The greatest concern at present regarding climate change impacts on human health is related to freshwater resources[88]. Increases in intense rain events and tropical storms will lead to increases in flooding events and storm surges. This will affect freshwater sources as they become contaminated by rising flood water levels. Furthermore, rising sea-levels will result in fresh groundwater resources being displaced with salt water. An increase in non-potable fresh water sources will result in communities without safe drinking water and increasing dehydration risks, further exacerbated by diarrheal diseases. In addition, increases in occurrence and severity of droughts will decrease water availability and water quality[89]. The impacts of extreme weather events on the agriculture and fisheries sectors will also have knock-on effects on food security increasing malnutrition in the country.

Water resources

Climate change-induced changes to hydrological cycles will deteriorate water quality, quantity, and accessibility. Several sections of the hydrological cycle are vulnerable to climate change. The rate of snow and glacial melt is expected to increase resulting in changing river flows and unpredictable flooding events. The late onset and early withdrawal of the monsoon period will result in large quantities of rain falling over short periods. This will result in flooding, contamination of water resources, erosion and limited replenishment of waterways. Furthermore, changes in river flow and discharge will increase the risk of flash floods as well as decrease ground water recharge. Vast areas of lowland regions will be regularly inundated as a result of flooding events. Conversely, increases in drought events will increase utilisation pressures on ground water for expanding irrigated agriculture. Rising sea-levels, however, will lead to salt-water intrusion into groundwater supplies particularly as existing water levels decrease. Ground water supplies will be particularly vulnerable to saline intrusion during the dry season as a result of low water volumes in river systems. Furthermore, regardless of the quantity of water available increased temperatures from climate change will increase evaporation rates, raising the concentration of dissolved salts in the water often deeming it unsuitable for drinking purposes[90].

[82] Forest Department, 2010. Forestry in Myanmar. Nay Pyi Taw (Unpublished)
[83] Thaung Naing Oo and Ohn Lwin, 2010. Adaptation to Vulnerability in Climate Change in Coastal Areas with Emphasis on Mangroves in Myanmar. Paper presented at the 8th Annual Meeting of the Academy of Forestry Science. (8th Annual Meeting of the Myanmar Academy of Agricultural, Forestry, Livestock and Fishery Sciences.
[84] Kovats, S. and Akhtar, R. 2008. Climate, climate change and human health in Asian cities. Environment and Urbanization 20:165-175.
[85] Kovats, S. and Akhtar, R. 2008. Climate, climate change and human health in Asian cities. Environment and Urbanization 20:165-175.
[86] Prof Dr Soe Lwin Nyein. 2010. Climate change on communicable diseases. Director of Epidemiology, Ministry of Health.
[87] Kovats, S. and Akhtar, R. 2008. Climate, climate change and human health in Asian cities. Environment and Urbanization 20:165-175.
[88] Lian, K. K. and Bhullar, L. 2010. Adaptation to Climate Change in the ASEAN Region.
[89] Kovats, S. and Akhtar, R. 2008. Climate, climate change and human health in Asian cities. Environment and Urbanization 20:165-175.
[90] Ministry of Agriculture and Irrigation, Government of the Union of Myanmar, Ti, L. H. and Facon, T. Report on the formulation of a national water vision to action in the Union of Myanmar. Last Accessed 17/02/2012.
http://www.fao.org/docrep/008/ae546e/ae546e04.htm

Coastal Zone

Myanmar is particularly vulnerable to rising sea-levels as a result of its highly populated, low-lying coastline. An increase in sea-level will provide a higher base for storm surges and other extreme climate events. Therefore, sea-level rise and associated impacts will threaten coastal ecosystems, agricultural land and infrastructure (roads, property, and businesses). Certain low-lying coastal zones will be at risk of complete inundation resulting in a loss of agricultural and residential land. The extent of inundation will be largely determined by the slope of the land. For example, the low-lying Ayeyarwady Delta is particular at risk as even a small rise in sea-level will lead to a large portion of the Delta being inundated. Rising sea-levels will also threaten water tables as saline water enters into freshwater ground water supplies.

Biodiversity

The affects of climate change on biodiversity are already evident in Myanmar. For example, shifts in the range as well as migration patterns of certain species of insects, marine/terrestrial mammals, birds and fish of have been observed[91]. Furthermore, there have been notable changes in the flowering and fruiting seasons/times of certain plant species. Changes in temperature and precipitation levels, as well as extreme climate events (drought and floods) have caused forest die back, conversion of forests to grasslands/steppes/deserts as well as increased the spread of invasive species/insect pests. Future climate change will exacerbate these current impacts with increases in extreme weather events such as cyclones, droughts, floods and fires negatively impacting ecosystem functioning as well as species compositions, distributions and richness. An increase in extreme heat days and drought periods, as well as rising sea-levels, will change the chemical composition of water resources. This is likely to impact freshwater biodiversity. Similarly, increasing sea temperatures and changes to seawater chemical composition will affect marine biodiversity, particularly coral reef ecosystems. Impacts will result in cascading effects whereby failure or changes in certain species or functions within an ecosystem will have knock-on effects on other species and functions. This has the potential to result in large-scale loss in biodiversity and related ecosystem services. For example, increases in the frequency of El Niño events will lead to a decrease in plankton biomass resulting in knock-on effects such as a reduction in the abundance of fish larvae[92]. This in turn will cause a decline in adult fish stocks and consequential negative impacts on the fishing industry.

Energy, Transport and Industry

The hydropower potential of many of Myanmar's rivers will be significantly affected by climate change impacts such as intense rainfall events, erratic rainfall as well as increases in the occurrence and severity of droughts. Intense rains will trigger large-scale erosion resulting in siltation and sedimentation of waterways and dams. This will reduce the water-storage capacity of dams and cause structural damages, increased maintenance costs as well as increased operational costs[93]. Transport in Myanmar will also be impacted. An increase in extreme weather events will cause significant damages to existing transport infrastructure as well as increase maintenance costs. For example, Cyclone Nargis resulted in a loss of ~US$ 36 million on road damages/losses alone. Increasing sea-level will also impact coastal transport infrastructure, as roads in the path of rising water levels will be vulnerable to collapse as a result of erosion. Industry will also be affected. For example, industry was one of the sectors most affected by Cyclone Nargis with estimated damage/loss costs of ~US$ 1,814 million. Furthermore, climate extremes will result in considerable socio-economic knock-on effects, such as a drop in employment and industrial productivity which will impact food security and the country's economy.

Myanmar NAPA Framework

NAPA Goal and Objectives

The overarching **goal** of the NAPA is **to identify and communicate** priority activities (referred to as **Priority Adaptation Projects**) to address Myanmar's immediate and urgent **adaptation needs** for **implementation in Myanmar** that will assist the country **adapt to climate change impacts** by building/enhancing **resilience** of vulnerable communities.

[91] Maung, U. H. 2009. Global Warming and World Climate Change (Myanmar version).

[92] OneWorld. 2010. Burma climate change; A OneWorld briefing. Last Accessed 16/02/2012 http://uk.oneworld.net/guides/burma/climate-change

[93] Pattanapanchai, M., Shah, F. and Annandale, G. 2002. Sediment Management in Flood Control Dams. American Agricultural Economics Association Annual Meeting.

The **objectives** of the NAPA are to: i) communicate observed and projected climate change impacts in Myanmar; ii) **prioritise adaptation projects** for **eight main sectors/themes**, namely Agriculture, Early Warning Systems, Forest, Public Health, Water Resources, Coastal Zone, Energy and Industry, and Biodiversity; iii) **assist Myanmar in achieving its national development goals and strategies**, including the Myanmar Agenda 21, the National Sustainable Development Strategy (2009), and the Millennium Development Goals; and iv) **communicate NAPA Priority Adaptation Projects** for **implementation in Myanmar** for addressing immediate climate change adaptation needs and thereby **building the climate change resilience of vulnerable communities**.

Thirty two Priority Adaptation Projects (priority activities) have been identified for effective climate change adaptation in Myanmar for eight main sectors/themes (i.e. four Project Options per sector/theme), namely: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy, and Industry; and viii) Biodiversity (see Chapter 5 and Annex 1). Sectors in which Priority Adaptation Projects should be implemented first include: 1) **Agriculture, Early Warning Systems and Forest** (First Priority Level Sectors) (Table 3). This is followed by: 2): Public Health and Water Resources (Second Priority Level Sectors); 3) Coastal Zone (Third Priority Level Sector); and 4): Energy and Industry, and Biodiversity (Fourth Priority Level Sectors). Although, project profiles are presented separately for each Priority Adaptation Project, it is important to note that project ideas/activities/elements can be blended across projects and sectors when designing final project concepts for implementation in the country.

Table 3. First Priority Level Sector's top Priority Adaptation Projects for implementation in Myanmar (Please see Chapter 5 and Annex 1 for the top 32 Priority Adaptation Projects for eight socio-economic sectors).

Sector/Theme	Priority Adaptation Project Title
FIRST PRIORITY LEVEL SECTORS: Agriculture, Early Warning Systems and Forest	
AGRICULTURE	**First priority:** Enhanced rice production through farm mechanisation and breeding new rice varieties to ensure food security in areas most vulnerable to climate change.
	Second priority: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.
	Third priority: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.
	Fourth priority: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.
EARLY WARNING SYSTEMS	**First priority:** Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events.
	Second priority: Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.
	Third priority: Assessing the hydrological impact of climate change on river systems.
	Fourth priority: Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.
FOREST	**First priority:** Building the resilience of degraded/sensitive forest areas to climate change impacts through reforestation.
	Second priority: Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.
	Third priority: Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.
	Fourth priority: Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.

To achieve the above objectives and thus main goal of the NAPA i.e. to identify and communicate Priority Adaptation Projects, the Myanmar NAPA preparation process followed the guidelines outlined by the United Nations Framework Convention on Climate Change (UNFCCC) Least Developed Countries (LDC) Expert Group[94,95]. This was achieved using seven main steps (Table 4).

[94] Least Developed Countries Expert Group. 2002. Annotated guidelines for the preparation of national adaptation programmes of action.

[95] Least Developed Countries Expert Group. 2009. National adaptation Programmes of action: Overview of preparation, design of implementation strategies and submission of revised project lists and profiles.

Table 4. The seven main steps of the Myanmar NAPA preparation process.

Step 1	Establishment of NAPA Project Management and multidisciplinary teams (April 2011)
Step 2	Synthesis of available information (May – July 2011)
Step 3	Stakeholder and public consultation to establish Myanmar's **adaptation needs** and potential **adaptation projects/options** (July – September 2011) • **Step 3.1.** Participatory assessment (comprising a Rapid Rural Appraisal (RRA) and a Participatory Rural Appraisal (PRA)) to establish climate change vulnerability, **adaptation needs** and **possible adaption projects** (see Annex 2 for detailed methods and results of the PRA). • **Step 3.2.** Focus group discussions with eight socio-economic sectoral working groups (WGs) to establish the adaptation projects/options according to the available information (synthesised in **Step 2**) and the information identified in the PRA and RRA (**Step 3.1**).
Step 4	Sectoral working group meetings to identify and draft a list of **Adaptation Project Options** (October – November 2011). Adaptation needs and potential adaptation projects/options (established in **Step 3**) were used to identify a list of 77 Adaptation Project Options to be ranked and prioritised (under **Step 5**). Eight to ten Adaptation Project Options were identified for each sector.
Step 5	Sectoral working group meetings for screening, ranking and prioritising identified Adaptation Project Options (October – November 2011 and March-April 2012). Multi-criteria analyses (a **series of 15 criteria developed by the LDCExpert Group**) were used to rank and prioritise **Adaptation Project Options** for implementation. Criteria were based on both social and economic benefits, for example, improved public health, improved water quality, and improved food security and were weighted in importance for each specific sector. A bonus point system was used to further screen Adaptation Project Options. The resulting scores for each **Adaptation Project Option** were used to determine **32 Priority Adaptation Projects** for further development and implementation in the country (see Chapter 4 for more details on the criteria for selecting Priority Adaptation Projects).
Step 6	Public Review Process of NAPA draft (February to April 2012) to solicit public opinion on the NAPA draft document including Priority Adaptation Projects as well as sector prioritisation.
Step 7	Development of the NAPA project profiles (March - April 2012). Project profiles were developed for the **Priority Adaptation Projects** using focus group discussions and meetings with working group members as well as other key stakeholders. Please refer to Annex 1 for detailed ~1-2 page project profiles for each Priority Adaptation Project. Selection of Priority Adaptation Projects was based on the weighted criteria and methodology described in Chapter 4.

The following were considered when prioritising and designing the **NAPA Priority Adaptation Projects** during steps 5, 6 and 7 above:

- scientific and participatory/traditional approaches for assessing climate change vulnerability and adaptation needs; and
- local community empowerment for identifying their adaptation needs through Participatory Rural Appraisals.

Furthermore, NAPA adaptation projects were developed based on the following **strategies** for the country:

- **Strategy 1:** Create adaptive capacities for responding to climate change impacts focussed on preparedness, monitoring, pilot projects and restoration of natural capital.
- **Strategy 2:** Support the country's aim to reduce greenhouse gas emissions through increasing carbon sinks and utilising sustainable development practices e.g. fuel, electricity, transport, efficiency; industrial efficiency as well as sustainable agriculture and forestry that reduces emissions and increases absorption.
- **Strategy 3:** Integrate climate change management i.e. knowledge management, database and tools, management preparedness and multilateral participation into national, regional and local level policies and plans.

- **Strategy 4:** Increase climate change research including assessing future climate risks and current vulnerability.
- **Strategy 5:** Mainstream climate change adaptation into policy, planning and relevant projects to ensure scaling up of climate change adaptation across the country at national, regional and local levels.

Please see Chapter 4 for more details on the criteria used to select Priority Adaptation Projects, Chapter 6 for a full detailed description of the NAPA preparation process including institutional arrangements that supported and coordinated the NAPA preparation process, and Annex 2 for a detailed description of the Rapid Rural Appraisal (RRA) and a Participatory Rural Appraisal (PRA) conducted during the NAPA preparation process.

Myanmar's development goals/strategies, existing institutional frameworks and multi/bi-lateral treaties/agreements

The Government of Myanmar has taken several steps to address the impact of environmental stresses on socio-economic sectors. These include policies, strategies, plans and programmes that focus on i) sustainable development; ii) sustainable utilisation of natural resources; iii) forest conservation; iv) disaster risk reduction; and v) environmental protection. Almost all the ministries have laid out policies, objectives and strategies for developing their respective socio-economic sectors. These strategies are indirectly related to climate change adaptation as they encourage sustainable development of socio-economic sectors and this "sustainable aspect" overlaps in general with adaptation strategies for reducing climate change impacts.

It is important that Myanmar's existing goals, strategies, institutions, policies, plans and treaties/agreements form the framework to support NAPA Priority Projects. Therefore, potential synergies between identified NAPA Project Options and the national development framework (e.g. strategies, institutions, policies, plans and treaties/agreements) was included as a selection criteria when prioritising projects for implementation. For example, the following overarching development goals and strategies were considered when prioritising and designing NAPA Priority Adaptation Projects:

- **Myanmar's market-orientated policy scheme (1988**) which indicates that Myanmar's ultimate goal is to become a peaceful, modern and developed country[96]. There are three national development plans to achieve this goal, namely; i) the Development of Border Area; ii) the Plan for 24 Special Development Zones; and iii) the Integrated Rural Development Plan. The policy specifies twelve objectives including four political, four economic[97], and four social objectives[98]. A series of four/five year short-term plans were implemented from 1992 to 2011 to enhance economic development in Myanmar. These plans proved to be effective as represented by a consistent GDP annual growth in the country during the time[99].
- **Myanmar Agenda 21 (1997)** which was formulated by the National Commission for Environmental Affairs (NCEA) (now called the National Environmental Conservation Committee [NECC]) as an expression of political commitment by government to achieve sustainable development. Myanmar Agenda 21 serves as a framework to integrate environmental considerations into future national development plans as well as sectoral development programmes.
- **The National Sustainable Development Strategy (NSDS) (2009)** which further developed the principles identified in the Myanmar Agenda 21. NSDS comprehensively incorporates

[96] Zaw, K. 2008. Challenges, Prospects and Strategies for CLMV Development: The Case of Myanmar," in Sotharith, C. (ed.) ERIA Research Project Research 2007 No.4: Development Strategy for CLMV in the Age of Economic integration. Tokyo: IDE-JETRO.

[97] Economic objectives: Building of modern industrialized nation through the agricultural development and all-round development of other sectors of the economy; Proper evolution of the market-oriented economic system, Development of the economy inviting participation in terms of technical know-how and investment from sources inside the country and abroad and the Initiative to shape the national economy must be kept in the hands of the state and the national peoples.

[98] Social objectives: Uplift of national prestige and integrity and preservation and safeguarding the national heritage and national character, Flourishing of Union Spirit, the true patriotism and uplift of health, fitness and education standards of the entire nation.

[99] With the objectives of enhancing economic development in Myanmar, the Short-Term First Four-Year Plan was implemented from 1992/93 to 1995/96. It achieved an average annual growth rate of 7.5 per cent. The Second Five-Year Plan, 1996/97 to 2000/01, achieved an average annual growth rate of 8.5 per cent. The Third Five-Year Plan during the years 2001/02 to 2005/06, achieved an average annual growth rate of 12.8 per cent. Recently, the fourth Short-Term Five-Year Plan (2006/07 to 2010/11) has been formulated with an average annual growth rate of 12% (Ministry of National Planning and Economic Development, 2006).

environmental considerations into social and economic development to achieve the overarching goal of sustainable development. The document identifies three main goals for the country[100]: i) Sustainable Management of Natural Resources; ii) Integrated Economic Development; and iii) Sustainable Social Development.

- **The Millennium Development Goals (MDG) (2000-2015)** which Myanmar is striving to achieve by 2015. These include: i) eradicate extreme poverty and hunger; ii) achieve universal primary education; iii) promote gender equality and empowerment; iv) reduce child mortality; v) reduce maternal mortality; vi) combat HIV/AIDS malaria and other diseases; vii) ensure environmental sustainability; and viii) develop a global partnership for development.

The following institutional framework already existing in the country was considered when prioritising and designing NAPA Adaptation Projects:

- **The National Commission for Environmental Affairs (NCEA)** which was established in 1990 to: i) advise the government on environmental policies; ii) act as a coordinating body for environmental affairs; and iii) promote environmentally sound sustainable development. The NCEA was reorganized into the Planning and Statistics Department, under the Ministry of Environmental Conservation and Forestry, with a new identity of the National Environmental Conservation Committee (NECC) in April 2011. The NECC (located within the Ministry of Environmental Conservation and Forestry) is responsible for guiding national activities to address climate change-related problems. Furthermore, the NECC manages and coordinates all climate change-related activities in Myanmar including developing climate change related policies and strategies as well as programmes of action.
- **The Ministry of Environmental Conservation and Forestry (formerly the Ministry of Forestry)** which was established to ensure that environmental affairs are considered in development plans. The Ministry is responsible for assessing the environmental impact of national development projects.
- **The ASEAN Committee on Disaster Management (ACDM)** which consists of the heads of the national agencies that are responsible for disaster management in ASEAN member countries (including Myanmar). The ADCM is responsible for coordinating and implementing regional disaster management activities within member countries.
- **The National Disaster Preparedness Central Committee (NDPCC)** which was established in 2005 to prevent/mitigate the loss of human lives, settlement and property to disaster events. In accordance with guidance of the NDPCC, Government departments are currently (2012) preparing Natural Disaster Management Plans. Certain departments have already completed their respective Plans e.g. Health and Agriculture Planning Department.

The following supporting policy and planning framework was considered when prioritising and designing NAPA adaptation projects:

- **The National Environment Policy** which was adopted by the Government in 1994 to establish sound environmental policies for regulating the utilisation of water, land, forests, mineral, marine, and other natural resources. The overarching objective of the policy is to achieve harmony and balance between Myanmar's people, cultural heritage, environment, and natural resources. The policy works towards sustainable development in Myanmar by prioritizing environmental protection within economic development. One of the basic principles under the policy focuses on climate change. This section indicates that economic sectors should be climate-adaptive and resilient to secure national economic growth. The policy forms the basis for developing environmental strategies, programmes and plans which provide sound legislative basis to ensure that environmental concerns are integrated into development planning to support sustainable development.
- **The Myanmar Action Plan on Disaster Risk Reduction (MAPDRR*)* (2009-2015)** which aims to improve disaster management in Myanmar e.g. protect lives, livelihoods, and secure development. The MAPDRR has five objectives: i) build a more resilient and safer community through the conceptualization, development and implementation of appropriate disaster risk reduction programmes and culture of safety; ii) provide a framework for implementing Myanmar's DRR commitments at the global and regional levels, under Hyogo Framework for Action (HFA) and ASEAN Agreement on Disaster Management and Emergency Response (AADMER); iii)

100 National Commission for Environmental Affairs (NCEA), Ministry of Forestry (MOF), United Nations Environment Programme, Regional Resource Center for Asia and the Pacific (UNEP.RRC.AP). 2009. National Sustainable Development Strategy for Myanmar.

provide a mechanism where the disaster risk reduction initiatives of all Government Ministries and Departments, supported by UN organizations and other stakeholders, can be coordinated and monitored; iv) provide a conducive environment for mainstreaming DRR into development plans, and programs at the National, State, Region, Township, and Village Tract levels; and v) support mutually beneficial partnerships between the Myanmar Government and their development cooperation partners in DRR programmes. The MAPDRR is composed of seven components, which align with the Hyogo Framework for Action (see below). The seven components are: i) policy, institutional arrangements and further institutional development; ii) hazard, vulnerability and risk assessment; iii) Multi-hazard Early Warning Systems; iv) preparedness and response programs at national, State/Region, District & Township levels; v) mainstreaming of DRR into Development; vi) community-based disaster preparedness and risk reduction; and vii) public awareness, education and training.

- **The Myanmar Action Plan on Disaster Risk Reduction, Preparedness, Relief and Rehabilitation** (also known as 'Master Plan for Disaster Preparedness') which is an updated version of the above MAPDRR plan. This updated plan has been approved and launched on 4 June 2012 and details the foundations for disaster management institutional arrangements in Myanmar.

The following main treaties/agreements were considered when prioritising NAPA Adaptation Projects (see Annex 5 for a comprehensive list of Myanmar's environmental national and multilateral treaties/agreements):

- **United Nations Framework Convention on Climate Change (UNFCCC - 1992)** which is an international environmental treaty established in 1992 at the Earth Summit in Rio de Janeiro. The objective of the UNFCCC is to stabilise greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. The UNFCCC is not legally binding and it has no enforcement mechanisms. It instead provides updates (or 'protocols') which set mandatory emission limits.
- **Convention on Biological Diversity (CBD - 1994)** which is the first global agreement on conservation and the sustainable use of biodiversity. Myanmar succeeded in maintaining the agreement as the government produced all three of the required national biodiversity reports. The success of the agreement is evident in the significant protected area expansion that occurred in the country. By 2009, ~4.35% of the required 5% had been achieved[101]. Furthermore, the NCEA developed the National Biodiversity Strategy Action Plan (NBSAP). This plan integrated conservation and sustainable use of biological resources into national decision-making while mainstreaming relevant issues across all sectors of the national economy and policy-making framework.
- **The Kyoto Protocol (1997)** which was initially adopted in 1997 as a protocol within the UNFCCC. Under the Kyoto Protocol, 37 countries committed themselves to reducing greenhouse gas (GHG) emissions. Countries collectively agreed to reduce GHG emissions for the period 2008-2012. The protocol incorporates some flexible mechanisms, such as emissions trading, the clean development mechanism (CDM) and joint implementation to allow countries to realistically meet GHG emission limitations.
- **United Nations Convention to Combat Desertification (UNCCD – 1997)** which protects the Central Dry Zone from deforestation and desertification. The Dry Zone Greening Department (a governmental department created to combat desertification in the Dry Zone) undertakes re/afforestation projects in the Central Dry Zone to develop water resources, develop/encourage fuel-wood substitutes, and to conserve and improve the residual natural forests.
- **The Hyogo Framework for Action (HFA)** which is a plan that describes the work required from different sectors/actors to reduce disaster losses. The goal of the HFA is to reduce disaster-induced losses of lives and social, economic, and environmental assets by 2015 by building the resilience of communities and nations to disasters. The framework outlines five priority actions: i) ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation; ii) Identify, assess and monitor disaster risks and enhance early warning; iii) use knowledge, innovation and education to build a culture of safety and resilience at all levels; iv) reduce the underlying risk factors; and v) strengthen disaster preparedness for effective response at all levels.

101 National Commission for Environmental Affairs (NCEA). 2010: Vulnerability and Adaptation Assessments. Initial National Communication (Draft).

- **The ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries and Forestry towards Food Security (AFCC)** which is an integrated framework (finalised in 2009) to facilitate ASEAN to respond to climate change threats and food security. The AFCC has a cross-sectoral approach for effective policy-making and implementation. It provides an arena for ASEAN to coordinate the support it receives. The AFCC aims to minimise the risk and impacts of climate change to contribute to food security through sustainable, efficient and effective use of land, forest, and water resources. To achieve this, the AFCC has two major objectives: i) coordination on the development of adaptation and mitigation strategies; and ii) cooperation on the implementation of integrated adaptation and mitigation measures[102].

Although the government has taken several steps towards sustainable development, conservation of natural resources and disaster risk reduction, such as drafting of Disaster Risk Reduction Law, there are still needs for laws or regulatory mechanisms directly focussed on building the resilience of communities and ecosystems (and thus socio-economic sectors) to climate change impacts. There are some laws that directly relate to climate change mitigation, in particular, the emissions of Green House Gasses (GHG) and pollutants. Furthermore, a new Disaster Management Law is at present being prepared. Other laws that are in some way promoting adaptation to climate change include the Forest Law Act (1992), Wildlife Act (1994) and Protected Area and Forest Policy Statement (1995). As climate change impacts could severely undermine economic growth in Myanmar, the formulation and implementation of policies on climate change adaptation is vital for sustainable development.

Potential Barriers to NAPA Implementation

A number of barriers may affect the implementation of NAPA Priority Adaptation Projects at national, provincial and local levels. These include:

- limited technical capacity of local and national stakeholders for planning (including cross-sectoral planning) and implementing climate change adaptation;
- limited understanding of the political scope needed for using climate change adaptation to reduce the vulnerability of communities and a wide-range of sectors to climate change;
- limited availability of locally relevant, usable climate information for the end users;
- insufficient evidence and demonstration of climate change adaptation benefits in the country to influence policy- and decision-making;
- limited policy, strategy and legislative environment for providing incentives for adapting communities to climate change;
- limited community awareness and understanding regarding climate change impacts and adaptation;
- poor understanding of climate change adaptation benefits as a result of limited on-the-ground adaptation intervention demonstrations to enhance resilience to climate change - without access to replicable demonstrations, government decision-makers and resource users do not have the tools and knowledge necessary to decrease climate change vulnerability;
- limited financial resources to adapt to climate change and climate variability;
- limited effective assessment of climate change impacts in Myanmar, which in turn limits the planning of effective adaptation activities; and
- limited secure land tenure particularly for rural communities.

Measures to Address Barriers to NAPA Implementation

A number of measures can be implemented to address barriers to NAPA implementation presented above. These measures should be included when designing projects to address NAPA Priority Adaptation Projects. These include:

- improving national institutional capacity to undertaking effective adaptation planning;
- improving local institutional capacity including promoting decentralised government structures;
- improving local community capacity to ensure a bottom-up approach to adaptation planning;
- awareness raising activities in vulnerable communities to improve their knowledge on climate change and adaptation;
- promoting community-based natural resource management, improved water management and low-water usage agriculture within local communities;

[102] ASEAN Secretariat, 2009. The ASEAN Multi-Sectoral Framework on Climate Change. http://www.asean-cn.org/Item/1151.aspx

- improving inter-ministerial coordination to promote management of environmental and climate change adaptation related matters between all relevant ministries;
- improving inter-ministerial communication by establishing a data management network to ensure duplication of effort is avoided and appropriate adaptation approaches are integrated across ministries;
- improving adaptation knowledge and awareness by facilitating information gathering and exchange structures;
- developing best practice guidelines for ecosystem adaptation interventions and policies that integrate climate change adaptation;
- improving public awareness of climate change and adaptation by integrating adaptation into national curricula and publicity campaigns in national and local media;
- facilitating the establishment of climate early warning systems by providing training to staff at the Department of Meteorology and Hydrology as well as early warning user-agencies and grass root communities;
- promoting decentralisation and devolution for securing community land tenure and promoting ownership; and
- facilitating research (including long-term research) on the impacts of climate change, costs and benefits of adaptation and appropriate adaptation measures for addressing these impacts.

3. Identification of Adaptation Needs and Project Options

Increasing the climate change resilience of vulnerable communities and socio-economic sectors

This section of the NAPA details past and current mechanisms/practices used by communities and socio-economic sectors for managing climate change/climate variability and extreme weather events. Adaptation needs identified by vulnerable communities during the PRA are highlighted (see Annex 2 for more details) and described for eight socio-economic sectors/themes: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public health; v) Water Resources; vi) Coastal zone; vii) Energy and Industry; and viii) Biodiversity.

Participants in the PRA were chosen to represent the most climate change vulnerable communities in Myanmar. Participants were selected by Integrated Community Development Project (ICDP) Project Township Managers according to specific criteria stipulated by the NAPA team. Selection criteria were based on climate change projections (including hazard levels) for Myanmar as well as characteristics of vulnerable regions, socio-economic sectors and communities described in Chapter 2, including i) geographic areas; ii) gender; and iii) livelihood types. This ensured equal representation of a balance of vulnerable groups while addressing the most marginalised/defenceless communities.

Townships were selected to represent the most vulnerable regions in Myanmar's three agro-ecological zones: i) Hilly Zone represented by the Nyaungshwe Township in the Shan State; ii) Dry Zone represented by the Kyaukpadaung Township in the Mandalay Region; and iii) Coastal Zone represented by the Bogale Township in the Ayeyarwady Region. Participants at a township level included personnel from line departments, local authorities and development agencies (mainly UNDP) involved with food security, sustainable development and environmental work. These included experts/specialists working in the following sectors/themes: i) public health; ii) education; iii) transport; iv) forestry; v) fisheries; vi) alternative livelihoods; vii) disaster risk reduction; viii) forestry, ix) water resources; x) sanitation/hygiene; and xi) agriculture. Participants at a village level included community group members representing vulnerable livelihood strategies (e.g. farmers, wood cutters, charcoal bakers, fisher folk, grocery merchants, livestock keepers, farmer workers, fishery/aquaculture workers, casual workers, housewives, collectors and retailers of NTFPs) and geographic areas (e.g. hilly, coastal, river/lake side areas and urban). Six village communities were identified in each township, according to the following vulnerable geographic and livelihood characteristics (Table 5).

Table 5. Characteristics of vulnerable areas and livelihoods that were used to select participants to represent vulnerable communities within Myanmar's three agro-ecological zones.

Township	Geographic area	Livelihood type
Nyaungshwe (Hilly Zone)	Hill villages	Farmers, wood cutters and migrant workers
	Near-shore villages	Fisher folk, handicraft and migrant workers
	Lake area villages	Fisher folk, vegetable growers, weavers and blacksmiths
Kyaukpadaung (Dry Zone)	Marginalized villages	Mining workers, wood cutters and flower collectors.
	Villages near Mount Poppa	Fruit gardeners, charcoal bakers and seasonal migrant workers
	Villages near urban area	Farmland workers, livestock farmers, potters and palm producers
Bogale (Coastal Zone)	Coastal villages –	Fisher folk, casual labourers and farmers.
	Inland island villages –	Farm labourers and wood cutters
	Riverside villages	Farmers, fisherfolk, farm labourers and wood cutters.

Based on adaptation needs identified by vulnerable communities during the PRA, eight to ten Adaptation Project Options were identified and ranked for potential implementation in Myanmar. Adaptation Project Options aim to address the gaps in current practices as well as fulfil the adaptation

needs indicated by local communities. The top four Adaptation Projects per sector are considered Priority Adaptation Projects for implementation in the country. Details for Priority Adaptation Projects as well as one to two page project profiles are presented in Chapter 5 and Annex 1 respectively.

Please see Chapter 4 for more details on the criteria used to select Priority Adaptation Projects, Chapter 6 for a full detailed description of the NAPA preparation process including institutional arrangements that supported and coordinated the NAPA preparation process, and Annex 2 for a detailed description of the Rapid Rural Appraisal (RRA) and a Participatory Rural Appraisal (PRA) conducted during the NAPA preparation process.

Agriculture

The following measures have been implemented in Myanmar to improve agricultural productivity and ensure food security:

- The Government **implemented 129 irrigation projects** between 1988 and 2002. This includes the Thaphanseik dam, which is the largest dam in Southeast Asia.
- The International Development Enterprise (IDE) project: i) developed small-plot water technologies e.g. **micro-irrigation facilities** (treadle pumps and engines); and ii) created **linkages between local farmers and fruit and vegetable markets**. This has enabled certain farmers in Myanmar to move from subsistence rain-fed farming to small-scale commercial (and thus income-generating) farming.
- **In the Central Dry Zone,** varieties of crops are cultivated using crop intensification farming systems. This includes: i) mix/multiple cropping systems i.e. two or more crops in the same field to improve soil fertility, increase crop yield and act as insurance against crop failure; and ii) sequence cropping systems i.e. two or more crops in a time sequence in a year to reduce intercrop competition.
- **In the Ayeyarwaddy Delta,** a range of rice varieties have been introduced for cultivation including traditional quality, salt-tolerant, deep-water, waterlogged and submerged rice varieties e.g. Pawsan Hmway, Pawsan Baygyar and Pharpon Pawsan rice varieties are highly valued and cover ~20% of the Delta region.

Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the agriculture sector:

- **planning for climate change/variability to** reduce the impacts of drought, heat stress and other climate extremes on crop yields;
- **agronomic management** practices to conserve soil and water e.g. mulching, cover crops, conservation tillage, integrated nutrient management and contour terraces;
- **sustainable water use and management** to increase/maintain availability of water supplies for drinking and irrigation;
- **sustainable crop management including** climate-resilient and early maturing varieties and conservation of traditional varieties to increase/maintain crop production under a changing climate;
- **sustainable climate-resilient mixed farming systems** (including floating farmlands), that integrate livestock (cattle, goats, pigs, ducks and fish) and crops, as well as agroforestry systems that mix crops, trees (e.g. tamarind, mango, neem, lead tree and cutch tree) and livestock; and
- **restoration of abandoned agricultural fields** with perennial and species with soil binding root systems in order to conserve soil, increase water infiltration and reverse land degradation/aridification.

The above adaptation options have been incorporated into ten Adaptation Project Options for potential implementation in Myanmar (Table 6). Adaptation Project Options have been ranked in importance (1 = highest priority, 10 = lowest priority) for reducing the vulnerability of the agriculture sector and related communities to climate change impacts. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 6. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Agriculture Sector to climate change impacts.

AGRICULTURE SECTOR: Adaptation Project Options	RANK
Reduced climate change vulnerability of rural and subsistence farmers through locally relevant technologies, climate-resilient rice varieties, and ex/in-situ conservation of plant genetic resources.	1
Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.	2
Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.	3
Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.	4
Enhancing the climate change resilience of rural communities in the Coastal and Dry Zone through intensified and diversified cropping systems.	5
Enhancing the resilience of the agriculture sector to climate change impacts through post-harvest technologies to ensure grain/feed supplies despite climate change impacts.	6
Strengthening adaptive capacity of agriculture in coastal areas through implementing mixed (crop, livestock and fish) farming systems.	7
Enhancing the resilience of flood-prone agricultural regions to climate change through the introduction of integrated/mixed farming systems for greater food security and improved household nutrition levels.	8
Improving the resilience of the agriculture sector to climate change using organic farming technologies.	9
Enhancing the resilience of rain-fed agriculture in the highlands to climate change impacts using ecosystem-based approaches and climate-smart agriculture.	10

Early Warning Systems

The following measures have been implemented in Myanmar to ensure effective early warning for severe weather events:

- **The Department of Meteorology and Hydrology (DMH)** collects, analyses and archives meteorological, hydrological and seismological related data to inform early warnings for extreme weather events. This is achieved using 161 manual meteorological observation stations across the country in combination with satellite-based estimation techniques and forecast information received from Global Producing Centres. Early warnings and weather related bulletins are disseminated using television and radio.
- **The Relief and Resettlement Department (RRD)** conducts disaster response and recovery activities including training and awareness raising campaigns at grass-root, regional and national levels.
- **The RRD and DMH** collaborate to disseminate early warnings to local authorities who transfer warnings to district and grass-root levels.
- **Regional Integrated Multi-hazard Early Warning Systems (RIMES)** are conducting **community-based pilot programmes** for training local communities to prepare for and respond to early warnings received from DMH and RRD.
- The United Nations Development Programme developed **multi-hazard risk assessments** for Ayeyarwady, Bago, Yangon and Rakhine Regions/States in 2011**.**

Myanmar has limited technology for remotely and automatically forecasting extreme weather events. This reduces the time available for local communities to take necessary actions and preparations relative to Early Warning Systems in other more developed countries. However, even in cases when technology has been effective in providing sufficient lead-time for local communities to prepare, lives have still been lost and property damaged. This is as a result of three main reasons: i) warnings do not reach communities in remote areas; ii) communities do not know how to respond; iii) communities do not understand or cannot interpret the warning received. For example during Cyclone Nargis communities in the Ayeyarwady Delta refused to respond to warnings as they did not understand/realise the magnitude of the threat. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for establishing

effective early warning systems for reducing vulnerability to climate change-induced extreme weather events:

- **improved sensor technology including real-time observation stations** for monitoring and predicting/detecting extreme weather events**,** including drought monitoring systems;
- **strengthened capacity for** analysing real-time, historical and satellite meteorological data to assist with monitoring and predicting extreme weather events;
- **improved extreme weather warning dissemination/interpretation** for communicating warnings to communities to ensure adequate time for response and preparation;
- strengthened capacity of local level authorities (e.g. at a township level) for understanding, interpreting and responding to warnings received as well as communicating early warnings to grass root communities;
- **education and awareness raising** at grass roots levels (e.g. community-based early warning systems and adapting primary school curriculum to include disaster risk reduction);
- **climate-proof infrastructure** such as i) weather-proof buildings (particularly schools and hospitals); ii) climate-resilient public shelters, iii) seawalls and drainage canals; iv) large-scale mangroves ecosystem shelter belts;
- **distribution of life jackets** and other equipment/gear for ensuring safety during flooding and storm surges.

The above adaptation options have been incorporated into nine Adaptation Project Options for potential implementation in Myanmar (Table 7). Adaptation Project Options have been ranked in importance (1 = highest priority, 9= lowest priority) for reducing the vulnerability of the communities to climate change-induced extreme weather events. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 7. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of socio-economic sectors and communities to climate change impacts.

EARLY WARNING SYSTEM THEME: Adaptation Project Options	RANK
Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events.	1
Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.	2
Assessing the hydrological impact of climate change on river systems.	3
Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.	4
Adaptation to climate change through establishing a FM radio transmission network for disseminating severe weather early warnings and climate information (e.g. monthly, seasonal forecasts) to grass-root communities and local farmers.	5
Adaptation to climate change through flood risk assessment and mapping for Northern Delta regions.	6
Developing an intense rainfall and landslide early warning system for reducing the vulnerability of local communities to climate change impacts.	7
Adaptation to climate change through establishing coastal observation networks for predicting storm surge risks and tracking cyclones.	8
Adaptation to climate change through multi-hazard early warning systems.	9

Forestry

The following measures have been implemented in Myanmar to ensure sustainable and community-based forestry in the country:

- **A Thirty year Forest Action Plan** has been developed on disaster risk reduction, sustainable forest management including natural, plantation and community forests.
- **A people centred Community Forestry approach (Community Forestry Instruction 1995)** is being used in several regions including the Ayeyarwady Delta, Yangon Deltaic region and Central Dry Zone. This approach aims to promote sustainable management of natural forests through decentralisation to established Forest User Groups (~30-year lease).
- **Reforestation efforts** are being undertaken in the Ayeyarwady Delta and Yangon Deltaic region. This includes the establishment of ~65,108 ha of plantation forests comprising mangrove and other forestry species.

- The **Integrated Mangrove Rehabilitation and Management Project** (Japan International Cooperation Agency [JICA] 2007-2013) is being implemented to ensure sustainable management of mangrove ecosystems and poverty alleviation in the Ayeyarwady Delta.
- **Awareness raising** is being conducted using pamphlets and posters distributed throughout the Ayeyarwady Delta and Yangon Deltaic regions.

One of the most important aspects for increasing the adaptive capacity of the forest sector to climate change is using a community approach. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the forest sector.

- **climate-resilient forest species** for reforestation and afforestation programs throughout Myanmar to increase forest regeneration and recovery under future climate conditions;
- **intensified mangrove reforestation** in coastal zones for coastal buffering against cyclones, flooding and storm surges;
- **restoration of degraded forest** areas using **multi-use forest species** (e.g. mango, tamarind, lead tree and cutch trees) for increasing community safety-nets and diversifying livelihoods;
- implementing **fire protection and fire fighting measures** (e.g. fire breaks) within forest ecosystems;
- **increased public participation** including the devolution of forestry management and rights to lower governmental levels as well as to local communities;
- **public awareness** (using signboards; radio and television) and education on the effects of climate change on forest ecosystems and economic activities;
- **capacity building for improved community forestry implementation** including training on seed collection, cleaning, storage, sowing, propagation and planting; and
- **improved efficiency of fuelwood use** by adopting technologies such as energy efficient stoves and introducing sustainable woodlots.

The above adaptation options have been incorporated into 11 Adaptation Project Options for potential implementation in Myanmar (Table 8). Adaptation Project Options have been ranked in importance (1 = highest priority, 11 = lowest priority) for reducing the vulnerability of the forest sector and related communities to climate change impacts. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 8. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Forest Sector to climate change impacts.

FOREST SECTOR: Adaptation Project Options	RANK
Building the resilience of environmentally fragile forest areas to climate change impacts through reforestation.	1
Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.	2
Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.	3
Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.	4
Adaptation to climate change through the establishment of multi-use agro-forestry systems in three environmentally critical areas.	5
Strengthening the adaptive capacity of protected areas to provide a buffer for rural livelihoods against climate change impacts.	6
Monitoring the impact of climate change on plant species composition in agro-ecological zones.	7
Developing and implementing school curricula courses and awareness raising campaigns focused on the importance of climate change adaptation for buffering local communities against climate-related impacts.	8
Mainstreaming climate change adaptation into the National Forest Management Master Plan.	9
Enhancing the resilience of rural communities to climate change through the establishment of multi-use forests including Bamboo and Rattan tree species.	10
Enhancing the resilience of rural communities to climate change through climate-resilient medicinal plant cultivation.	11

Public Health

The following measures have been implemented in Myanmar to reduce health risks to local communities associated with climate variability:

- The **Department of Health** raises awareness using newspapers, TV Spot and posters on the necessary precautions (appropriate behaviour changes) vulnerable communities should take to prevent climate-related health risks such as heat-related disorders and the spread of water-borne diseases. Campaigns mainly target communities in the Central Dry Zone and flood risk areas of the country.
- **Twenty national hospitals and 32 state and regional hospitals** exist in Myanmar. These hospitals have been supported by the World Health Organisation (WHO) since 2006.
- The **Department of Health** (DoH) provides local communities with pan and pipe sanitation systems for reducing outbreaks of water-borne diseases.
- **'National Sanitation Week' is held annually** to highlight the importance of personal hygiene and sanitation for decreasing health risks.

A two-pronged approach is needed to improve the adaptive capacity of the Public Health Sector in Myanmar. This includes: i) the development of climate-resilient health care units; and ii) the dissemination of information to change community behaviour to prepare them for climate-induced health risks. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the public health sector:

- **improving public awareness and education** to prevent potential climate-induced health risks such as heat stress and water-borne diseases;
- **researching the short- and long- term effects of climate change on human health risk** e.g. relationships between microbial ecology, meteorological and projected/historical climate change data;
- improving the management of the government's **medical registration/information database**;
- **expansion of diagnosis, treatment and prevention systems** in response to new infectious diseases and other illnesses linked to climate change; and
- construction of **climate proof health care** centres in vulnerable areas.

The above adaptation options have been incorporated into ten Adaptation Project Options for potential implementation in Myanmar (Table 9). Adaptation Project Options have been ranked in importance (1 = highest priority, 10 = lowest priority) for reducing the vulnerability of the Public Health sector and related communities to climate change impacts. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 9. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Public Health Sector to climate change impacts.

PUBLIC HEALTH SECTOR: Adaptation Project Options	Rank
Adaptation to climate change through climate-resilient health facilities in the Rakhine State and Ayeyarwady Region.	1
Integrating climate change adaptation strategies into the prevention of heat-related disorders in agricultural and industrial workers.	2
Supporting Intensive Care Units (ICU) in hospitals to treat heat-related disorders.	3
Reducing the vulnerability of local communities to climate-induced water-related health hazards through the provision of safe water supplies and sanitary latrines.	4
Climate change adaptation through establishing post-disaster rapid response networks to meet the immediate nutritional needs of disaster-affected communities.	5
Adaptation to climate change through the construction of climate-resilient health facilities in Bago, Mandalay and Sagaing Regions.	6
Integrating climate adaptation strategies into the prevention and control of diarrheal diseases.	7
Integrating climate change adaptation strategies into the prevention and control of malaria and dengue hemorrhagic fever.	8
Building the capacity of the health sector for determining the direct and indirect impacts of climate change on the transmission of current and emerging diseases.	9
Adaptation to climate change through integrated plague and rodent control strategies.	10

Water Resources

Considerable investments have been made to ensure water security across Myanmar. The Government initiated a number of irrigation schemes from 1988 to 2010 to maintain agriculture productivity during dry periods. Additional measures to assist water security in Myanmar include:

- The **Yangon City Development Committee** (YCDC) has been implementing tube-wells to supplement piped water supply from reservoirs.
- The **Water Resources Utilization Department (WRUD)** is using artesian tube-wells in the Sagaing Region and shallow/deep tube-wells in the Mandalay Region to utilise ground water for irrigation.
- The **Electric-powered Water Pumping Project** and the **Meiktila-Thazi Groundwater Irrigation Project** were recently implemented in the Meiktila plain.
- A range of **local and international NGOs provide treadle pumps** for assisting communities to obtain drinking water in rural areas.
- The Irrigation Department in collaboration with the Italian Government and Food and Agriculture Organisation (FAO) **installed a number of small-scale water impoundments** during 2010 and 2011.

An integrated approach to water resource management is essential to ensure the resilience of water supply under future climate change conditions. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the water resources sector:

- **improving residential water supply by** i) adapting dams, weirs and ponds ii) reducing water losses in distribution pipes; iii) developing water level monitoring systems; iv) introducing water saving technologies; v) rainwater harvesting; vi) raising awareness of water saving practices; and vii) constructing gravity-flow water supply systems;
- **improving the efficiency of irrigation systems by** introducing: i) water efficient irrigation schemes e.g. drip, micro-spray and night irrigation; ii) salt- and drought-tolerant crop varieties; and iii) effective methods for utilising groundwater resources;
- **improving water quality by:** i) renovating waste water treatment plants (WWTP); ii) recycling wastewater; iii) developing river protection and sanitation zones; iv) improving chemical and biological monitoring; and v) construction of filtration systems at village water ponds;
- **increasing public awareness by** training people of different ages/social status on water saving and sanitation methods;
- **conducting research to estimate the impacts of hydrological disasters**; and
- **improving flood prediction and prevention systems.**

The above adaptation options have been incorporated into ten Adaptation Project Options for potential implementation in Myanmar (Table 10). Adaptation Project Options have been ranked in importance (1 = highest priority, 10 = lowest priority) for reducing the vulnerability of the Water Resources sector and related communities to climate change impacts. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 10. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Water Resources Sector to climate change impacts.

WATER RESOURCES SECTOR: Adaptation Project Options	RANK
Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change conditions.	1
Constructing small-scale water impoundments in Naypyidaw for flood control and increasing water supplies for local communities.	2
Protecting human life and property against climate extremes in the Ayeyarwady river system through channel improvement and adaptation structures.	3
Estimating regional rainfall-runoff relationships for supporting the development of flood early warning systems and ensuring sustainable water management.	4
Installing low-cost climate-resilient (e.g. raised) pond- and hand-pump systems to ensure water security in rural areas and to protect drinking water from contamination after extreme weather events.	5
Assessing the hydrological and socio-economic impacts of climate change on ecosystem services such as water quantity, water quality, water flow regulation and erosion control.	6

Increasing watershed ecosystem services to reduce the vulnerability of communities and economic sectors to climate change.	7
Securing water resources in the face of climate change through new approaches for groundwater exploration.	8
Enhancing the resilience of rural communities to climate change impacts through adaptation technologies for sustainable rainwater use and management.	9
Building local capacity for water saving practices and technologies to reduce water loss, waste and usage.	10

Coastal Zone

The following measures have been implemented in Myanmar to ensure sustainable and community-based coastal management:

- The Government of Myanmar is currently involved in the **Bay of Bengal Large Marine Ecosystem (BOBLME) Programme**, which promotes sustainable marine ecosystem management and sustainable coastal livelihood development. The programme aims to improve the lives of coastal populations through effective regional management of marine biodiversity and fisheries.
- **Four Marine Protected Areas (MPAs)** have been established along Myanmar's coast, including i) Moscos Island; ii) Thamihla Kyuun; iii) Mainmahla Kyuun; and iv) Lampi.
- The **Department of Fisheries** in collaboration with Biodiversity And Nature Conservation Association (BANCA) and Fauna and Flora International (FFI) are planning to establish an MPA Network System that will incorporate existing MPAs, for example, the Shark Reserves in the Myeik archipelago (Lampi MPA).
- A number of different agencies and organisations, including JICA (Japan International Cooperation Agency), FREDA (Forest Resource Environment Development and Conservation Association), and UNDP/MERN (Mangrove Environmental Rehabilitation Network) are undertaking **mangrove and coastal forest restoration** efforts following damage from recent cyclones in Myanmar's coastal areas.
- The **Department of Marine Science** within the University of Mawlamyine has established an aquaculture research centre.

Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the Coastal Zone:

- **restoration of mangrove forest shelter belts and establishment of coastal mangrove plantations and tidal woods using appropriate plant species** for buffering coastal communities against the impacts of extreme weather events such as storm surges and tropical cycles;
- **using ecosystem sensitive harvesting (timber, crab, shrimp etc.) and aquaculture practices** to promote the recovery of mangrove ecosystems;
- **replacing current detrimental activities and livelihoods** with sustainable alternatives;
- **building capacity to promote/support** autonomous responses to external pressures, e.g. farmers switching to salt-tolerant crops; and
- **developing mechanisms (seawalls, dykes)** to protect coastal communities and agricultural land from sea-borne extreme weather events such as storm surges and cyclones.

The above adaptation options have been incorporated into nine Adaptation Project Options for potential implementation in Myanmar (Table 11). Adaptation Project Options have been ranked in importance (1 = highest priority, 9 = lowest priority) for reducing the vulnerability of communities and economic activities in the coastal zone. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 11. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Coastal Zone Sector to climate change impacts.

COASTAL ZONE THEME/SECTOR: Adaptation Project Options	RANK
Adaptation to climate change through the implementation of Integrated Coastal Zone Management (ICZM) for the Myeik Archipelago, Tanintharyi Region.	1
Community-based mangrove reforestation for building climate-resilient ecosystems and rural livelihoods in degraded coastal areas in the Rakhine State.	2

Community based eco-friendly aquaculture systems (e.g. mudcrab, clam, shrimp and tilapia) for enhancing the climate change resilience of rural livelihoods and supporting the recovery of mangrove forest ecosystems.	3
Small-scale aquaculture and mangrove buffer demonstration sites for transferring adaptation technologies to Mon and Tanintharyi coastal communities.	4
Building capacity to monitor physical, chemical and biological climate change indicators at the Salween/Thanlwin River Mouth to safeguard lives, property and livelihoods.	5
Building alternative livelihoods for climate change adaptation in the Myeik Archipelagos.	6
Increasing resilience of rural fisheries to climate change effects through sustainable coastal development and maritime safety training.	7
Increasing the resilience of coastal communities in the Myeik Archipelagos to climate change impacts through restoring threatened marine habitats.	8
Reducing the vulnerability of coastal farming communities to climate change through mixed (crop, livestock and fish) farming systems.	9

Energy and Industry

Many industries and economic sectors in Myanmar have limited capacity or financing to use modern technologies for harnessing efficient and renewable energy sources. The Water Resources Sector, for example, has limited access to energy efficient water purification technologies. Therefore, many communities suffer from scarcity of safe water supplies. Despite this, efforts are currently being made to support/promote the utilisation of efficient and renewable energy sources in the country. These include:

- **Projects have been implemented for harnessing Myanmar's solar energy,** including: i) Photovoltaic Power Systems are being installed in remote villages under the Technical Cooperation among the Developing Countries Programme; ii) a number of pilot projects are being undertaken by Solar Photovoltaic Battery Charging Community Enterprise; and iii) the Myanmar Scientific and Technological Research Department (MSTRD) in collaboration with the Department of Physics (Yangon University) are implementing the Solar Power Village Electrification Scheme.
- **Research on solar energy** is being conducted, including the development of prototypes of solar equipment and the potential use of solar energy in: i) cooking and other household purposes; ii) water pumps; iii) solar drying for grain and fish products; and iv) salt extraction from seawater.
- **Research/implementation of pilot projects using 'biogas'** is being conducted to capture cheap and efficient energy from methane gas produced from animal waste, particularly cow dung. Approximately 400 biogas stations have been constructed in the rural areas throughout Myanmar to provide cooking gas and light energy.
- **Myanmar's fourth short-term five-year plan (2006/2007 to 2010/2011)** of the National 30-year Energy Development Plan indicated that the country will invest in measures to improve energy supply, particularly within rural areas.

One of the most important aspects for increasing the adaptive capacity of the Energy and Industry Sector in Myanmar is providing energy sources, which are sustainable. This will ensure that communities have access to energy supplies without natural resource depletion. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the Energy and Industry sector:

- **installation of solar power technologies** for water pumping and purification systems for increasing water supplies in the face of climate change while reducing high water pumping costs;
- **dissemination of information and transfer of technology/equipment for promoting alternative energy sources** e.g. *inter alia* appropriate stoves, alternative fuel sources (legume plants and paddy stems), renewable energy electricity systems, heated driers, for increasing agricultural productivity and to create an enabling environment for job creation, employment and education.
- **installation of solar-powered aerobic septic tank systems** and other appropriate sanitation technologies for improving public health and ensuring climate-resilient water supply and sanitation systems; and
- **development of road and transport infrastructure.**

The above adaptation options have been incorporated into ten Adaptation Project Options for potential implementation in Myanmar (Table 12). Adaptation Project Options have been ranked in

importance (1 = highest priority, 10 = lowest priority) for reducing the vulnerability of the Energy and Industry sector and related communities to climate change impacts. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 12. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Energy and Industry Sector to climate change impacts.

ENERGY AND INDUSTRY: Adaptation Project Options	RANK
Enhancing the resilience of water supply in the face of climate change for rural communities through solar powered water purification and irrigation pumping systems.	1
Enhancing the resilience of sanitation in the Shan Region to climate change impacts through solar-powered aerobic septic tanks.	2
Increasing climate change resilience of rural communities in the Sagaing, Mandalay and Ayeyarwady Regions through renewable solar electricity systems.	3
Reducing the vulnerability of seed/grain quality to climate change impacts through heated-air mechanical drying technologies.	4
Enhancing the resilience of rural community livelihoods in the Coastal, Chin and Shan regions through micro-hydropower and wind energy development.	5
Increasing the climate change resilience of isolated rural farmers in the Sagaing, Mandalay and Ayeyarwady regions through simple and locally appropriate solar dryer technologies.	6
Adaptation to climate change in the Ayeyarwady and Bago regions of Myanmar through alternative energy sources for electrification and crop drying.	7
Building the resilience of rural communities to climate change through efficient harvesting strategies/technologies to reduce post-harvest losses.	8
Reducing the vulnerability of agriculture production to climate change and ensuring food security through efficient grain storage technologies.	9
Enhancing the adaptive capacity of communities in the Ayeyarwady and Bago regions through low cost biogasifiers for rural power development.	10

Biodiversity

Myanmar has made concerted efforts to protect biodiversity within the country including:

- **An extensive Protected Area (PA) system** comprising 43 PAs (35 designated and 8 proposed) covering 49,500 km^2 (7.3% of total land area). This surpasses the 5% target set by the Myanmar's Forest Policy but is still under the 10% set by the National Forest Master Plan (2001).
- **Protection and restoration** of the spawning and feeding habitats for fish and other marine species as well as conservation of sea turtles through extension services and education activities.
- **Sustainable utilisation of aquatic resources** through closed seasons, licensing, surveillance and enforcement of existing Fishery Law e.g. closed fishing season during June-August (spawning and feeding season of juvenile fish and shrimp species).
- **Restrictions on removal and trade** of restricted species e.g. Asian elephant (*Elephas maximus*), Bengal tiger (*Panthera tigris tigris*), Saing/Banteng/wild cow (*Bos javanicus*), Ayeyarwady-linpaing/Irrawaddy Dolphin (*Orcaella brevirostris*), Golden deer/Brow antlered deer(*Rucervus eldi eldi*) and Spotted deer (*Axis axis*) through the Protection of Wildlife and Conservation of Natural Areas Law, International Union for Conservation of Nature and Natural Resources (IUCN) red data list as well as Convention on International Trade in Endangered Species (CITIES).
- **Community based approaches for site based conservation by Biodiversity And Nature Conservation Association BANCA** including identifying Important Bird Areas in Myanmar and promoting biodiversity through research, partnerships, environmental education and improvement of rural livelihoods. BANCA has identified more than 1000 bird species in Myanmar, including a rediscovery of the critically endangered Gurney's pitta (*Pitta gurneyi)* in 2003 within the Ngawun Reserved Forests.
- **Wildlife conservation training courses and small research grant programs** are being undertaken by Wildlife Conservation Society (WCS) for Hkakaborazi National Park, Hukaung Tiger Reserve, and Hponkanrazi Wildlife Sanctuary. WCS is currently exploring additional areas for potential PAs and environmental education programmes.

One of the most important aspects for increasing the adaptive capacity of the biodiversity sector in Myanmar to climate change is to comply with sustainable harvesting strategies. This includes protecting sources of ecosystem goods and services in order to ensure continued yields. In particular, the conservation of wild populations as well as the protection of ecosystem services and biodiversity

hotspots using well designed and buffered PAs and MPAs will be needed under future climate change conditions. Based on the adaptation needs identified by vulnerable communities during the PRA (see Annex 2 for a detailed list of these adaptation needs), the following is a summary of the adaptation options that should be considered for effective adaptation in the Biodiversity sector:

- **expansion and establishment of climate-resilient PAs and MPAs** for buffering local communities and biodiversity against climate change impacts;
- developing a **management model for PAs and MPAs** through time as conditions change;
- **sustainable harvesting strategies** including the provision of appropriate fishing gear and aquaculture technologies for reducing pressure on marine species and ensuring maximum sustainable yields despite climate change impacts; and
- **sustainable climate-resilient aquaculture technologies** including locally adapted fish species for diversifying livelihoods and ensuring income.

The above adaptation options have been incorporated into eight Adaptation Project Options below for potential implementation in Myanmar (Table 13). Adaptation Project Options have been ranked in importance (1 = highest priority, 8 = lowest priority) for reducing the vulnerability of the biodiversity and related ecosystem services. Please see the methods and criteria used for ranking Adaptation Project Options in Chapter 4 and 6.

Table 13. Adaptation Project Options ranked in importance for implementation for reducing the vulnerability of the Biodiversity Sector to climate change impacts.

BIODIVERSITY SECTOR: Adaptation Project Options	RANK
Buffering marine habitats and sustaining fish populations under climate change impacts through community-based MPA management and ecosystem sensitive fishery practices at the Sister Group Islands of the Myeik Archipelago.	1
Raising awareness on the importance of ecosystem-based climate change adaptation for buffering rural communities against climate change impacts.	2
Buffering marine habitats and sustaining fish populations under climate change impacts through community-based MPA management and ecosystem sensitive fishery practices at Wetthay Chaing (bay) coastal area.	3
Buffering marine habitats and sustaining fish populations under climate change impacts through community-based MPA management and ecosystem sensitive fishery practices at the Thameehla Island, Ayeyarwady Region.	4
Sustaining freshwater fish populations and rural livelihoods in the face of climate change through small-scale aquaculture interventions in the Sagaing and Mandalay regions.	5
Sustaining freshwater fish populations and rural livelihoods using climate-resilient culture based and capture fisheries in the Sagaing and Mandalay regions.	6
Enhancing the adaptive capacity of rural livelihoods through locally managed cage culture production systems for accommodating sea-level rise, flooding and saline intrusion.	7
Buffering local communities and biodiversity against climate change impacts through expanding and adapting terrestrial Protected Areas.	8

4. Selecting Priority Adaptation Projects for implementation

Ranking and Prioritising Adaptation Project Options

A simple multi-criteria analysis was used to rank and prioritise Adaptation Project Options presented in Chapter 3 above. This included: i) developing selection criteria; ii) weighting selection criteria per sector; and iii) scoring each of the eight/ten Adaptation Project Options per sector against the weighted selection criteria. A bonus point system was further used to screen Adaptation Project Options.

Multi-Criteria Analysis (MCA)

A set of 15 criteria were developed by the NAPA team in collaboration with local communities during the PRA. The final selection criteria used (Table 14) were based on the criteria recommended by LDC Expert Group[103].

Table 14. Selection Criteria used to rank and prioritise Adaptation Project Options

Criteria	Explanation
1	Safeguarding lives and property
2	Livelihood
3	Public health
4	Food security
5	Water availability and accessibility
6	Water quality
7	Biodiversity and other environmental goods and services
8	Appropriate and environmentally friendly technology
9	Cultural and historical heritage
10	Protection, rehabilitation and construction of infrastructure
11	Responsiveness to immediate needs of affected communities
12	Capacity building
13	Synergy and complementarities with other projects
14	Sustainability
15	Mainstreaming with national plans

The selection criteria were used to rank Adaptation Project Options by a range of stakeholders from government, private sector and NGOs (~30 participants per sector) during sectoral Working Group Adaptation Prioritization and Validation Meetings. This entailed:

- scoring each Adaptation Project Option as "0 or 1" against the full set of 15 criteria (Table 14) for eight main socio-economic sectors: i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy, and Transport; and viii) Biodiversity; and
- breaking ties between Adaptation Project Options by assessing the projects against an additional set of tie-breaking criteria.

Once scores had been achieved per each Adaptation Project Option, the 15 selection criteria were weighted per sector by NAPA sector Working Groups (~2-3 individuals). Original scores obtained above were then multiplied by the weights determined for the 15 selection criteria and then summed to form an updated priority score for each Adaptation Project Option. An additional bonus point system was used for further screening of Adaptation Project Options. This included scoring each Project Option out of ten based on the level or degree to which the Project Option: i) addresses

[103] Least Developed Countries Expert Group. 2002. Annotated guidelines for the preparation of national adaptation programmes of action.

adverse effects of climate change; ii) reduces poverty to enhance adaptive capacity; iii) in alignment with other multilateral environmental agreements; iv) is cost-effective; and v) enhances adaptive capacity of communities, economic sectors and ecosystems. The bonus point system resulted in the potential for each Adaptation Project Option to gain an additional one to five points[104]. Final scores were used to rank Adaptation Project Options in order of importance for implementation in the country. Based on this ranking, the top four projects per sector were considered Priority Adaptation Projects for implementation in Myanmar. Relevant information to support the implementation of these projects was developed and drafted into individual project profiles (see Chapter 5 and Annex 1). Socio-economic sectors were then prioritised in order to determine which Priority Adaptation Projects should be implemented first in the country.

Prioritising socio-economic sectors/themes for implementing Priority Adaptation Projects

In order to determine which projects should be implemented first in the country, a sector priority level was assigned to the eight main NAPA socio-economic sectors/themes by the NAPA team. Sector priority levels were then further refined during a public review process in April 2012, whereby professionals and government staff from a range of fields reviewed the prioritisation based on local experiences (see Chapter 6 for more details on the review process). The final sector prioritisation for determining projects for implementation is presented below in Table 15.

Table 15. Priority levels assigned to NAPA socio-economic sectors by the NAPA team and further refined through a public review process.

Priority Level	Sector
First	Agriculture, Early Warning Systems, Forest,
Second	Public Health, Water Resources
Third	Coastal Zone
Fourth	Energy and Industry, Biodiversity

[104]The score for each Adaptation Project Option was divided by two i.e. 4 out of 10 resulted in 2 out of 5.

5. List of Priority Adaptation Projects for implementation in Myanmar

This chapter presents the top four priority adaptation projects per sector for addressing Myanmar's urgent/immediate climate change adaptation needs. A brief summary is provided per project in Table 16 below. Priority Adaptation Projects have been selected based on the weighted criteria and methodology described in Chapter 4. Please refer to Annex 1 for detailed ~1-2 page project profiles for each Priority project including further information on the project's: i) Area/Location; ii) Beneficiaries; iii) Period; iv) Estimated Budget; v) framework including Main Components, Outcomes, and Outputs; vi) Agencies Involved; vii) Baseline Information; and viii) Climate Change Adaptation Rationale. The top priority socio-economic sector/theme in which Priority Adaptation Projects should be implemented first include, Agriculture, Early Warning Systems and Forest. This is followed by second priority level sectors Public Health and Water Resources as well as a third priority level sector Coastal Zone. Fourth priority level sectors include Energy and Industry, and Biodiversity. Although, project profiles are presented separately for each Priority Adaptation Project, it is important to note that project ideas/activities/elements can be blended across projects and sectors when designing final project concepts for implementation in the country. Furthermore, it should be highlighted that budget estimates: i) were based on course and subjective calculations; ii) were not determined at a fine scale of detail/at an Output or Activity level; and iii) can change according to the scale at which a project is implemented.

Table 16. Priority Adaptation Projects (first to fourth priority projects) for implementation in Myanmar.

Sector/Theme	Adaptation Project Title	Project Objective	Project Area	Executing Agency	Budget
FIRST PRIORITY LEVEL SECTORS: Agriculture, Early Warning Systems and Forestry					
AGRICULTURE	**First priority:** Reduced climate change vulnerability of rural and subsistence farmers through locally relevant technologies, climate-resilient rice varieties, and ex/in-situ conservation of plant genetic resources.	To reduce the vulnerability of local farmers in Myanmar's three agro-ecological zones to climate change impacts through locally relevant technologies, climate-resilient rice varieties and ex/in-situ conservation of plant genetic resources.	Central Dry and Coastal Zone as well as rain-fed areas in the Hilly Zone.	Yezin Agricultural University, Ministry of Agriculture and Irrigation.	US$ 1.5 million
	Second priority: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.	To reduce the vulnerability of subsistence and rural communities in Myanmar's Dry and Hilly Zones by decreasing input costs while increasing food legume production under climate change impacts.	Central Dry and Hilly Zone		US$ 1.5 million
	Third priority: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.	To increase food supply and income through diversifying and intensifying home-gardens using climate-smart agriculture approaches and solar power tube-well technology for cultivating high-income fruit crops.	Mandalay Region: Nyaung U and Kyauk Pa Daung Townships.		US$ 1.5 million
	Fourth priority: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-	To produce high-yielding and climate-resilient rice varieties appropriate for both the irrigated lowlands and the historically unfavourable areas (rain-fed lowlands, hilly and high altitudinal uplands) in	Irrigated and rain-fed lowlands as well as other areas in the Hilly Zone.		US$ 1.5 million

	resilient rice varieties.	Myanmar's agro-ecological zones. New rice varieties will have increased adaptive capacity to a range of climate change stresses e.g. drought resistant, aerobic, salt-tolerant, cold temperature-tolerant, deep-water rice, waterlogged/submerged varieties, quality rice and hybrid rice.			
EARLY WARNING SYSTEMS	**First priority:** Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events.	To improve observation and monitoring capacity for extreme weather events (including *inter alia* floods, intense rain, strong winds with squalls and cyclones) in order to ensure fast and effective early warnings for communities at risk.	Central Dry and Coastal Zone.	Department of Meteorology and Hydrology, Ministry of Transport.	US$ 3 million
	Second priority: Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.	To improve early warning for hydrological flooding events through increased observation and monitoring capacity in combination with community based methods.	Ayeyarwady Region.		US$ 1 million
	Third priority: Assessing the hydrological impact of climate change on river systems.	To assess the impact of climate change on the Ayeyarwaddy River flow with a focus on flooding extent.	Ayeyarwady River.		US$ 1.5 million
	Fourth priority: Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.	To develop and implement an integrated approach to drought monitoring, management, early warning, forecasting and response mechanisms.	Central Dry Zone.		US$ 1.5 million
FOREST	**First priority:** Building the resilience of degraded/sensitive forest areas to climate change impacts through reforestation.	To restore degraded areas in Myanmar's Dry, Hilly and Coastal Zones using climate-resilient species and technologies for increasing ecosystem goods/services under a changing climate.	Central Dry and Hilly Zone as well as the Ayeyarwady Delta.	Forest Department, Ministry of Environmental Conservation and Forestry.	US$ 3.5 million
	Second priority: Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.	To restore degraded watershed areas in Myanmar's Central Dry Zone using climate-resilient species and technologies for increasing ecosystem goods/services under a changing climate.	Central Dry Zone.		US$ 2.5 million
	Third priority: Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.	To restore degraded mangrove forests in Myanmar's Coastal Regions for increasing ecosystem goods/services as well as buffering local communities and ecosystems in the face of climate change.	Rakhine, Tanintharyi and Ayeyarwady Regions/States.		US$ 2.5 million
	Fourth priority: Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.	To restore the degraded Indawgyi and Inle watershed areas using climate-resilient species and technologies for increasing ecosystem goods/services, while buffering local communities and ecosystems under a changing climate.	Kachin State (Indawgyi Lake) and Shan State (South, Inle Lake).		US$ 2.5 million

SECOND PRIORITY LEVEL SECTORS: Public Health and Water Resources					
PUBLIC HEALTH	**First priority:** Adaptation to climate change through climate-resilient health facilities in the Rakhine State and Ayeyarwady Region.	Ensure health facilities are resilient to climate extremes to prevent damages and resulting high repair costs in the Rakhine State and Ayeyarwady Region.	Rakhine State and Ayeyarwady Region.	Department of Health, Ministry of Health.	(US$ 200 000 per health centre)
	Second priority: Integrating climate change adaptation strategies into the prevention of heat- related disorders in agricultural and industrial workers.	To protect agricultural and industrial workers from morbidity and mortality as a result of heat-related disorders through promoting appropriate behaviour changes.	Mandalay, Magway and Sagaing Regions.		US$ 1.5 million
	Third priority: Supporting Intensive Care Units (ICU) in hospitals to treat heat-related disorders.	To provide quality intensive health care for heat-related disorders.	Magway, Mandalay and Sagaing hospitals.		US$ 1 million
	Fourth priority: Reducing the vulnerability of local communities to climate-induced water-related health hazards through the provision of safe water supplies and sanitary latrines.	To reduce climate-induced water-related health disorders (diarrheal diseases) through increased access to safe drinking water, improved sanitation and Behaviour Change Communication (BCC).	Central Dry Zone and other identified disaster-affected areas.		US$ 1.5 million
WATER RESOURCES	**First priority:** Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change.	To re-evaluate the current design parameters of three of Myanmar's large storage dams to provide recommendations and guidelines on future design parameters for withstanding current and future climate change impacts on water supplies and flooding events.	Magway, Yangon and Sagaing Regions.	Irrigation Department, Ministry of Agriculture and Irrigation.	US$ 1.5 million
	Second priority: Constructing small-scale water impoundments in Naypyidaw for flood control and increasing water supplies for local communities.	To supply sufficient and secure drinking and irrigation water to the Naypyidaw Region through two small-scale earth fill dams. This will contribute directly to reducing water shortage problems as well as assist with managing flood risks.	Naypyidaw Region.		US$ 3.56 million
	Third priority: Protecting human life and property against climate extremes in the Ayeyarwady river system through channel improvement and adaptation structures.	To enhance physical safety including protecting life and property against climate extremes and disasters in the Ayeyarwady river system while increasing water supplies for irrigation and domestic use through appropriate channel improvement and bed regulating methods.	Mu Township, Ayeyarwady River.	Ministry of Water Resources and Improvement of River Systems, Ministry of Transport.	US$ 0.6 million
	Fourth priority: Estimating regional rainfall-runoff relationships for supporting the development of flood early warning systems and ensuring sustainable water	To estimate current and future regional rainfall-runoff relationships to inform optimum hydro-meteorological design parameters and flood EWSs, and therefore assist regional water managers	Central Dry Zone and Lower Myanmar.	Irrigation Department, Ministry of Agriculture	US$ 1 million

	management.	manage anticipated changes in the hydrological cycle.		and Irrigation.	
THIRD LEVEL PRIORITY SECTOR: Coastal Zone					
COASTAL ZONE	**First priority:** Adaptation to climate change through Integrated Coastal Zone Management (ICZM).	To achieve sustainable coastal zone management and livelihoods in the face of climate change.	Myeik Archipelagos, Tanintharyi Region.	Biodiversity and Nature Conservation Association (BANCA).	US$ 800,000
	Second priority: Community-based mangrove reforestation for building climate-resilient ecosystems and rural livelihoods in degraded coastal areas in the Rakhine State.	To reduce the vulnerability of communities in the Rakhine Coastal Zone through climate-resilient mangrove forests and integrated farming systems.	Gwa Township, Thandwe District, Rakhine State.	Forest Department, Ministry of Environmental Conservation and Forestry.	US$ 3 million
	Third priority: Community based eco-friendly aquaculture systems (e.g. mudcrab, clam, shrimp and tilapia) for enhancing the climate change resilience of rural livelihoods and supporting the recovery of mangrove forest ecosystems.	To reduce the vulnerability of coastal livelihoods to climate change affects such as salt-water intrusion and flooding through integrated eco/mangrove-friendly aquaculture systems (including *inter alia* mudcrab, clam, shrimp and Tilapia).	Pulaw Township, Tanintharyi Region.	Department of Fisheries, Ministry of Livestock and Fisheries.	US$ 600,000
	Fourth priority: Small-scale aquaculture and mangrove buffers demonstration sites for transferring adaptation technologies to Mon and Tanintharyi coastal communities.	To build the capacity of local communities for planning and implementing adaptation options for small-scale aquaculture.	Thanphyuzayat, Chaungzone and Paung Townships, Mon State.	Department of Marine Science, University of Mawlamyine.	US$ 600,000
FOURTH LEVEL PRIORITY SECTORS: Energy and Industry, and Biodiversity Sectors					
ENERGY AND INDUSTRY	**First priority:** Enhancing the resilience of water supplies in the face of climate change for rural communities through solar powered water purification and irrigation pumping systems.	To ensure cleaner and safer water for drinking as well as sustained water supplies for irrigation under a changing climate through solar power.	Central Dry Zone and townships in the Ayeyarwady Region.	Rural Energy Development Committee.	US$ 3 Million
	Second priority: Enhancing the resilience of sanitation in the Shan Region to climate change impacts through solar powered aerobic septic tanks.	To improve sanitation in the Shan Region through sustainable solutions for reducing health risks (water-borne diseases) and increasing drinking water supplies in the face of climate change.	Inle Lake area in the Southern Shan State.		US$ 2 million
	Third priority: Increasing climate change resilience of rural communities in the Sagaing, Mandalay and Ayeyarwady Regions by increasing livelihood opportunities through renewable solar electricity systems.	To increase community access to energy for supporting job creation, employment, education and channels for communicating early warnings to villages vulnerable to extreme weather events.	Sagaing, Mandalay and Ayeyarwady Regions.		US$ 5 million

	Fourth priority: Increasing climate-resilience of harvested seed/grains through heated-air mechanical drying technologies.	To improve seed/grain storage techniques in the face of climate change to reduce product and associated financial losses.	Sagaing, Mandalay and Ayeyarwady Regions.	Ministry of Industry.	US$ 3 million
BIODIVERSITY	**First priority:** Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Sister Group Islands of the Myeik Archipelago.	To manage existing MPA area at the Sister Group Islands of the Myeik Archipelago to maximise the resilience of marine biodiversity, fish populations and local community livelihoods.	Sister Group islands, Myeik archipelagos, Tanintharyi Coastal area.	Department of Fisheries, Forest Department.	US$ 800, 000
	Second priority: Mainstreaming ecosystem-based climate change adaptation for buffering rural communities against climate change impacts into policy, planning and relevant projects.	To disseminate information and demonstrate the importance of biodiversity and ecosystem services in buffering local communities against climate change impacts.	Ayeyarwady, Sagaing and Mandalay Region.		US$ 1.5 million
	Third priority: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at Wetthay Chaing (bay) coastal area.	To manage the Wetthay Chaing coastal MPA in the Ayeyarwady Region to maximise the resilience of marine biodiversity (including the endangered dugong and various turtle species), fish populations and local community livelihoods.	Wetthay Chaing, Gwa Township, Rakhine Coastal Area.		US$ 800, 000
	Fourth priority: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Thameehla Island, Ayeyarwady Region.	To manage the Thameehla Island coastal MPA in the Ayeyarwady Region to maximise the resilience of marine biodiversity (including endangered turtle species), fish populations and local community livelihoods.	Thameehla Island, Ngaputaw Township, Ayeyarwady Region.		US $ 800, 000

6. NAPA Preparation Process

The Evolution and Progress of the NAPA

As a result of a series of unforeseeable circumstances/influences, the NAPA project deadlines and timeframes changed considerably throughout the NAPA preparation process. The NAPA project was first initiated in 2007, and assigned an 18-month timeline. However, following the retirement of the project coordinator Dr Tun Lwin (Director General of the DMH), in 2009 the NAPA project was terminated. The NAPA was, however, reinitiated in March 2011 under U Tin Ngwe as acting Director General of the DMH. A new 10-month timeline was established (with a deadline of December 2011). The project was further extended to a 15-month timeline (with a deadline of May 2012) when U Aung Win (NAPA Project Coordinator) indicated that 10-months was insufficient time for effective completion of the NAPA.

Institutional Arrangements

The NAPA preparation process consisted of seven steps that were coordinated and implemented by various institutions, teams and stakeholders. The institutional framework/arrangements that supported and coordinated the NAPA preparation process is presented in Figure 13.

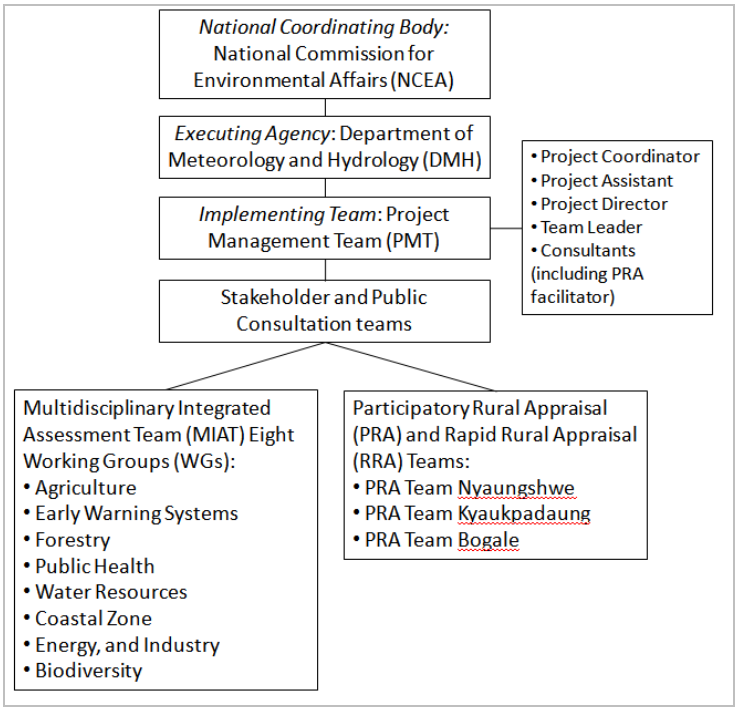

Figure 13. The institutions and teams involved in the NAPA preparation process.

Steps in the Development of the Myanmar NAPA

The Myanmar NAPA preparation process followed the generic steps outlined by the United Nations Framework Convention on Climate Change (UNFCCC) Least Developed Countries (LDC) Expert Group[105][106] (see Figure 14). The process was structured around eight socio-economic sectors/themes i) Agriculture; ii) Early Warning Systems; iii) Forestry; iv) Public Health;; v) Water Resources; vi) Coastal Zone; vii) Energy and Industry; and viii) Biodiversity.

[105] Least Developed Countries Expert Group. 2002. Annotated guidelines for the preparation of national adaptation programmes of action.

[106] Least Developed Countries Expert Group. 2009. National adaptation Programmes of action: Overview of preparation, design of implementation strategies and submission of revised project lists and profiles.

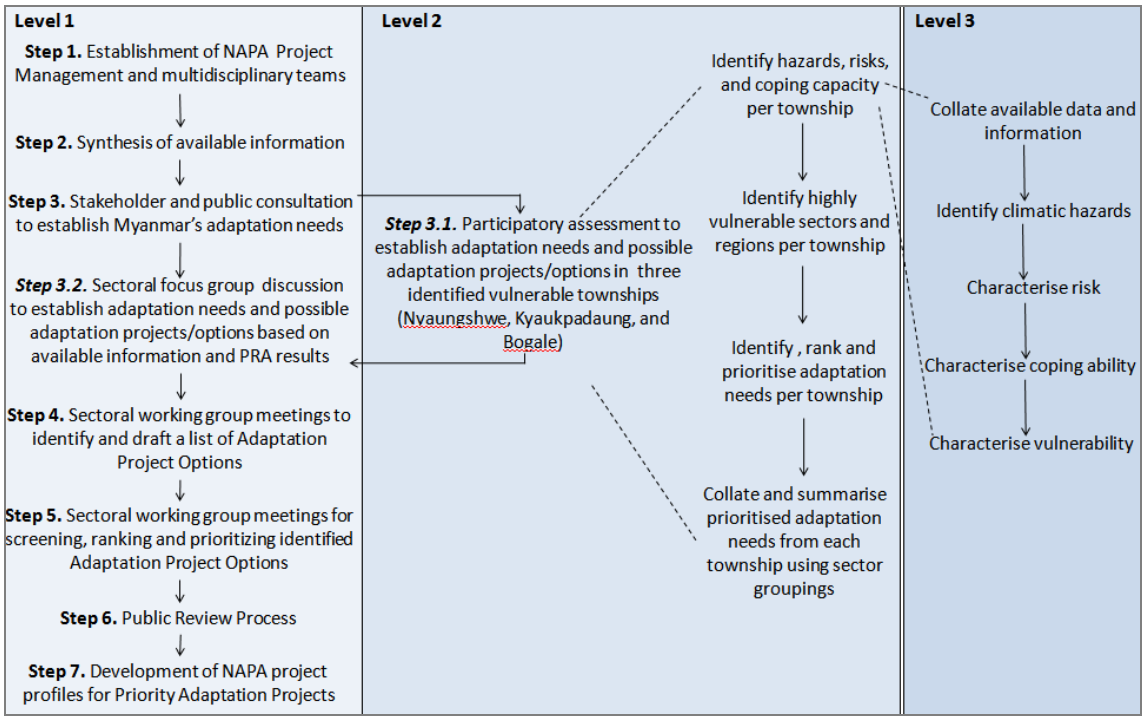

Figure 14. An outline of the steps used in the Myanmar NAPA preparation process[107]

Step 1: Establishment of NAPA Project Management and multidisciplinary teams (April 2011)
Teams were established for the management of the NAPA and to ensure stakeholder participation. These teams included:

- The Project Management Team (PMT), which was responsible for the production of the NAPA document and the overall management of the NAPA process. This team was formed from members of the Department of Meteorology and Hydrology (DMH) and relevant national experts. The team included a project coordinator, project assistant, project director, team leader and consultants (including PRA facilitator).
- Eight sectoral Working Groups (WG), namely; i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy and Industry; and viii) Biodiversity. WGs comprised a combination of experts from a variety of institutions across Myanmar for each specific sector. These working groups combined to form the Multi-disciplinary Integrated Assessment Team (MIAT).

PMT and MIAT facilitated and executed the NAPA process. Both teams included stakeholders actively involved in the eight socio-economic sectors/themes in an effort to capture the immediate climate change pressures and adaptation needs in Myanmar. Teams also included individuals, such as the PRA facilitator, who were able to ensure a strong public participatory approach throughout the process. The inclusion of a bottom-up approach allowed for the integration of indigenous knowledge into the NAPA process.

Step 2: Synthesis of available information (May – July 2011)
Sectoral literature reviews were conducted by the eight WGs in the MIAT. The PMT conducted a further literature review, and integrated the sectoral literature reviews to form a combined synthesis of available information. Within the synthesis, information was compiled and analysed on the observed and projected climate change trends in Myanmar. This step was necessary to identify which geographic areas and socio-economic sectors are most vulnerable to the impacts of climate change. This review acted as the foundation for the next steps of the NAPA process.

[107] Adapted form Dr. Paul V. Desanker, Vice-Chair, UNFCCC LDC Expert Group, in 'Methods for Identifying Urgent Adaptation Needs and Actions under the LDC NAPA'.

Step 3: Stakeholder and public consultation to establish Myanmar's adaptation needs and potential adaptation projects/options (July – September 2011)
This step was achieved through two interacting components: i) a participatory assessment (comprising a Rapid Rural Appraisal (RRA) and a Participatory Rural Appraisal (PRA)); and ii) a series of sector focused WG meetings. This step was designed to identify Myanmar's climate change vulnerabilities and adaptation needs according to both rural communities and expert groups.

Step 3.1. Participatory assessment to establish climate change vulnerability, adaptation needs and possible adaption projects (Annex 2). The following is an outline of the PRA process:

- The participatory assessment comprised two appraisals, namely the Rapid Rural Appraisal (RRA) and the Participatory Rural Appraisal (PRA). The RRA method is economical in terms of the research time, and allowed for fast assessment of the vulnerabilities and adaptation needs of the rural community. The PRA, on the other hand, used similar methods as the RRA however placed strong emphasis on community empowerment and participation.
- The assessment was conducted in collaboration with local UNDP Integrated Community Development Project (ICDP) and Community Development for Remote Townships (CDRT) offices.
- A small team comprising Myanmar nationals and staff from the local CDRT and ICDP offices conducted the groundwork and community surveys for the PRA and RRA. The assessment was conducted in three townships; i) Nyaungshwe Township (Shan State); ii) Kyaukpadaung Township (Mandalay Region); and iii) Bogale Township (Ayeyarwady Region). Townships were chosen to represent three vulnerable and ecologically distinct areas; the Hilly, the Central Dry, and the Coastal Zone.
- The assessments were conducted to: i) identify the hazards, risks, and coping abilities of townships; ii) identify highly vulnerable sectors and regions in each township; iii) identify, rank and prioritise specific adaptation needs in each township (achieved by group consensus); and iv) collate and summarise these prioritised adaptation needs from each township into sector groupings.
- A series of tools and processes were used to conduct the PRA, including: i) Focus Group Discussions (FDGs) and questionnaires; ii) seasonal calendars; iii) historical transects; iv) matrix ranking; v) community identification of needs for adaptation measures; vi) the selection of criteria for prioritization of adaptation measures; and vii) the prioritization of adaptation measures by the communities (using agreed criteria).

Step 3.2. Focus group discussions with the eight socio-economic sectoral working groups (WGs). These meetings were designed to establish the adaptation projects/options according to the available information (synthesised in **Step 2**) and the information identified in the PRA and RRA (**Step 3.1**).

Step 4: Sectoral working group meetings to identify and draft a list of Adaptation Project Options (October – November 2011)
Adaptation needs and potential adaptation projects/options (established in **Step 3**) were used to identify a list of 77 Adaptation Project Options to be ranked and prioritised (under **Step 5**) for potential implementation in Myanmar. Eight to ten potential projects were identified for each sector.

Step 5: Sectoral working group meetings for screening, ranking and prioritising identified adaptation projects (October – November 2011 and March-April 2012)
The NAPA activities identified in **Step 4** were consolidated and validated during prioritization and validation meetings by sectoral working groups. Multi-criteria analyses (a series of 15 criteria developed by the LDCExpert Group) were used to rank and then prioritise Adaptation Project Options for implementation. Criteria were based on both social and economic benefits, for example, improved public health, improved water quality, and improved food security and were weighted in importance for each specific sector. A bonus point system was used to further screen Adaptation Project Options. The resulting scores for each Project Option were used to prioritise projects for further development and implementation (see Chapter 4).

Step 6: Public Review Process of NAPA draft (February to April 2012)
A public review process was undertaken in order to solicit public opinion on the NAPA draft document including Priority Adaptation Projects as well as sector prioritisation. A number of steps were undertaken to gather public opinion:

- A press meeting was conducted to release the NAPA draft to the public. Reporters from 17 local newspapers and journal houses attended this meeting.
- A summary of the NAPA was disseminated to local communities using daily newspapers and weekly journals.
- Two public meetings were organized to inform the public of the NAPA Project and solicit their opinion.
- NAPA Draft Reports were distributed to Sectoral NAPA Working Group leaders who further distributed the document to the public through their township offices.
- The journal “The Voice” was used to invite readers to provide their views on the report as well as Adaptation Projects and priority adaptation sectors.

A total of 363 replies were collected and reviewed by the NAPA team. Relevant insights and suggestions were then incorporated into the report.

Step 7: Development of the NAPA project profiles (March - April 2012)
To determine which projects should be implemented first in the country, a sector priority level was assigned to the eight main NAPA sectors/themes by the NAPA team. Sector priority levels were then further refined during a public review process in April 2012. Project profiles were developed for the Priority Adaptation Projects using focus group discussions and meetings with working group members as well as other key stakeholders. Project profiles include the: i) Project Objective; ii) Project Area; iii) Beneficiaries; iv) Period; v) Estimated Budget; vi) Project Framework including Main Components, Outcomes, and Outputs; vii) Agencies Involved; viii) Baseline Information; and ix) Climate Change Adaptation Rationale. Please refer to Annex 1 for detailed ~1-2 page project profiles for each Priority Adaptation Project. Selection of Priority Adaptation Projects was based on the weighted criteria and methodology described in Chapter 4.

7. ANNEXES

Annex 1: Priority Adaptation Project Profiles i.e. information for project implementation

A detailed project profile is presented below for each Priority Adaptation Project. This includes: i) Project Objective; ii) Project Area; iii) Beneficiaries; iv) Period; v) Estimated Budget; vi) Project Framework including Main Components, Outcomes, and Outputs; vii) Agencies Involved; viii) Baseline Information; and ix) Climate Change Adaptation Rationale. Although, project profiles are presented separately for each Priority Adaptation Project, project ideas/activities/elements can be blended across projects and sectors when designing final project concepts for implementation in the country. It is also important to note that parts of the information described in the project profiles is subject to change. For example, by the time a project is fully designed, the baseline situation in the country could have changed and furthermore additional projects could be running in the country. Furthermore, budget estimates i) were based on course and subjective calculations; ii) were not determined at a fine scale of detail/at an Output or Activity level; and iii) can change according to the scale at which a project is implemented.

Agriculture Sector: Priority Adaptation Project Profiles

First Priority Project: Enhanced rice production through farm mechanization and breeding new rice varieties to ensure food security in areas most vulnerable to climate change

Project Objective: To reduce the vulnerability of local farmers in Myanmar's three agro-ecological zones to climate change impacts through locally relevant technologies, climate-resilient rice varieties and ex/in-situ conservation of plant genetic resources.

Project Area/Location: i) Yezin Agricultural University (Mandalay Region, local point for education, training and research); ii) Dry zone (Mandalay Region, Magway and Sagaing Region); iii) Coastal and rain-fed areas (Ayeyarwady Region, Mon State and Pago Region); and iv) Hilly zone (Chin and Shan States).

Beneficiaries: i) Local farmers at the project sites in the Central Dry Zone, Coastal and rain-fed areas and Hilly zones; ii) MSc and PhD students at Yezin Agricultural University, iii) Line Government Departments; and iv) local Non Government Organizations (NGOs).

Period: 4 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building and research for selecting/developing early maturing and heat-tolerant rice varieties.	**1.1:** Rice genetic resources representing Myanmar's three ecological zones conserved in-situ and ex-situ.	**1.1.1:** A storage facility established at the Yezin Agricultural University. **1.1.2:** Training for students, staff and local farmers conducted on the importance of local rice varieties. **1.1.3:** Appropriate in-situ and ex-situ methods for conserving genetic resources established and transferred to students, staff and local farmers. **1.1.4:** Rice genetic resources from different ecological zones collected by local farmers, university staff and students, and stored in the Yezin Agricultural University's storage room. **1.1.5:** Seed germplasm made available for breeding and planting programmes.
	1.2: Early maturing and heat-tolerant rice	**1.2.1:** Seed germplasm used to produce early maturing and heat-tolerant rice varieties.

	varieties appropriate for Myanmar's three ecological regions produced and/or distributed.	**1.2.2:** Appropriate existing rice varieties identified for planting in selected regions. **1.2.3:** Farmer based field trials of existing climate-resilient as well as new early maturing/heat-tolerant rice varieties established to assess the suitability and cost-effectiveness of assorted rice varieties for improving rice yields and climate resilience. **1.2.4:** PhD and MSc theses completed and scientific articles published in key journals.
Component 2: Locally relevant technologies for Myanmar's three agri-ecological zones.	**2.1:** Resilience of grain/seed harvesting and drying practices to intense rain and other extreme weather events increased.	**2.1.1:** Combine harvester, dryer machines and grain silo provided to local communities and farmers **2.1.2:** Farmers and local communities trained to sustainably use technologies/equipment.
	2.2: Enhanced rice production and increased income of farmers and local communities in vulnerable areas.	**2.2.1:** Mechanising system established among local farmers through on-going training and capacity building programmes **2.2.2:** Early maturing and heat-tolerant rice varieties distributed to farmers in vulnerable areas.
Component 3: Education, agricultural extension and training for scaling up project activities.	**3.1.** Drought-prone and high temperature areas of the country adopt new and appropriate rice varieties as well as locally relevant technologies for reducing their vulnerability to climate change impacts.	**3.1.1:** Demonstration projects replicated through wider farmer participation and training. **3.1.2:** A project website developed as a knowledge platform. **3.1.3:** Best practice guidelines, knowledge dissemination tools and communication products developed in local languages appropriate for Myanmar's three agri-ecological zones. **3.1.4:** Lessons learned collected and disseminated. **3.1.5:** National seminar held for collating and disseminating lessons learned. **3.1.6**: Integrated Pest Management are operated to solve the rice pest problem from farm to lab and then lab to farm system

Agencies Involved: Executing Agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation; Partner/Cooperating Agencies: Department of Agricultural Research, Department of Agriculture, Department of Agricultural Planning, Line Ministries, local NGOs, local farmers and Myanmar rice crop entrepreneur agency.

Baseline Information: The Agricultural Mechanisation Department (AMD) under the Ministry of Agriculture and Irrigation (MoAI) is responsible for the: i) provision of farm mechanisation services on land preparation, harvesting and threshing; ii) production and distribution of appropriate farm machineries; and iii) dissemination of technical know-how on utilisation of farm machinery to local farmers. Despite efforts by the ADM, communities and local farmers do not have adequate agricultural machinery including combine harvesters, dryer machines and grain silos for ensuring agricultural productivity under future climate change conditions. Development of high yielding crop varieties and ensuring sustainable use of natural resources and conservation and utilisation of crop genetic resources is the main function of the Department of Agricultural Research (MoAI). Yezin Agricultural University is responsible for training and producing highly qualified agriculturalists. Please see the table below for information regarding related on-going projects.

On-going projects	Budget (USD)	Duration	Funding Agency	Executing Agency
Estimates of methane emission from rice fields in selected regions in Myanmar.	$ 5,000	3 years	UNEP	**Yezin** Agricultural University
Breeding early maturing and high yielding rice varieties. MSc Thesis.	$ 3,000	3 years	Rice crop entrepreneur agency in Myanmar	
Managing soil and water for increasing	$3,000	3 years	Rice crop entrepreneur	

rice production in paddy fields.			agency in Myanmar	
International Biodiversity (regeneration project in Seed Bank). PhD Thesis.	$ 48,000	3 years	FAO	Department of Agricultural Research
Addressing climate change risks on water resources and food security in the Dry Zone of Myanmar	$ 7,909,026	2012-2016	UNDP	Ministry of Environmental Conservation and Forestry

Climate Change Adaptation Rationale: Agriculture is the backbone of Myanmar's economy, contributing to 43% of GDP (in 2011) and making up to 11% of export earnings. Overall trends in observed climate variability/change in Myanmar indicate that temperatures have increased over the last six decades (~0.8ºC per decade) across the whole country. Furthermore, there has been an increase in occurrence and frequency of flood and drought events. These changes in climate have resulted in negative effects on crop production. In particular, local rice varieties are no longer adapted to local climate conditions. Furthermore, traditional drying, harvesting and storing practices are not effective under these climate extremes. Future climate change impacts will exacerbate this situation with increases in temperature and extreme weather events further hampering agricultural production. To ensure food security there is an urgent need to identify/develop early maturing and heat-tolerant rice varieties for Myanmar's three agri-ecological zones. Furthermore, mechanised technology such as combine harvesters and mechanical dryers particularly in Myanmar's rain fed agriculture areas are needed to ensure resilience of harvesting, drying and storing methods under future increases in flooding and drought events.

Second Priority Project: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.

Project Objective: To reduce the vulnerability of subsistence and rural communities in Myanmar's Dry and Hilly Zones by decreasing input costs while increasing food legume production under climate change impacts.

Project Area/Location: i) Yezin Agricultural University (Mandalay Region, local point for education, training and research); ii) Dry Zone (Mandalay, Sagaing and Magway Region); and iv) Hilly zone (Shan State).

Beneficiaries: i) Local farmers at the project sites in the Dry and Hilly zones; ii) MSc and PhD students at Yezin Agricultural University, iii) Line Departments; and iv) local Non Government Organizations (NGOs).

Period: 4 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building and research for selecting/developing climate-resilient legume varieties.	**1.1:** Legume crop varieties (landraces/wild crop relatives) from the Dry and Hilly Zone conserved in-situ and ex-situ.	**1.1.1:** A seed storage facility established at the Yezin Agricultural University. **1.1.2:** Training for students, staff and local farmers conducted on the importance of local food legume varieties. **1.1.3:** Appropriate in-situ and ex-situ methods for conserving legume genetic resources established and transferred to students, staff and local farmers. **1.1.4:** Legume genetic resources from different ecological zones collected by local farmers, university staff and students and stored in the Yezin Agricultural University's storage room. **1.1.5:** Seed germplasm made available for breeding programmes.

	1.2: Improved and heat-tolerant food legume varieties produced appropriate for cultivation under low fertiliser requirements in Myanmar's Dry and Hilly Zones.	**1.2.1:** Germplasm used to produce heat-tolerant food legume varieties. **1.2.2:** Appropriate food legume varieties identified for planting in selected regions. **1.2.3:** Farmer based field trials of heat-tolerant legume varieties established under different fertiliser levels to assess the suitability and cost-effectiveness for improving/maintaining legume yields under climate change impacts. **1.2.4:** PhD and MSc theses completed and scientific articles published in peer-reviewed journals. 1.2.5: Appropriate food legume cropping pattern observed for planting in selected regions. 1.2.6: Identifying the suitable marketing for obtaining high income.
Component 2: Climate-smart agriculture interventions to reduce vulnerability in the Dry and Hilly zones.	**2.2:** Food legume production maintained/enhanced with reduced fertiliser requirements (and thus costs).	**2.2.1:** Heat-tolerant food legume varieties distributed to farmers in vulnerable areas. **2.2.2:** Soil conservation management practices transferred to local farmers.
Component 3: Education, agricultural extension and training for scaling up project activities.	**3.1.** Drought-prone and high temperature areas of the country adopt new and appropriate legume varieties for increasing incomes and reducing their vulnerability to climate change impacts.	**3.1.1:** Demonstration projects replicated through wider farmer participation and training. **3.1.2:** A project website developed as a knowledge platform. **3.1.3:** Best practice guidelines, knowledge dissemination tools and communication products developed in local languages. **3.1.4:** Lessons learned collected and disseminated. **3.1.5:** National seminar held for collating and disseminating lessons learned.

Agencies Involved: Executing agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation; Partner/Cooperating Agencies: Department of Agricultural Research, Department of Agriculture, Department of Agricultural Planning, Line Ministries, local NGOs, local farmers and Myanmar pulses crop entrepreneur agency.

Baseline Information: Myanmar Agriculture Service (MoAI) is presently focusing its efforts on increasing production of major crops including pulses, paddy, oil crops, kitchen crops, vegetables and fruits. Please see table below for information regarding related on-going projects.

On-going projects	Budget (US$)	Duration	Funding Agency	Executing Agency
Selecting and improving varieties of cowpea, groundnut and chickpea crops in the Central Dry Zone.	$ 2,000,000	3 years	Australia (ACIAR project)	Department of Agriculture and Department of Agricultural Research
Improving food legume crops in the Central Dry Zone areas. MSc Research.	$ 10,000	3 years	Action Aid, India	Yezin Agricultural University
Breeding improved soybean varieties in Myanmar.	$ 60,000	6 years	KOPIA, Korea	Department of Agriculture and Department of Agricultural Research
Addressing climate change risks on water resources and food security in the Central Dry Zone of Myanmar.	$ 7,909,026	2012-2016	UNDP	Ministry of Environmental Conservation and Forestry
Evaluation of pulse production practices for sustainable rural development in Myanmar.	$ 7,500	2011-2013	Department of Agriculture	Pulses Section, Department of Agriculture

Breeding high quality legume seeds using a farmers' participatory approach.	$ 10,000	2011-2013	Department of Agriculture	Pulses Section, Department of Agriculture.

Climate Change Adaptation Rationale: Food legumes are one of Myanmar's main export crops and as a result play a considerable role in the country's economy. Breeding new and improved legume varieties enhances the resistance of these plants to a variety of stresses that could result from climate change. New and improved varieties will ensure that agricultural production and thus exports of this crop can continue despite climate change impacts. Encouraging farmers to cultivate more than one legume crop type reduces their risks to unforeseen climate events. Significant climate change impacts have already been witnessed in Myanmar's Dry and Hilly Zones. To ensure food security under further climate change impacts, conserving plant genetic resources, breeding new and improved varieties, land management and capacity building are urgently needed.

Third Priority Project: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.

Project Objective: To increase food supply and income through diversifying and intensifying home-gardens using climate-smart agriculture approaches and to construct the water preserver for collecting rain water and underground water with helping of solar power technology for cultivating high-income fruit crops.

Project Area/Location: i) Dry Zone (Mandalay Region, Nyaung U and Kyauk Pa Daung Townships).

Beneficiaries: i) Local communities at the project sites; ii) Line Departments; iii) local NGOs; and iv) MSc and PhD students.

Period: 4 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Biophysical, ecological and socio-economic assessments of Dry Zone farming communities and areas.	**1.1:** Technical expertise developed for intensifying and diversifying local home-gardens combining traditional and modern/scientific approaches.	**1.1.1:** Relevant information on the use, availability and status of natural resources, food supply needs and the vulnerability of the Dry Zone communities to climate change impacts collected by staff of Yezin Agricultural University, Department of Agriculture and local NGOs. **1.1.2:** Local home-gardens assessed to determine: i) the potential to install solar power technologies with water storage tanks as water sources and implement climate-smart agriculture practices; ii) the range of crops currently being cultivated; iii) potential climate-resilient crops that farmers would consider cultivating; and iv) the technical capacity of farmers. **1.1.3:** Assessments and profiles of water resources conducted in appropriate home gardens to identify sites for installing solar-powered water supply.
Component: 2: Interventions that reduce vulnerability to climate change and increase income levels.	**2.1:** Increased resilience and enhanced production through intensified and diversified climate-resilient home-gardens.	**2.1.1:** Climate-smart agriculture approaches used for intensifying and diversifying home-gardens e.g.: i) climate-resilient species; ii) cover crops/green manure; iii) crop diversification; and iv) new crop varieties including nitrogen-fixing food legume crops for providing fodder for livestock production and increasing soil fertility. **2.1.2:** Climate-resilient multi-use tree species planted to supply communities with multiple

		benefits, e.g. i) Non-timber Forest Products; ii) soil stabilisation; iii) increased water infiltration rates; iv) reduced evaporation of water from rice areas; v) improved soil structure as a result of increased leaf litter from tree canopies; and vi) increased soil fertility.
	2.2: Income and access to markets for local communities increased through cultivation of high-income crops.	**2.2.1:** Solar energy for increasing water supply and reducing input costs assembled and installed for supporting high-income water dependent fruit trees. **2.2.2:** High-income crops and fruit trees planted, e.g. dragon fruit supported by solar-powered water storage tanks. **2.2.3:** Training conducted to ensure maintenance and efficient operation of installed solar energy power water supply system. 2.2.4: Food preservation technology is developed among the community.
Component 3: Awareness raising and training for scaling up climate-smart agriculture practices throughout the Dry Zone.	**3.1:** Farming practices in drought-prone and high temperature areas adapted using new and appropriate climate-smart agriculture.	**3.1.1:** Community-based agricultural extension services developed for transferring knowledge and demonstrating climate-smart agriculture to local communities. **3.1.2:** Communication between scientists and local communities enhanced for increasing the transfer of knowledge on new crop and fruit varieties for local home-gardens.

Agencies Involved: Executing agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation; Partner/Cooperating agencies: Department of Agricultural Research, Department of Agriculture, Department of Agricultural Planning, Line Ministries, Local NGOs, local farmers and Myanmar Horticultural Crop Entrepreneur Agency.

Baseline Information: Department of Agriculture focuses its efforts to increase production of major crops including pulses, paddy, oil crops, kitchen crops, vegetables and fruits. Please see table below for information regarding related on-going projects.

On-going projects	Budget (US$)	Duration	Funding Agency	Executing Agency
Evaluation techniques for breeding dragon fruit. MSc Thesis.	$ 1,000	3 years	Myanm ar Awba Enterprise, Myanmar	Yezin Agricultural University
Addressing climate change risks on water resources and food security in the Dry Zone of Myanmar.	$ 7,909,026	2012-2016	UNDP	Ministry of Environmental Conservation and Forestry

Climate Change Adaptation Rationale: The Dry Zone is one of the most climate sensitive and natural resource poor regions in Myanmar. Despite the fact that water is scarce, vegetation cover is thin, and soil is degraded, population densities in the Dry Zone are high and agriculture constitutes the primary land use in the area. The region, already characterized by low annual rainfall (508 mm per annum), is currently undergoing further decreases in rainfall as a result of climate variability and change. Therefore, there is an urgent need to reduce poverty levels and food insecurity in Dry Zone farming communities. With a diversified and intensified home-garden, a local famer will be better equipped to manage the uncertainty and changes created by climate change. New and improved local crop varieties will improve nutritional value for people and livestock, and help reduce vulnerability to illness. Furthermore, reducing input costs through climate-smart agriculture and solar powered technologies will increase income levels for the local communities.

Fourth Priority Project: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.

Project Objective: To produce high-yielding and climate-resilient rice varieties appropriate for both the irrigated lowlands and the historically unfavourable areas (rain-fed lowlands, hilly and high altitudinal uplands) in Myanmar's agro-ecological zones. New rice varieties will have increased adaptive capacity to a range of climate change stresses e.g. drought resistant, aerobic, salt-tolerant, cold temperature-tolerant, deep-water rice, waterlogged/submerged varieties, quality rice and hybrid rice.

Project Area/Location: Ecological rice growing areas in Myanmar including: i) irrigated and rain-fed lowlands; and ii) Hilly Zone areas.
Beneficiaries: i) Local farmers at the project sites, ii) staff and under-graduate and post-graduate students of the Yezin Agricultural University; iii) Line Departments; and iv) local NGOs.

Period: 4 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building and research for high yielding and climate-resilient rice varieties with increased adaptive potential for projected climate change impacts on Myanmar's three agri-ecological zones.	**1.1:** Rice genetic resources occuring across irrigated and rain-fed lowlands and hilly upland areas in Myanmar conserved in-situ and ex-situ.	**1.1.1:** A storage facility with refrigerator and dryer oven established at the Yezin Agricultural University. **1.1.2:** Surveys conducted to capture local/traditional knowledge on wild crop rice relatives, rice landraces and sustainable farming systems. **1.1.3:** Training for students, staff and local farmers conducted on the importance of local rice varieties. **1.1.4:** Appropriate in-situ and ex-situ methods for conserving plant genetic resources established and transferred to students, staff and local farmers. **1.1.5:** Rice and other plant genetic resources from different ecological zones collected by local farmers, university staff and students and stored in storage room at Yezin Agricultural University. **1.1.6:** Seed germplasm made available for abiotic and biotic resistance breeding programmes. 1.1.7: Integrated Pest Management is widely used for pest management.
	1.2: Resistance of rice varieties, appropriate for Myanmar's irrigated as well as rain fed lowlands and hilly upland areas, enhanced to a range of stresses that could result from climate change (e.g. water, heat and salinity stress and the emergence of new pests).	**1.2.1:** Rice germplasm used to produce a range of varieties e.g. drought resistant, aerobic, salt-tolerant, cold temperature-tolerant, deep-water rice, waterlogged/submerged varieties, quality rice and hybrid rice. **1.2.2:** Appropriate rice varieties identified for planting in selected regions. **1.2.3:** Farmer-based field trials of certain rice varieties conducted to assess the suitability and cost-effectiveness of assorted climate-resilient rice varieties for improving rice yields and climate resilience. **1.2.4:** Post-graduate theses completed and scientific articles published in peer-reviewed journals.
Component 2: Demonstration measures that reduce vulnerability of communities to climate change impacts on rice production.	**2.2:** Climate-resilient rice produced and income increased for rural farmers	**2.2.1** Climate-resilient rice varieties distributed to farmers in vulnerable areas. **2.2.2** Soil conservation management practices, integrated pest management and climate-smart agriculture practices transferred to local farmers.

Component 3: Education, agricultural extension and training for scaling up project activities.	**3.1:** Farmers in irrigated and rain fed lowlands as well as Hilly areas adopt climate-resilient and appropriate rice varieties for reducing vulnerability to climate change.	**3.1.1:** Demonstration projects replicated through farmer participation and training. **3.1.2:** Series of hands-on training, field days and workshops conducted for capacity building of local farmers and students. **3.1.3:** A project website developed as a knowledge platform. **3.1.4:** Best practice guidelines, knowledge dissemination tools and communication products developed in local languages appropriate for Myanmar's three agri-ecological zones. **3.1.5:** Lessons learned collected and disseminated. **3.1.6:** National seminar held for collating and disseminating lessons learned.

Agencies Involved: Executing agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation; Partner/Cooperating agencies: Department of Agricultural Research, Department of Agriculture, Department of Agricultural Planning, Line Ministries, local NGOs, local farmers and Myanmar Rice Crop Entrepreneur Agency.

Baseline information: The Department of Agricultural Research (MoAI) and the Yezin Agricultural University are responsible for training high calibre agriculturalists. Please see table below for information regarding related on-going projects.

On-going projects	Budget (US$)	Duration	Funding Agency	Executing Agency
Determining high yielding rice varieties for rain fed and irrigated areas in Myanmar. MSc Thesis.	$ 2,000	3 years	Myanmar Rice Entrepreneur Agency	Yezin Agricultural University
Evaluation of hybrid rice varieties for breeding good quality and high yielding varieties. MSc Thesis.		3 year	Myanmar Rice Entrepreneur Agency	Yezin Agricultural University and Department of Agricultural Research
Addressing climate change risks on water resources and food security in the Dry Zone of Myanmar	$7,909,026	2012-2016	UNDP	Ministry of Environmental Conservation and Forestry

Climate Change Adaptation Rationale:
Myanmar's dependence on rain-fed agriculture renders it extremely vulnerable to climate change impacts such as drought, flooding, high temperatures and prolonged dry spells. Such events precipitate widespread crop failure and food and water insecurity, and ultimately affect the sustainability of rural livelihoods. The conservation of indigenous rice varieties and breeding new, high yielding and climate-resilient rice varieties is a necessity for successful adaptation and food security, particularly in Myanmar's rain-fed lowlands and hilly and high altitudinal uplands.

Early Warning Systems: Priority Adaptation Project Profiles

First Priority Project: Improving weather observation capacity through a mobile and deployable weather radar system for providing early warning systems against extreme weather events.

Project Objective: To improve observation and monitoring capacity for extreme weather events (including *inter alia* floods, intense rain, strong winds with squalls and cyclones) in order to ensure fast and effective early warnings for communities at risk.

Project Area/Location: Central Dry Zone and Coastal Zone

Beneficiaries: Local communities, the Department of Meteorology and Hydrology as well as all other line departments at risk to extreme weather events

Period: 1 year

Estimated Budget: US$ 3 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building for analysis and prediction of extreme weather events	**1.1:** Capacity of hydrometeorological services and networks enhanced for predicting extreme weather events.	**1.1.1:** Radar (including mobile and deployable systems) global best practice reviewed for identifying the most cost effective and efficient system for Myanmar. **1.1.2:** Global best practices reviewed regarding radar and satellite precipitation estimation techniques. **1.1.3:** Techniques developed for using radar and satellite rainfall estimates for determining precipitation amounts. **1.1.4:** Institutional and human capacity developed to analyse data received from mobile and deployable radar systems to determine the structure of storms and their potential to cause extreme weather events. **1.1.5:** An appropriate mobile and deployable radar system identified and purchased for tracking extreme weather events. **1.1.6:** Hazard maps developed for informing positioning of radar systems.
Component 2: Real-time monitoring of extreme weather established for effective early warning	**2.1:** A planning and communication framework established for a mobile and deployable radar system.	**2.1.1:** A report/manual drafted describing the procedures for operating and maintaining the purchased radar system. **2.1.2:** Communication channels established for effective communication between DMH and ground teams operating mobile and deployable radar systems.
Component 3: Extreme weather warnings dissemination and communication to end-users	**3.1:** Improved delivery of early warnings, i.e. warnings more effective, efficient and targeted.	**3.1.1:** Appropriate and effective channels established for the communication of relevant climate information.

Agencies involved: Executing Agency: Department of Meteorology and Hydrology (DMH).

Baseline information: The DMH is the main authority responsible for meteorological, hydrological and seismological related data collection, analysis and archiving. They are also responsible for early warnings and weather related bulletin dissemination. The main objectives of the DMH include:

- to exchange information with other meteorological centres;
- to safeguard lives and properties by issuing early warnings and bulletins for all natural hazards;

- to expand public awareness and education programmes on natural hazards and environmental issues;
- to monitor climate change, water resources, air and water quality;
- to assist all government organizations, NGOs and stakeholders by providing weather, hydrological and seismological information; and
- to effectively assist all national projects through World Meteorological Organisation (WMO) and international/ regional/ bilateral cooperation.

In order to achieve the above, the DMH has 161 manual meteorological observation stations. These stations are not evenly distributed across the country as locations are chosen based on ease of access and other logistical requirements as opposed to technical requirements. As a result, the station network is more concentrated in accessible plain areas than in remote mountainous areas.

Climate Change Adaptation Rationale: Changes in Myanmar's climate system will result in more frequent extreme weather events and an increased likelihood of temperature extremes, heat waves, and heavy precipitation events. The importance of early warning systems to warn local communities of such extreme weather events is therefore increasingly important and urgent. While precipitation measurements can be achieved by means of rain gauges, there are disadvantages of point measurements (e.g. *inter alia* spatial coverage), which are driving meteorologists towards using remote sensing methods. More sophisticated nowcasting technology such as radar systems (in combination with satellite-based estimates) have the potential to provide accurate precipitation estimations in data sparse regions of Myanmar. With an increased likelihood of future climate extremes in Myanmar, radar systems will be able to play an increasingly important role in safeguarding lives and property.

Second Priority Project: Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.

Project Objective: To improve early warning for hydrological flooding events through increased observation and monitoring capacity in combination with community based methods.

Project Area/Location: Ayeyarwady Region

Beneficiaries: Department of Meteorology and Hydrology and local communities

Period: 2 years

Estimated Budget: US$ 1 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building for meteorological and hydrological assessment	**1.1:** Capacity of hydrometeorological services for flood warning and forecasting strengthened.	**1.1.1:** Appropriate sensor equipment (e.g. automatic weather stations) installed. **1.1.2:** Information communication technology installed for sensor data transmission, filtering and analysis as well as middleware for connecting sensor data. **1.1.3:** Computational models and simulation of possible flood dynamics conducted to develop and optimize evacuation strategies. **1.1.4:** Technologies such as 'advanced interactive visualisation' investigated as a method to better communicate risks to user agencies and communities. **1.1.5:** Relevant departments trained on operation and technical maintenance of sensor systems as well as usage of relevant computational and statistical models and simulation techniques.
Component 2: Flood information dissemination and communication to	**2.1:** Improved delivery of flood information and early warnings, i.e. warnings more	**2.1.1:** Early warning and decision support systems developed and disseminated. **2.1.2:** A decision support system developed and disseminated to assist public authorities and citizens

end-users	effective, efficient and targeted.	in choosing flood protection tactics and in managing emergencies.
Component 3: Community-based early warning pilot projects	**3.1:** Community response to flood warnings improved.	**3.1.1:** Community teams at pilot sites established and trained. **3.1.2:** Flood preparedness and response plans developed and practiced. **3.1.3:** Awareness campaign conducted.

Agencies involved: Executing Agency: The Department of Meteorology and Hydrology; Partner/Cooperating agencies: Local Authorities, Local Communities, Department of Irrigation, Water Research Utilization Department, Department of Agriculture, Relief and Resettlement Department and NGOs.

Baseline information: Flood forecasting and warning is the responsibility of the Department of Meteorology and Hydrology. The flood forecasting and warning system covers eight major river basins in the country. Daily river surface levels are issued for ~30 manual stations along eight major rivers in Myanmar.

Climate Change Adaptation Rationale: Flood forecasting and early warning systems contribute to climate change adaptation by improving the capacity of communities to prepare for and respond to flooding events, thereby safeguarding lives, infrastructure and livelihoods. Climate change scenarios predict that over the next 5 decades, Myanmar will experience an increase in the occurrence and intensity of flooding events. Implementing effective flood early warning systems will provide user agencies/communities with sufficient lead time to: i) minimise risk to life; ii) evacuate vulnerable groups; iii) move assets (e.g. food, livestock and personal items) to safer locations; iv) effectively use existing flood control/rerouting structures (e.g. dam management, temporary flood defences) to prevent inundation of property and land; and v) install flood resilience measures (e.g. sandbags).

Third Priority Project: Assessing the hydrological impact of climate change on river systems.

Project Objective: To assess the impact of climate change on the Ayeyarwaddy River flow with a focus on flooding extent.

Project Area/Location: Ayeyarwady River

Beneficiaries: The Department of Meteorology and Hydrology, postgraduate students at local universities, agencies and line departments related to water utilization and flood EWSs in Myanmar

Period: 2 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Capacity building for hydrological and climate change modelling	**1.1:** Probabilistic projections of future flood zones as well as the state of future water resources generated.	**1.1.1:** A climate change research group established at the DMH or a nearby university to facilitate proposed research regarding climate change impacts on water resources and flooding extent. **1.1.2:** An international scientist/expert contracted to supervise research conducted. **1.1.3:** Post-graduate research designed and conducted for assessing the impact of climate change on the Ayeyarwady River flow (looking at sub-catchments and the entire basin) with a focus on flooding extent using hydrological and climate change models.
Component 2: Climate change integrated into	**2.1:** Flood management plans developed including	**2.1.1:** Results from studies conducted in Component 1 used to identify required actions for flood and drought management based on economic costs and

flood management plans	climate change adaptations.	existing uncertainties in climate change scenarios. **2.1.2:** Sub-catchment information (e.g. landuse, vegetation types) integrated into flood early warning systems by combining meteorological information (quantitative rainfall estimation from rainfall gauges) with hydrological modelling of soil moisture conditions to determine flooding potential. **2.1.3:** A flood management plan with actions for adaptation to climate change drafted, including a proposed plan for flood early warning systems. **2.1.4:** Proposed changes to policy recommended to promote the importance of undertaking adaptive measures for responding to climate change impacts in combination with ongoing flood management activities.
Component 3: Mainstreaming project results for effective flood management	**3.1:** Flood management adapted to incorporate adaptive measures with on-going activities.	**3.1.1:** A report generated and made available to appropriate government departments focused on water management and early warning systems. **3.1.2:** Results from post-graduate studies published in the peer-reviewed literature.

Agencies Involved: Executing Agencies: The Department of Meteorology and Hydrology; Partner/Cooperating agencies: The Irrigation Department, Ministry of Agriculture and Irrigation and an appropriate local university.

Baseline information: The last study published in Myanmar, which focused on analysing and reporting rainfall-runoff relationships for the country, was in April 1983. To date, the effects of climate change on the hydrological cycle of the Ayeyarwady River have not been modelled and therefore adaptive measures cannot be integrated into on-going management activities.

Climate Change Adaptation Rationale: Climate change will significantly affect the hydrological systems of major rivers in Myanmar. This in turn will affect water availability, runoff, river flow and flooding extent. Modelling the effects of climate change on water regimes at basin and sub-catchment levels will highlight actions required for responding to climate change conditions. Furthermore, information collected at a sub-catchment scale can be combined with meteorological information (for example, quantitative rainfall estimations, water level gauges and hydrological modelling) to determine the potential flooding risks during intense rain or storm events. The hydrological information collected and modelled in this project will assist with planning for water-related threats, implementing water resources development and early warning system design.

Fourth Priority Project: Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.

Project Objective: To develop and implement an integrated approach to drought monitoring, management, early warning, forecasting and response mechanisms.

Project Area/Location: Central Dry Zone

Beneficiaries: The Department of Meteorology and Hydrology and local communities

Period: 4 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Drought information,	**1.1:** Capacity of hydrometeorological services and networks	**1.1.1:** DMH's Agro-meteorological Division trained for effective drought monitoring and seasonal forecasting techniques.

monitoring and early warning systems	strengthened for drought monitoring.	**1.1.2:** Appropriate partnerships formed with scientific institutes and Global Producing Centres for sharing seasonal forecasts. **1.1.3:** Appropriate sensor equipment installed. **1.1.4:** Information communication technology for sensor data transmission, filtering and analysis as well as middleware for connecting sensor data installed. **1.1.5:** Technologies and support systems developed for communicating risks to user agencies and communities. **1.1.6:** Relevant departments trained on operation and technical maintenance of sensor systems as well as usage of relevant computational and statistical models and simulation techniques.
Component 2: Drought information dissemination and communication to end-users	**2.1:** Improved delivery of drought information including early warnings, i.e. warnings more effective, efficient and targeted.	**2.1.1:** Early warning and decision support systems developed and disseminated. **2.1.2:** A decision support system implemented to assist public authorities and local communities in interpreting and applying seasonal forecasts/drought early warning systems.
Component 3: Community based early warning pilot projects	**3.1:** Community planning and response to drought events improved.	**3.1.1:** Community teams at pilot sites established and trained. **3.1.2:** Drought preparedness and response plans developed and practiced. **3.1.3:** Awareness campaign conducted on methods for preparing and responding to drought events.

Agencies involved: Executing Agency: The Department of Meteorology and Hydrology; Partner/Cooperating agencies: Local authorities, local communities, Department of Irrigation, Water Research Utilization Department, Department of Agriculture, Relief and Resettlement Department and NGOs.

Baseline information: The Department of Meteorology and Hydrology (DMH) is responsible for providing effective early warnings for extreme weather events to a range of user agencies and local communities. Although not sophisticated, the DMH does have national systems for monitoring and issuing early warnings for cyclones, storm surges, flooding events, strong winds and intense rain. There is, however, currently no systematic drought monitoring or early warning system in place.

Climate Change Adaptation Rationale: A good historical record of point measurements provides the data for effective statistical analyses of climate mean values, trends and variations. Denser observation networks (point measurements) result in better information available for assessing and understanding current and future climate conditions of a country. The DMH only has 161 manual meteorological observation stations. These stations are not evenly distributed across the country, and locations are chosen based on ease of access and other logistical requirements as opposed to technical requirements. In order to adequately prepare for climate change impacts, including an increase in the occurrence and intensity of drought events, a greater number of point measurements are needed in certain areas at risk. Furthermore, increasing the capacity of the DMH to prepare seasonal forecasts can increase preparedness for climate change impacts and lead to better social, economic and environmental outcomes. Forming partnerships with Global Producing Centres for seasonal forecasting can reduce the high costs associated with drought monitoring and early warning.

Forest: Priority Adaptation Project Profiles

First Priority Project: Building the resilience of degraded/sensitive forest areas to climate change impacts through reforestation.

Project objective: To restore degraded areas in Myanmar's Dry, Hilly and Coastal Zones using climate-resilient species and technologies for increasing ecosystem goods/services under a changing climate.

Project Area/Location: i) Minbu, Magway and Nyaung-Oo Townships in the Central Dry Zone; ii) Nyaung Shwe, Kalaw and Pindaya Townships in the Hilly Zone; and iii) Labutta, Bogalay and Pyabon Townships in the Ayeyarwady Delta

Beneficiaries: i) Local communities in the project area, ii) Forest Department, iii) Dry Zone Greening Department; iv) Myanmar Agriculture Services, and v) NGOs (Ecosystem Conservation and Community Development Initiative (ECCDI), Forest Resource Environment Development and Conservation Association (FREDA), Biodiversity and Nature Conservation Association (BANCA), Economically Progressive Ecosystem Development (ECODEV))

Period: 5 years

Estimated Budget: US$ 3.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for climate-resilient restoration guidelines	**1.1:** Technical expertise developed on forest restoration approaches that build climate resilience and enhance ecosystem goods/services.	**1.1.1:** Forest User Groups/Community Based Organisations as well as other participants identified for implementing community forestry and social forestry programmes in proposed project sites. **1.1.2:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.3:** The response of degraded/sensitive forest areas to climate change impacts analysed. **1.1.4:** Climate-resilient, multi-use and appropriate tree species identified for planting. **1.1.5:** Appropriate short-rotation coppicing species identified for fuelwood and other agroforestry purposes. **1.1.6:** Reforestation techniques and forest restoration guidelines developed.
Component 2: Climate-resilient reforestation implementation	**2.1:** Forests and agro-forestry areas restored in the Ayeyarwady Delta as well as Watersheds of Inle Lake and Dry Zone areas that supply a diverse range of food and ecosystem services (e.g. erosion control, water flow regulation, Non-Forest Timber Products, carbon storage, timber) despite climate change impacts.	**2.1.1:** Forest restoration guidelines (including community nurseries) implemented for enhancing the supply of ecosystems services in the face of climate change. **2.1.2:** A series of hands-on training sessions, seminars and workshops conducted with relevant stakeholders. **2.1.3:** Training for Forest User Groups conducted including: i) nursery management; ii) planting; iii) climate-resilient and multi-use tree species; and iv) maintaining restored areas under climate change impacts. **2.1.4:** Local communities trained on diversifying income and employment opportunities through sustainable alternative livelihood. **2.1.5:** Appropriate alternative livelihoods identified for local communities including forest-based options. **2.1.6:** Forest-based employment created/piloted to increase/diversify income streams of local

		Communities.
Component 3: Scaling up climate-resilient reforestation activities	**3.1:** The importance of intact and climate-resilient ecosystems mainstreamed into Myanmar's forestry management framework and relevant policies/projects.	**3.1.1:** Wide ranging extension activities launched across degraded/sensitive areas of the country. **3.1.2:** Lessons learned on forest restoration to build climate resilience captured, disseminated and used to develop an upscaling strategy. **3.1.3:** Policy briefs generated that focus on the benefits of the project for increasing the climate resilience of livelihoods as well as relevant economic sectors.

Agencies Involved: Executing Agency: Forest Department, Ministry of Environmental Conservation and Forestry; Partner/Cooperating agencies: Dry Zone Greening Department, Planning and Statistics Department (MoECAF), line Ministries, NGOs (FREDA, BANCA) and local communities.

Baseline information: This project will complement the National Biodiversity Strategy and Action Plan, in which reforestation and forest conservation is one of the main foci. It will also build on the on-going restoration activities of the Department of Forestry (particularly activities based on the Community Forest Instruction (CFI)) as well as various donor agency projects in the region (see Table below).

On-going projects/activities	Budget (US$)	Duration	Implementing Agency	Executing Agency
Mitigating climate change impacts through restoration of degraded forests and REDD+ activities in Bago Yoma Region, Myanmar.	$ 100,000	2011-2012	Korea Forest Service	Forest Department
Capacity building for developing REDD+ activities in the context of sustainable forest management.	$ 571,890	2012-2015	International tropical timber organization (ITTO)	Forest Department
Rehabilitation of Dry Zone (Phase I to III).	-	2000-2010	KOICA	Dry Zone Greening Department
Kabani Community Forestry Project.	$ 81,849	2008-2013	JIFPRO	Forest Department
Integrated mangrove rehabilitation and management through community participation in the Ayeyarwady Delta, Myanmar.	$ 2 million	2007-2013	JICA	Forest Department
ASEAN-Korea Environmental Cooperation Project.	$ 60,000	2003-2012	Republic of Korea	Forest Department
Inle Lake Conservation and Rehabilitation Programme.	$ 2.6 million	2012-2013	UNDP	Forest Department

Climate Change Adaptation Rationale: Rivers and their valleys/basins are vulnerable to climate change related impacts, such as heavy rainfall, flash floods and droughts. Climate-resilient forests will reduce risks associated with these changing climatic conditions. The restored forests will be resilient to climate change impacts while enhancing ecosystem services such as: i) increased food supply; ii) soil stabilisation/erosion control (including decreased dam siltation); iii) soil fertility; iv) maintained/increased water quality; v) carbon sequestration; vi) maintained/increased water supply; vii) increased river flow for irrigation; and viii) increased hydro-electric power generation. An important component of the restored forests is that they will have a lower water demand compared with conventional planting and reforestation projects, and therefore will reduce water scarcity under climate change conditions. Furthermore, restoring ecosystems using a climate-resilient approach will reduce the impacts of climate change on vulnerable communities through providing alternative sources of income and a range of ecosystem services/goods. The presence of climate-resilient forests will play an important role in stabilizing degraded areas and the communities within them through providing a buffer against climate extremes.

Second Priority Project: Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.

Project objective: To restore degraded watershed areas in Myanmar's Central Dry Zone using climate-resilient species and technologies for increasing ecosystem goods/services under a changing climate.

Project Area/Location: i) Pakokku, Minbu and Magway Townships in the Magway Region; ii) Kyaukpadaung and Nyaung-Oo Townships in the Mandalay Region; iii) Sagaing and Monywa Townships in the Sagaing Region

Beneficiaries: i) Local communities in the project area, ii) Forest Department, Dry Zone Greening Department; iii) Myanmar Agriculture Services, and iv) NGOs (ECCDI, FREDA, BANCA, ECODEV, SPECTRUM)

Period: 3 years

Estimated Budget: US$ 2.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for climate-resilient restoration guidelines	**1.1:** Technical expertise developed on forest restoration approaches for Dry Zone areas that build climate resilience.	**1.1.1:** Forest User Groups/Community Based Organisations as well as other participants identified for implementing community forestry and social forestry programmes in proposed project sites. **1.1.2:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.3:** The response of Dry Zone watershed forests to climate change analysed. **1.1.4:** Climate-resilient, multi-use and appropriate tree species identified for planting. **1.1.5:** Appropriate short-rotation coppicing species identified for fuelwood and agroforestry purposes. **1.1.6:** Tailor-made reforestation techniques and forest restoration guidelines developed for watersheds in the Central Dry Zone.
Component 2: Climate-resilient reforestation implementation in watershed areas of the Central Dry Zone	**2.1:** Restored forests and agro-forestry areas, in the Central Dry Zone Watersheds, that supply a diverse range of food and ecosystem services (e.g. erosion control, water flow regulation, Non-Forest Timber Products, carbon storage, timber) despite climate change impacts.	**2.1.1:** Forest restoration guidelines (including community nurseries) implemented for enhancing the supply of ecosystems goods/services in the face of climate change. **2.1.2:** A series of hands-on training, seminars and workshops conducted with relevant stakeholders. **2.1.3:** Training for Forest User Groups conducted, including: i) nursery management; ii) tree planting; iii) climate-resilient and multi-use tree species; and iv) maintaining restored areas under climate change conditions. **2.1.4:** Local communities trained on diversifying income streams through sustainable alternative livelihoods. **2.1.5:** Appropriate alternative livelihoods identified for local communities including forest-based options. **2.1.6:** Forest-based employment created/piloted to increase/diversify income streams of local communities.
Component 3: Upscaling climate-resilient reforestation activities	**3.1:** The importance of intact and climate-resilient ecosystems mainstreamed into Myanmar's forestry	**3.1.1:** Wide ranging extension activities launched across vulnerable areas of the country. **3.1.2:** Lessons learned on forest restoration to build climate resilience captured, disseminated and used to develop an upscaling strategy.

	management framework and relevant policies/projects.	**3.1.3:** Policy briefs generated that focus on the benefits of the project for increasing the climate resilience of livelihoods as well as relevant economic sectors.

Agencies Involved Executing agency: Forest Department, Dry Zone Greening Department; Partner/Cooperating agencies: Planning and Statistics Department (MOECAF), Ministry of Agriculture and Irrigation, NGOs (FREDA, BANCA) and local communities.

Baseline Information: This project will complement the National Biodiversity Strategy and Action Plan, in which reforestation and forest conservation is one of the main foci. It will also build on the on-going restoration activities of the Department of Forestry (particularly activities based on the Community Forest Instruction (CFI)) as well as various Donor Agency projects in the region (see Table below).

On-going projects/activities	Budget (US$)	Duration	Funding Agency	Executing Agency
Capacity building for developing REDD+ activities in the context of sustainable forest management.	$ 571,890	2012-2015	International tropical timber organization (ITTO)	Forest Department
Rehabilitation of Dry Zone (Phase I to III).	-	2000-2010	KOICA	Dry Zone Greening Department
Kabani Community Forestry Project.	$ 81,849	2008-2013	JIFPRO	Forest Department
ASEAN-Korea Environmental Cooperation Project.	$ 60,000	2003-2012	Republic of Korea	Forest Department

Climate Change Adaptation Rationale: The Central Dry Zone is one of the most climate sensitive and natural resource poor regions in Myanmar. The region, already characterized by low annual rainfall (> 508 mm per annum), is currently undergoing further decreases in rainfall as a result of climate variability. These decreases will be further exacerbated by future climate change. Climate-resilient forests will reduce the risks associated with changing climatic conditions in the degraded watershed areas of the Central Dry Zone. This is because they will be highly resilient to climate change while enhancing/maintaining a range of ecosystem services such as: i) food supply; ii) soil stabilisation/erosion control (decreased dam siltation); iii) soil fertility; iv) water quality; v) carbon sequestration; vi) water supply; and vii) river flow (for irrigation and hydro-electric power generation). An important component of the restored forests is that they have a reduced water demand compared with conventional planting and reforestation projects, and therefore will increase water supply under climate change conditions. Furthermore, restoring ecosystems using a climate-resilient approach will reduce the impacts of climate change on vulnerable communities by providing alternative sources of income and a wide range of ecosystem goods/services. The presence of forests will play an important role in stabilizing degraded areas and building the climate-resilience of communities within in them through providing a buffer against climate extremes.

Third Priority Project: Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.

Project objective: To restore degraded mangrove forests in Myanmar's Coastal Regions for increasing ecosystem goods/services as well as buffering local communities and ecosystems in the face of climate change.

Project Area/Location: i) Yanbye, Myebon and Minbya Townships in the Rakhine State; ii) Bokepyin and Beik Townships in the Tanintharyi Region; iii) Laputta, Bogalay and Pyabon Townships in the Ayeyarwady Region

Beneficiaries: i) Local communities in the project area, ii) Forest Department, iii) Myanmar Agricultural Services, and iv) Department of Fisheries; and v) NGOs (ECCDI, FREDA, BANCA, ECODEV, SPECTRUM)

Period: 3 years

Estimated Budget: US$ 2.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for climate-resilient mangrove restoration guidelines	**1.1:** Technical expertise developed on mangrove (and other coastal) forest restoration approaches that build climate resilience.	**1.1.1:** Mangrove User Groups/Community Based Organisations as well as other participants identified for implementing community forestry and social mangrove programmes in proposed project sites **1.1.2:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.3:** The response of local mangrove ecosystems (including other coastal forests) to climate change impacts analysed, including sea-level rise, extreme weather events and changes in precipitation. **1.1.4:** Climate-resilient, multi-use and appropriate mangrove species (as well as other coastal species) identified for planting. **1.1.5:** Tailor-made reforestation techniques and restoration guidelines developed for coastal mangrove and forest areas.
Component 2: Climate-resilient reforestation implementation in coastal mangrove areas	**2.1:** Restored mangrove forests, in vulnerable coastal areas, that supply a diverse range of food and ecosystem services (e.g. fuelwood, protection against climate extremes, food, timber, medicine) despite climate change impacts.	**2.1.1:** Mangrove forest restoration guidelines (including community nurseries) implemented for enhancing the supply of ecosystems goods/services in the face of climate change. **2.1.2:** A series of hands-on training, seminars and workshops conducted with relevant stakeholders. **2.1.3:** Training for Mangrove User Groups including: i) nursery management; ii) tree planting; iii) climate-resilient and multi-use mangrove species; and iv) maintaining restored areas under climate change conditions. **2.1.4:** Local communities trained on diversifying income streams through sustainable alternative livelihoods. **2.1.5:** Appropriate alternative livelihoods identified for local communities including forest-based options. **2.1.6:** Forest-based employment created/piloted to increase/diversify income streams of local communities.
Component 3: Scaling up climate-resilient mangrove forest restoration activities	**3.1:** The importance of intact and climate-resilient ecosystems mainstreamed into Myanmar's forestry and coastal management frameworks and relevant policies/projects.	**3.1.1:** Wide ranging extension activities launched across vulnerable areas of the country. **3.1.2:** Lessons learned on mangrove forest restoration to build climate resilience captured, disseminated and used to develop an upscaling strategy. **3.1.3:** Policy briefs generated that focus on the benefits of the project for increasing the climate resilience of livelihoods as well as relevant economic sectors.

Agencies Involved: Executing agency: Forest Department; Partner/Cooperating agencies: Planning and Statistics Department (MOECAF), Ministry of Agriculture and Irrigation, Ministry of Livestock Breeding, line Ministries, NGOs (FREDA, BANCA, ECODEV, ECCDI) and local communities.

Baseline Information: This project will complement the National Biodiversity Strategy and Action Plan, in which reforestation and forest conservation is one of the main foci. It will also build on the on-going restoration activities of the Department of Forestry (particularly activities based on the Community Forest Instruction (CFI)) as well as various Donor Agency projects in the region (see Table below).

On-going projects/activities	Budget (US$)	Duration	Funding Agency	Executing Agency
Capacity building for developing REDD+ activities in the context of sustainable forest management.	$ 571,890	2012-2015	International tropical timber organization (ITTO)	Forest Department
Kabani Community Forestry Project.	$ 81,849	2008-2013	JIFPRO	Forest Department
Integrated mangrove rehabilitation and management through community participation in the Ayeyawady Delta, Myanmar.	$ 2 million	2007-2013	JICA	Forest Department
ASEAN-Korea Environmental Cooperation Project.	$ 60,000	2003-2012	Republic of Korea	Forest Department

Climate Change Adaptation Rationale: A number of global studies carried out after coastal disasters have documented the important role that coastal ecosystems play in coastal protection against extreme weather events[108]. Protection by vegetation depends upon the stand size, density, species composition and structure. Degraded ecosystems are less likely to function as buffers[109]. Mangrove forest areas along the Rakhine and Ayeyarwady coastal areas of Myanmar are severely degraded as a result of overexploitation and inappropriate agricultural practices, further exacerbated by the effects of climate extremes such as cyclones and flooding. The tropical cyclone 'Nargis' (2008) severely hit the lower parts of Myanmar, mainly Yangon and the Ayeyarwady Region, claiming many lives and causing damage to infrastructure, villages and remaining mangrove forests. Furthermore, tropical cyclones including 'Mala', 'Giri' and '02B' have also resulted in damages to livelihoods, property and mangroves. The loss of mangroves has severely reduced the flood regulation functions to protect local communities from climate extremes. Therefore, there is an urgent need to restore mangrove ecosystems, particularly in the face of increased intensities and frequencies of extreme weather events resulting from climate change.

Fourth Priority Project: Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.

Project Objective: To restore the degraded Indawgyi and Inle watershed areas using climate-resilient species and technologies for increasing ecosystem goods/services, while buffering local communities and ecosystems under a changing climate.

Project Area/Location: i), Moe Hnyin Township, Myitkyina District, Kachin State (Indawgyi Lake); ii) Nyaung Shwe Township, Taunggyi District, Shan State (South, Inle Lake)

Beneficiaries: i) Local communities in the project areas, ii) Forest Department, iii) Myanmar Agriculture Services, iv) Department of Fisheries, v) Water Resources Department; vi) NGOs (ECCDI, FREDA, BANCA, ECODEV, SPECTRUM)

Period: 3 years

Estimated Budget: US$ 2.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for climate-resilient restoration guidelines	**1.1:** Technical expertise developed on forest restoration approaches that build climate resilience.	**1.1.1:** Forest User Groups/Community Based Organisations as well as other participants identified for implementing forestry and social forestry programmes in proposed project sites. **1.1.2:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.3:** The response of watershed forest areas in Myanmar to climate change analysed.

[108] Danielson et al 2005; UNEP WCMC 2006; Granek and Ruttenberg 2007; Olwig et al 2007; Francisco 2008; Mattsson et al 2009.

[109] Cochard et al 2008; Koch et al 2008; Tanaka 2009;Alongi 2008; Cochard et al 2008; Koch et al 2008; Tanaka 2009;Alongi 2008

		1.1.4: Climate-resilient, multi-use and appropriate tree species identified for planting. **1.1.5:** Appropriate short-rotation coppicing species identified for fuelwood and agroforestry purposes. **1.1.6:** Reforestation techniques and forest restoration guidelines developed.
Component 2: Climate-resilient reforestation implementation	**2.1:** Restored forests and agro-forestry areas, in the Watersheds of Indawgyi and Inle Lake, that supply a diverse range of food and ecosystem services (e.g. erosion control, water flow regulation, Non-Forest Timber Products, carbon storage, timber) despite climate change impacts.	**2.1.1:** Forest restoration guidelines (including community nurseries) implemented for enhancing the supply of ecosystems services in the face of climate change. **2.1.2:** A series of hands-on training sessions, seminars and workshops conducted with relevant stakeholders. **2.1.3:** Training for Forest UGs including: i) nursery management; ii) tree planting; iii) climate-resilient and multi-use tree species; and iv) maintaining restored areas under climate change conditions. **2.1.4:** Local communities trained on diversifying income streams through sustainable alternative livelihoods. **2.1.5:** Appropriate alternative livelihoods identified for local communities including forest-based options. **2.1.6:** Forest-based employment created/piloted to increase/diversify income streams of local communities.
Component 3: Upscaling climate-resilient reforestation activities	**3.1:** The importance of intact and climate-resilient ecosystems mainstreamed into Myanmar's forestry management framework and relevant policies/projects.	**3.1.1:** Wide ranging extension activities launched across vulnerable areas of the country. **3.1.2:** Lessons learned on forest restoration to build climate resilience captured, disseminated and used to develop an upscaling strategy. **3.1.3:** Policy briefs generated that focus on the benefits of the project for increasing the climate resilience of livelihoods as well as relevant economic sectors.

Agencies Involved: Executing Agency: Forest Department; Partner/Cooperating agencies: Planning and Statistics Department (MOECAF), Ministry of Agriculture and Irrigation, Ministry of Livestock Breeding, line Ministries, NGOs (FREDA, BANCA, ECODEV, ECCDI) and local communities

Baseline information: This project will complement the National Biodiversity Strategy and Action Plan, in which reforestation and forest conservation is one of the main foci. It will also build on the on-going restoration activities of the Department of Forestry (particularly activities based on the Community Forest Instruction (CFI)) as well as various Donor Agency projects in the region (see Table below).

On-going projects/activities	Budget (USD)	Duration	Funding Agency	Executing Agency
Capacity building for developing REDD+ activities in the context of sustainable forest management	571,890	2012-2015	International tropical timber organization (ITTO)	Forest Department
Kabani Community Forestry Project	81,849	2008-2013	JIFPRO	Forest Department
ASEAN-Korea Environmental Cooperation Project	~60,000 and Post-graduate Scholarship	2003-2012	Republic of Korea	Forest Department
Inle Lake Conservation and Rehabilitation Programme	2.6 million	2012-2013	UNDP	Forest Department

Climate Change Adaptation Rationale: Myanmar is already prone to a range of extreme weather events (including droughts, cyclones and flooding). Upland areas already degraded as a result of shifting cultivation and unsustainable land use practices are particularly vulnerable to drought conditions. The Upland Watershed areas of Indawgyi and Inle Lakes are the biggest inland lakes in

Myanmar and support a range of activities and socio-economic sectors including rural livelihoods; cultural (these watersheds are ASEAN Heritage sites); energy (particularly hydro-power); agriculture; water resources; fisheries; biodiversity; tourism and industry. In 2010, as a result of extreme high temperatures coupled with prolonged drought, water volume within the two lakes decreased, causing a drop in the flow of the Ayeyarwady River. Thousands of local people (mostly ethnic groups within the areas) suffered a shortage of drinking water and resulting health impacts. Currently these watershed areas are severely degraded, and climate change impacts are likely to exacerbate climate extremes such as high temperatures and prolonged drought periods. Climate-resilient forests will reduce risks associated with changing climatic conditions in the degraded watershed areas. This is because they will be resilient to climate change while enhancing/maintaining a range of ecosystem services such as: i) food supply; ii) soil stabilisation/erosion control (decreased dam siltation); iii) soil fertility; iv) water quality; v) carbon sequestration; vi) water supply; and vii) river flow (for irrigation and hydro-electric power generation). An important component of the restored forests is that they have a reduced water demand compared with conventional planting and reforestation projects, and therefore will increase water supply under climate change conditions. Furthermore, restoring ecosystems using a climate-resilient approach will reduce the impacts of climate change on vulnerable communities by providing alternative sources of income and a wide range of ecosystem goods/services. The presence of forests will play an important role in stabilizing degraded areas and building the climate-resilience of communities within in them through providing a buffer against climate extremes.

Public Health: Priority Adaptation Project Profiles

First Priority Project: Adaptation to climate change through climate-resilient health facilities in the Rakhine State and Ayeyarwady Region.

Project Objective: Ensure health facilities are resilient to climate extremes to prevent damages and resulting high repair costs in the Rakhine State and Ayeyarwady Region.

Project Area/Location: Health facilities and vulnerable areas in Rakhine State and Ayeyarwady Region.

Beneficiaries: Local communities, health workers and patients.

Period: 2 years

Estimated Budget: (US$ 200 000 per health centre)

Project's Main Components, Outcomes and Outputs

Main Components	Main Outcomes	Main Outputs
Component 1: Quality control for rebuilding and repairing health facilities in the Rakhine State and Ayeyarwady Region.	**1.1:** Standards and guidelines developed for engineering and non-engineering climate proofing options.	**1.1.1:** Review of international best practice for climate-resilient infrastructure. **1.1.2:** Climate-proofing options identified for health facilities in the Rakhine and Ayeyarwady areas, including engineering (subsurface conditions, material specifications, cross section and standard dimensions, drainage and erosion, and protective engineering structures) and non-engineering (maintenance, planning and early warning, knowledge products development and dissemination, capacity development and environmental management) options. **1.1.3:** Climate-resilient health facility construction, repairing and rebuilding guideline and specification document developed for practitioners and planners. **1.1.4:** Survey of the effectiveness of existing rebuilding, repairing and construction activities in the region/state conducted.
Component 2: Construction of climate-resilient health facility/facilities in disaster prone areas.	**2.1:** Climate-resilient health facility/ies constructed in the Rakhine State and Ayeyarwady Region.	**2.1.1:** Climate and socio-economic surveys and assessments conducted in order to establish areas most vulnerable as well as the number of health facilities needed. **2.1.2:** Best practise climate-resilient health facility/ies constructed using appropriate engineering climate-proofing options.
Component 3: Capacity building for health workers, construction practitioners/planners and local communities.	**3.1:** Health workers trained on non-engineering climate proofing options.	**3.1.1:** A training course conducted focussed on non-engineering climate proofing options, i.e. maintenance, planning and early warning, and knowledge products development and dissemination.
	3.2: Awareness increased of the benefits of climate-resilient health facilities for local communities.	**3.2.1:** An awareness campaign conducted in disaster prone areas on the role of health facilities during climate extremes and the benefits of climate-resilient health facilities for local communities.
	3.3: Existing re-building, repairing and construction activities adapted.	**3.3.1:** A training workshop conducted for transferring appropriate climate proofing options to practitioners and planners.

Agencies Involved: Executing Agency: Department of Health, Ministry of Health; Partner/Cooperating Agencies: Myanmar Engineering Society, Ministry of Construction and Ministry of Housing.

Baseline Information: In 2008, Cyclone Nargis struck the Ayeyarwady Region resulting in damages to health facilities in the area. Damages included: i) 20% of health facilities completely destroyed; and ii) 66% of health facilities in need of some level of repair. The resulting costs for repairing and/or rebuilding facilities without climate-proofing options have been estimated at US$ 2 billion. Two years later Cyclone Giri caused additional damage and expense. At present, there are numerous repairing and rebuilding activities being conducted in the Ayeyarwady Region. However, there are no guidelines/specifications for climate-proofing options to ensure that appropriate methods are being used. Furthermore, the particular climate change risk for an area has not been considered when designing rebuilding/repairing plans. Quality control is urgently needed in these areas to ensure that current construction activities will result in health facilities that are resilient to the predicted increases in frequency and intensity of extreme weather events. There are very few health facilities in the Rakhine State in comparison to the Ayeyarwady Region. Therefore, if there are only funds available for one best practice climate-resilient health facility, this should be constructed in the Rakhine State.

Climate Change Adaptation Rationale: Over the last six decades, Myanmar has experienced an increase in the occurrence and severity of extreme weather events, including cyclones/strong winds, flood, storm surges and intense rains. Examples include the two recent cyclones, Nargis and Giri. The increase in occurrence and severity of extreme weather events will be exacerbated by climate change, with cyclones, flooding as well as other climate extremes occurring more frequently and at greater intensities. At present, the coastal areas of Rakhine State and Ayeyarwady Region encounter storms and tropical cyclones every year. In order to adapt to future increases in extreme weather events in these areas, climate-proofing options for existing and planned health facilities are needed. Climate-resilient health facilities will protect the life of patients and health workers during climate disasters, as well as ensure that health services are sustained during and after disaster periods.

Second Priority Project: Integrating climate change adaptation strategies into the prevention of heat-related disorders in agricultural and industrial workers.

Project Objective: To protect agricultural and industrial workers from morbidity and mortality as a result of heat-related disorders through promoting appropriate behaviour changes.

Project Area/Location: Mandalay, Magway and Sagaing Regions.

Beneficiaries: Agricultural and industrial workers in high-risk areas.

Period: 2 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs

Main Components	Main Outcomes	Main Outputs
Component 1: Research and planning for Behaviour Change Communication (BCC) strategies.	**1.1:** BCC strategies developed to promote desirable behaviour for reducing heat-related disorders in agriculture and industrial workers/owners/managers.	**1.1.1:** Agricultural and industrial workers, managers and owners surveyed and assessed on: i) vulnerability to heat-related disorders; ii) conflict and obstacles to desired change in behaviour; iii) message and communication media most appropriate; iv) resources available; and v) existing knowledge. **1.1.2:** Knowledge content and behaviour/attitude patterns of agricultural and industrial workers, managers and owners analysed and used to design/develop an appropriate BCC for implementation. **1.1.3:** Information, education and communication (IEC) materials developed for implementation.

Component 2: Behaviour Change Communication (BCC) interventions for agricultural and industrial workers in high-risk areas.	**2.1:** Desirable change in behaviour obtained to reduce heat-related disorders in agriculture and industrial workers/owners/managers.	**2.1.1:** An enabling environment using information (IEC materials including pamphlets, posters and guidelines) and communication (teaching) created for agriculture and industrial and workers, owners and managers. **2.1.2:** Appropriate media (e.g. Health talk and TV Spot) used for disseminating BCC information.

Agencies Involved: Executing Agency: Department of Health, Ministry of Health; Partner/Cooperating Agencies: Ministry of Industry and Ministry of Agriculture and Irrigation.

Baseline Information: During the hot season, temperatures in Myanmar's Central Dry Zone can reach 40ºC, often resulting in local communities suffering from heat stroke and other heat-related disorders. For example, during March-April 2010, a total of 1378 cases and 224 deaths were reported as a result of heat stroke in the Central Dry Zone. The Mandalay Region was most affected with ~9% of cases ending in fatality. As a result, the Department of Health presently focuses on using newspapers and TV-Spot to advise individuals on extreme high temperatures as well as the necessary precautions that they should be taken to prevent heat-related disorders. However, current efforts need to be enhanced and more focussed, particularly when considering climate change impacts.

Climate Change Adaptation Rationale: Climate change will exacerbate the current effects of extreme high temperatures and heat-related disorders. Under future climate conditions, there will be an increase in temperature across Myanmar, with the Central and Upper regions experiencing the greatest increases. This will increase current maximum temperatures experienced in these regions resulting in an increase in occurrence and intensity of extreme high temperature days. Agricultural and industrial workers, under the typical working conditions, are regularly exposed to extreme high temperatures on a daily basis and therefore are at high-risk to heat-related disorders. Simple behavioural changes undertaken by the individual workers, company owners or managers can reduce the vulnerability of agricultural and industrial workers to extreme high temperatures. BCC has been shown, when implemented effectively, to create the supportive environment needed for encouraging desirable behaviour changes in local communities for a range of health risks. Preventing heat stroke and heat-related disorders through BCC among high-risk groups in Myanmar is crucial for adaption to climate change.

Third Priority Project: Supporting Intensive Care Units (ICU) in hospitals to treat heat-related disorders.

Project Objective: To provide quality intensive health care for heat-related disorders.

Project Area/Location: Tertiary and secondary hospitals in high-risk States and Regions e.g.: Magway, Mandalay and Sagaing Regions.

Beneficiaries: Critically ill patients suffering from heat-related disorders.

Period: 2 years

Estimated Budget: US$ 1 million

Project's Main Components, Outcomes and Outputs

Main Components	Main Outcomes	Main Outputs
Component 1: ICUs for treating heat-related disorders in Tertiary and Secondary hospitals.	**1.1:** ICUs equipped with appropriate apparatus in areas where communities are	**1.1.1:** A needs assessment for heat-related supportive care apparatus conducted with a focus on hospitals in high-risk areas. **1.1.2:** ICU equipment for treating heat-related disorders provided to hospitals in high risk areas. **1.1.3:** ICU facilities established in hospitals that are

	most at risk to heat-related disorders.	currently lacking specialised departments for providing intensive care medicine.
Component 2: Capacity building for ICU health workers in Tertiary and Secondary hospitals.	**2.1:** Quality intensive care provided for the critically ill patients suffering from heat-related disorders.	**2.1.1:** A capacity needs assessment of ICUs in hospitals in high-risk areas conducted. **2.1.2:** Health care workers trained to provide critically ill patients suffering from heat-related disorders with active body cooling and organ failure treatment supportive care.

Agencies involved: Executing agency: Department of Health, Ministry of Health.

Baseline Information: At present, Myanmar has 25 national hospitals and 32 state and regional hospitals in the country. Whereby the national hospitals have relatively sophisticated ICU departments, the state and regional hospitals do not. World Health Organisation (WHO) has been providing support to state and regional hospitals in Myanmar since 2006, and will continue to provide support until the end of 2012. ICUs contain standard intensive care equipment; however, the rooms/departments have limited equipment for body cooling and heat-related organ failure treatment. The Department of Health has planned to replenish certain ICUs with standard equipment over the next year.

Climate Change Adaptation Rationale: Over the last six decades, Myanmar has experienced an increase in temperature as well as the occurrence and intensity of extreme high temperatures. As a result, Myanmar has been hit with heat waves in recent years, with high numbers of reported cases of heat-related disorders and deaths. For example, in the summer of 2010, extreme high temperatures caused 1482 cases of heat-related disorders and 260 heat-related deaths across Myanmar. Although body cooling emergency management at hospitals saved many lives during these heat waves, inadequate equipment and capacity reduced the effectiveness of this effort. Climate change will exacerbate the current effects of extreme high temperatures and heat-related disorders. Under future climate conditions, there will be an increase in temperature across the whole of Myanmar, with the Central and Upper regions experiencing the greatest increases. Provision of body cooling and heat-related organ failure intensive treatment/care is critical in managing heat-related disorders under future climatic conditions. Properly equipped ICUs and well-trained health workers at Tertiary and Secondary hospitals are essential for preventing further heat-related deaths.

Fourth Priority Project: Reducing the vulnerability of local communities to climate-induced water-related health hazards through the provision of safe water supplies and sanitary latrines.

Project Objective: To reduce climate-induced water-related health disorders (diarrheal diseases) through increased access to safe drinking water, improved sanitation and Behaviour Change Communication (BCC).

Project Area/Location: Central Dry Zone and other identified disaster affected areas.

Beneficiaries: Communities in the Central Dry Zone and other disaster affected areas.

Period: 2 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs

Main Components	Main Outcomes	Main Outputs
Component 1: Guidelines for resilient water supplies and sanitation.	**1.1:** Technical expertise developed for designing disaster	**1.1.1:** Information generated on appropriate design parameters for climate-resilient sanitary and water supply systems. **1.1.2:** Socio-economic assessments undertaken in the

	proof sanitary latrines and climate-resilient water supplies.	Central Dry Zone and other disaster affected areas in Myanmar to identify villages most at risk and the most appropriate interventions for implementation. **1.1.3:** Guidelines developed for climate-proofing sanitary pan and pipe systems as well as increasing access to safe water supplies.
Component 2: Effective water supply systems and adapted sanitation interventions.	**2.1:** Resilience of water supply and sanitation increased in disaster prone areas.	**2.1.1:** Water supply devices/systems (e.g. tube-wells; protected ponds, piped water and household rainwater collection) implemented in vulnerable areas. **2.1.2:** Sanitation devices/systems (e.g. pit latrines, raised latrines and different forms of latrine infrastructure) implemented in vulnerable areas.
Component 3: Behavioural Change Communication (BCC) strategies developed and implemented.	**3.1:** Vulnerability to diarrheal diseases reduced through appropriate changes in behaviour/attitude of local communities towards water supply and sanitation.	**3.1.1:** Surveys conducted of local communities in disaster affected areas, on: i) vulnerability to diarrheal and other water-related diseases; ii) conflict and obstacles to desired change in behaviour; iii) most appropriate message and communication media; iv) resources available; and v) existing knowledge. **3.1.2:** Information, education and communication (IEC) materials developed for disemintation. **3.1.3:** An enabling environment using information (IEC materials including pamphlets, posters and guidelines) and communication (teaching) created for local communities to actively engage in changing their behaviour to reduce vulnerability to water-borne diseases. **3.1.4:** Appropriate media (e.g. Health talk and TV-Spot) used for disseminating BCC information.

Agencies Involved: Executing Agency: Department of Health, Ministry of Health.

Baseline Information: Diarrheal outbreaks occur mostly during the summer and rainy seasons in Myanmar. Water source contamination resulting from extreme weather events and unsanitary practices is the main cause of these outbreaks. In order to reduce the prevalence of water-borne diseases, the Department of Health (DoH) provides local communities with pans and pipes for setting up sanitation systems. The DoH also provides advice to communities on how to use the sanitary latrines in an appropriate manner for reducing health risks. After extreme weather events (e.g. Cyclone Nargis and Giri), the Department of Health (in collaboration with other departments and various donor organisations) is presently focussing on communicable disease control, including activities to improve water supply and sanitation in affected areas. The government also runs a 'National Sanitation Week' in Myanmar to increase the awareness of local communities on the importance of hygiene and sanitation in decreasing health risks.

Climate Change Rationale: Climate extremes, such as drought and flooding, result in water scarcity and water source contamination, both of which are the main contributing factors for diarrheal disease outbreaks in Myanmar. Climate change scenarios predict that Myanmar will experience long-term climatic changes such as: i) an increase in temperature (~04 - 3.5ºC over the next 10 to 90 years); ii) rainfall variability; and iii) sea-level rise. Furthermore, there will be an increase in the occurrence and intensity of extreme weather events such asi) cyclones/strong winds; ii) flood, iii) storm surge; iv)intense rains; v) extreme high temperatures; and vi) drought. Without resilient water supplies and sanitation for communities in Myanmar, climate change impacts will result in unsanitary drinking water, which will have negative affects on personal hygiene and lead to the transmission of diarrhoeal diseases. Solutions for resilient water supplies and improved sanitation in the face of climate change are urgently needed in Myanmar, particularly for areas that are prone to extreme weather events.

Water Resources Sector: Priority Adaptation Project Profiles

First Priority Project: Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change.

Project Objective: To re-evaluate the current design parameters of three of Myanmar's large storage dams to provide recommendations and guidelines on future design parameters for withstanding current and future climate change impacts on water supplies and flooding events.

Project Area/Location: i) Mone Multipurpose Dam, Setuktara Township (Magway Region); ii) Ngamoeyeik Dam, Hlegu Township (Yangon Region); iii) Thaphanseik Dam, Kyunhla Township (Sagaing Region).

Beneficiaries: Local communities near project sites.

Period: 2 Years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Institutional capacity building for improving dam design and management.	**1.1:** Strengthened institutional capacity to prepare and plan for climate change including an increased frequency of climate extremes such as drought and flooding.	**1.1.1:** Long-term hydrological and meteorological data as well as other relevant information collected. **1.1.2:** A user-friendly database for data storing and data processing established and developed. **1.1.3:** Training courses conducted with the engineering staff of the Irrigation Department for flood forecasting as well as hydrological and simulation modelling. **1.1.4:** International and local experts contracted to work with engineering staff for conducting dam assessments.
Component 2: Assessment of the need for rehabilitation/ reinforcement activities in existing dams.	**2.1:** Guidelines developed for dam rehabilitation and design as well as observation technologies.	**2.1.1:** Dam hydrological stability, storage capacity, sedimentation rates, water quality and water usage evaluated. **2.1.2:** An assessment conducted to evaluate the need for advanced/appropriate monitoring equipment with the ability to collect series data relevant for flood forecasting and early warning systems (e.g. advanced/real-time observation stations, water level sensor equipment and Doppler technology). **2.1.3:** Dam rehabilitation and reinforcement guidelines developed including: i) new design parameters (e.g. spillway crest, level, fixation and length); ii) appropriate monitoring and forecasting technologies; and iii) flood and water safety adaptation structures (e.g. emergency spillways) to safeguard lives and properties and ensure water supplies in the face of climate change.
Component 3: Mainstreaming climate change considerations into the design of future irrigation facilities including dams and small-scale reservoirs.	**3.1:** Guidelines mainstreamed and recommendations adopted throughout ministries involved in the water sector in Myanmar.	**3.1.1:** Proposed dam rehabilitation and reinforcement guidelines including water and flood safety adaptation technologies presented to relevant ministries and departments through workshops and seminars. **3.1.2:** An up-scaling strategy developed for facilitating and promoting similar assessments for existing water impoundments in the country.

Agencies Involved: Executing agency: Irrigation Department, Ministry of Agriculture and Irrigation.
Baseline Information: The government has invested large amounts of capital in constructing irrigation facilities across Myanmar. These include 251 dams and reservoirs (most being earth fill dams) and 48 storage tanks. One of the main objectives of the Ministry of Agriculture and Irrigation is to improve the agriculture sector through increasing paddy production by ensuring adequate water supplies. Therefore, rehabilitating and reinforcing conventional dams for withstanding climate change impacts falls in line with this objective. To date, the Irrigation Department has not yet implemented a project related to climate change adaptation measures in cooperation with an international agency.

Climate Change Adaptation Rationale: Myanmar's Dams are unprepared for climate change conditions. Most of the 251 dams and reservoirs in Myanmar were constructed between 1988 and 2000, and were designed for river flows that have subsequently changed. Climate variability and change has resulted in altered temperatures, rainfall patterns/intensities and other hydrological processes over the last ~six decades. Changes in hydro-meteorological patterns have resulted in two predominant problems for Myanmar's dams: i) a reduction of inflow; or ii) excessive inflows resulting in extreme unmanageable flooding events. As a result of excessive flooding events, the amount of water stored in existing dams has fluctuated drastically. This has caused extensive water spillage and damage to spillway facilities. Reduced inflow in some cases has resulted in a reduction of water supplies for irrigation. This problem has worsened in recent years, resulting in storage water in certain reservoirs being reserved only for drinking purposes. Climate change impacts are expected to exacerbate these problems, causing future difficulties in managing water supplies and flooding events. The conventional methods for building and repairing dams in Myanmar is fundamentally flawed when considering likely climate change impacts. In this regard, re-evaluating existing dams in Myanmar is urgently required in order to analyse the original design parameters, and to develop innovative design parameters appropriate for future climate change conditions.

Second Priority Project: Constructing small-scale water impoundments in Naypyidaw for flood control and increasing water supplies for local communities.

Project Objective: To supply sufficient and secure drinking and irrigation water to the Naypyidaw Region through two small-scale earth fill dams. This will contribute directly to reducing water shortage problems as well as assist with managing flood risks.

Project Area/Location: Oatarathiri Township, Naypyidaw Region including the Chaungmagyi and Ngaleik catchment areas and associated existing dams.

Beneficiaries: Local communities near projects sites in the Naypyidaw Region.

Period: 1 Year

Estimated Budget: US$ 3.56 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Interventions to increase the capacity of the water supply systems to adapt to climate change impacts.	**1.1:** Increased water supplies for urban and rural communities in Naypyidaw as well as enhanced flood protection for existing dams in the river system.	**1.1.1:** Hydrological, geological and topographic information collected at relevant dam sites to inform design parameters. **1.1.2:** Safe, secure and cost-effective small-scale water impoundments (e.g. earth fill dams with a total water volume of 22,000 Ac-ft, 26.62 MCM) constructed in the Chaungmagyi and Ngaleik catchment areas upstream to the Chaungmagyi and Ngaleik Dams.
Component 2: Water-saving awareness campaigns.	**2.1:** Water-saving practices adopted by communities living in Naypyidaw.	**2.1.1:** Efficient irrigation systems and water saving practices promoted in Naypyidaw and nearby townships.

Agencies Involved: Executing Agency: Irrigation Department, Ministry of Agriculture and Irrigation; Partner/Cooperating agencies: Line Departments or Private Sector Companies.

Baseline Information: The Irrigation Department implemented seven small-scale water impoundments (tanks) during 2010 and 2011 in Yamethin District of Dry Zone Area near Naypyidaw. These water tanks were mainly funded by the Italian Government through the Food and Agriculture Organisation (FAO).

Climate Change Adaptation Rationale: Current decreases in rainfall and increases in temperature have resulted in reservoirs and water tanks in Myanmar receiving decreased inflow, resulting in large-scale water shortages. These changes have been particularly prevalent in the Dry Zones of Myanmar. Climate change is projected to further increase the variability and intensity of rainfall over Myanmar, resulting in both increased flooding and increased dry spells. Implementing large dams to meet the urgent and immediate needs of communities for water supplies is not feasible, mainly because of the extensive time requirements and costs for building these structures. Using small-scale, cost-effective and rapidly installed earth fill dams in the upstream areas of Chaungmagyi and Ngaleik catchment will provide a convenient and reliable water supply, particularly during seasonal dry periods and droughts. The implementation of these earth fill dams near urban and rural communities in the Naypyidaw Region will also act to increase agricultural production. Increased rainwater storage capacity upstream will reduce the effect of flooding events on downstream infrastructure and lives.

Third Priority Project: Protecting human life and property against climate extremes in the Ayeyarwady river system through channel improvement and adaptation structures.

Project Objective: To enhance physical safety including protecting life and property against climate extremes and disasters in the Ayeyarwady river system while increasing water supplies for irrigation and domestic use through appropriate channel improvement and using regulating methods.

Project Area/Location: Mayoegone waterways, Myin Mu Township, Ayeyarwady River.

Beneficiaries: Local communities that use the river for transport, fishing activities and water supplies; private sector vessels and related companies; communities and infrastructure at risk to climate extremes such as flooding and drought.

Period: 1 year

Estimated Budget: US$ 0.6 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Design and construction of appropriate adaptation structures for improving channel systems, riverbeds and banks of the Ayeyarwady river.	**1.1:** Improved navigation and enhanced physical safety to climate extremes through channel improvement and riverbed regulating methods.	**1.1.1:** One 400 m sand core stone groyne constructed. **1.1.2:** One 800 m sand core stone groyne constructed. **1.1.3:** One 900 m wooden pile groyne constructed. **1.1.4:** One 1100 m wooden pile groyne constructed. **1.1.5:** 1100 m of dangerous riverbed areas dredged.
	1.2: Water supplies increased for irrigation and domestic use during dry periods.	**1.2.1:** Water from dredged areas made available through pumping for irrigation and domestic use.
Component 2: Monitoring and reporting.	**2.1:** Sustainability and maintenance of adaptation structures to climate change impacts.	**2.1.1:** Surveys undertaken to monitor the efficiency of structures implemented.

Agencies Involved: Executing Agency: Directorate of Water Resources and Improvement of River Systems, Ministry of Transport; Partner/Cooperating agencies: Local communities, related government organizations and investors.

Baseline Information: The main objectives of **t**he Directorate of Water Resources and Improvement of River Systems are to: i) improve the river navigation channels; ii) stabilise inland river ports; iii) reduce river bank erosion; iv) cooperate with other organisations to demarcate danger levels for nearby towns; v) utilise river water for domestic use and agriculture; vi) observe the long-term existence of cross river bridges; vii) manage river water pollution; and viii) ensure river depths are adequate for maximum loading capacity vessels. These activities are planned around current river conditions without taking into consideration future climate change impacts and changes.

Climate Change Adaptation Rationale: Myanmar's major river systems are largely influenced by monsoon events. The current condition of Myanmar's river systems are not suitable for ensuring physical safety (including life and property) under climate extremes (flood and drought). For example, river systems are severely degraded and display visible signs of degradation and altered hydrology e.g. braided channels, insufficient depth in the low water season, erosion and sedimentation in the wet season. This degradation is further aggravated during flooding events. Climate change impacts will exacerbate the already degraded conditions of these river systems resulting in further decreases in navigation potential and capacity for providing water supplies. Mayoegone waterway is located on the Ayeyarwady River, 20 km downstream from Myin Mu. During the low water season, braided channels lead to create shallow depths and sand bars in this stretch of the river. Constructing channel improvement structures (e.g. installation of groynes) and implementing riverbed regulation methods (e.g. dredging) will increase the river's ability to withstand climate extremes and will safeguard life and property. Furthermore, improved waterways will assist nearby water pumping stations provide water supplies to local communities for irrigation and domestic use.

Fourth Priority Project: Estimating regional rainfall-runoff relationships for supporting the development of flood early warning systems (EWS) and ensuring sustainable water management.

Project Objective: To estimate current and future regional rainfall-runoff relationships to inform optimum hydro-meteorological design parameters and flood EWSs, and therefore assist regional water managers manage anticipated changes in the hydrological cycle.

Project Area/Location: Central Dry Zone and southern Myanmar.

Beneficiaries: Agencies and Line Departments related to water utilization and flood EWSs in Myanmar.

Period: 1.5 years

Estimated Budget: US$ 1 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Institutional capacity building for hydrological and climate change modelling.	**1.1:** Comprehensive hydrological and meteorological database established, including historical data and information for informing regional rainfall-runoff relationships.	**1.1.1:** Long-term hydrometeorology and other water resources-related data and information collected and compiled, including relevant catchment/watershed information. **1.1.2:** A database system established for storing and processing data. **1.1.3:** Technical and modelling training for the Irrigation Department conducted, using input from international and local experts.
Component 2: Run-off model to inform water and flood management.	**2.1:** Effective flood forecasting and optimum design parameters for irrigation systems in the Dry Zone and Lower	**2.1.1:** Regional rainfall-runoff relationship derived (run-off models, hydrographs) for the Central Dry Zone and southern parts of Myanmar. **2.1.2:** The impacts of climate change on future rainfall-runoff relationships determined using a

	Myanmar.	range of climate change scenarios. **2.1.3:** Water and flood management plans that incorporate climate change impacts developed.
Component 3: Mainstreaming of results for effective water and flood management.	**3.1:** New management systems developed for increasing water storage capacity of dams and reducing flood risks.	**3.1.1:** A report generated and disseminated to various departments focused on water management and early warning systems. **3.1.2:** Results published in peer reviewed literature.

Agencies Involved: Executing agency: Irrigation Department, Ministry of Agriculture and Irrigation; Partner/Cooperating agencies: other Line Departments and the Private Sector.

Baseline Information: The last study published in Myanmar that focused on analysing and reporting rainfall-runoff relationships for the country was in April 1983. At present, the Irrigation Department within the Ministry of Agriculture and Irrigation are using either out of date historical data or basic isohyets for determining flood management procedures as well as for informing key design parameters for infrastructure and storage dams.

Climate Change Adaptation Rationale: The hydrological cycle (surface and ground sources, glaciers, precipitation and runoff) is very sensitive to small climatic shifts as well as changes in land use e.g. agriculture land conversions and urbanisation. Therefore, future climate changes will play a significant role in altering Myanmar's hydrological cycles. This means that historic data will not be a reliable predictor of future hydrological pattern. For future water management in Myanmar, managers will have to use historical records as well as longer-term forecasts to calculate dam management procedures under a warmer climate with more climatic extremes (droughts and flooding). In order to generate cost-effective and optimum design parameters for planning and implementing water resources development in Myanmar, a run-off model for future climate trends needs to be developed. In addition to this, a model for the future climate change effects on regional rainfall-runoff relationships needs to be generated. This information will assist with planning for water related threats, implementing water resources development and early warning system design.

Coastal Zone: Priority Adaptation Project Profiles

First Priority Project: Adaptation to climate change through Integrated Coastal Zone Management (ICZM).

Project Objective: To achieve sustainable coastal zone management and livelihoods in the face of climate change.

Project Area/Location: Myeik Archipelago, Tanintharyi Region

Beneficiaries: i) Local communities, ii) Fisheries Sector; iii) Forestry Sector; and iv) Biodiversity Sector

Period: 4 years

Estimated Budget: US$ 800,000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Research focused on climate change impacts on coastal ecosystems and local communities	**1.1.** Information obtained for planning and implementing ICZM under a changing climate.	**1.1.1:** Main stakeholders as well as major threats and opportunities for Integrated Coastal Zone Management identified. **1.1.2:** Local fisheries and social surveys conducted to analyse the status/trends of coastal ecosystems, aquatic biodiversity, local livelihoods and potential climate change impacts within the Myeik Archipelago. **1.1.3:** Status/trends of the fisheries sector analysed with particular reference to endangered species/habitats as well as potential climate change impacts. **1.1.4:** Climate change vulnerability assessment and mapping undertaken. **1.1.5:** Pilot sites identified for engaging local communities, NGOs and government departments in coastal zone management.
Component 2: Local capacity development for ICZM	**2.1:** ICZM model developed for the Myeik Archipelago.	**2.1.1:** Training workshops and meetings conducted with participating NGOs, government departments and local community representatives on techniques for assessing/mapping biodiversity, local community livelihoods and climate change vulnerability. **2.1.2:** Coastal areas zoned into different land-uses and ecosystems. **2.1.3:** Hazard maps developed for climate change impacts. **2.1.4:** Local coastal zone management plans developed for different zones, using a participatory approach,. **2.1.5:** An Integrated Coastal Zone management model for the Myeik Archipelago developed integrating a range of ecosystems (marine and terrestrial) and using a participatory approach.
Component 3: Mainstreaming ICZM for enhancing the resilience of coastal ecosystems and livelihoods	**3.1:** ICZM strategic plan/proposal drafted for the Myeik Archipelago.	**3.1.1:** ICZM Proposal (strategic plan) for the Myeik Archipelago drafted, and submitted to the Government of Myanmar. **3.1.2:** A national workshop conducted with appropriate government departments and agencies to present the ICZM proposal and to promote the development of an ICZM plan for Myanmar's entire coastal area

Agencies Involved: Executing agency: Biodiversity and Nature Conservation Association (BANCA);

Partner/Cooperating agencies: Forest Department, Ministry of Environmental Conservation and Forestry, Department of Fisheries, Ministry of Livestock and Fisheries, Marine Science Departments, Ministry of Education, Myanmar Naval Forces, local Authorities, Myanmar Fisheries Federation (MFF) and local communities.

Baseline information: The Government of Myanmar has expressed its commitment to sustainable marine ecosystem management and sustainable coastal livelihoods through its involvement in the Bay of Bengal Large Marine Ecosystem (BOBLME) Programme (US$ 32 million over a 5-year period). This programme focuses on improving the lives of coastal populations through effective regional management of the Bay of Bengal's marine biodiversity and fisheries. Furthermore, the Department of Fisheries in collaboration with BANCA and Fauna and Flora International (FFI) plan to develop a MPA network system for Myanmar's coastline.

Climate Change Adaptation Rationale: ICZM is a multi-purpose strategy that analyses and addresses implications of development, conflicting uses, and interrelationships between physical processes and human activities within a coastal zone. It promotes linkages as well as collaboration among the different sectors/activities occurring in the coastal zone. ICZM within the Myeik Archipelago is urgently required to sustainably develop the area's tourism potential while protecting the diverse array of intact marine habitats (e.g. coral reef, seagrass, and mangroves) and species that exist in the region. Climate change is already negatively affecting Myanmar's coastal communities. According to the Inter-governmental Panel on Climate Change (IPCC), three adaptation strategies are recommended for responding to sea-level rise, including: i) retreat and resettle inland; ii) continue to occupy the land but make certain adjustments to livelihood practices; and iii) protect land and livelihoods using hard and soft measures. In order to adequately plan for sea-level rise within the coastal zone, cross-sectoral planning and decision-making (including local community participatory approaches) are required to improve economic opportunities (i.e. tourism) and environmental conditions for coastal communities. Such planning and decision-making will also help to conserve biodiversity within these areas in the face of climate change. Conventional ICZM (without considering future climate change impacts) considers natural hazards and climate variability, and programmes often address erosion, storm impacts, water quality, sanitation, fisheries, tourism, ports, infrastructure, floodplain management, building standards and conservation of ecosystems. ICZM within this programme will incorporate the latter conventional considerations as well as planning for future climate change impacts through the provision of technical and scientific information.

Second Priority Project: Community-based mangrove reforestation for building climate-resilient ecosystems and rural livelihoods in degraded coastal areas in the Rakhine State.

Project Objective: To reduce the vulnerability of communities in the Rakhine Coastal Zone through climate-resilient mangrove forests and integrated farming systems.

Project Area/Location: Gwa Township, Thandwe District, Rakhine State

Beneficiaries: i) Local communities; ii) Forestry Sector; and iii) Fisheries Sector

Period: 5 years

Estimated Budget: US$ 3 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Research for maximising the climate-resilience of reforested areas and coastal livelihoods	**1.1:** Technical expertise developed for restoring coastal forests and implementing integrated farming systems that are resilient to climate change impacts.	**1.1.1:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.2:** The response of local mangrove ecosystems (and other coastal forests) to climate change stimuli analysed, including sea-level rise, extreme weather events and changes in precipitation. **1.1.3:** Climate-resilient, multi-use and appropriate mangrove as well as other coastal species identified for planting.

		1.1.4: Pilot sites identified for engaging local communities and departments. **1.1.5:** Mangrove and integrated farming User Groups/Community Based Organizations and other participants identified for the implementation and coordination of mangrove reforestation and integrated farming systems.
Component 2: Local capacity development to plan and implement mangrove reforestation and integrated farming systems	**2.1:** Increased options for local communities to face uncertain weather conditions through integrated farming systems and restored mangrove forests.	**2.1.1:** A series of hands-on training, seminars and workshops on the importance of mangroves and mixed farming systems conducted with relevant stakeholders (e.g. NGOs, government departments and other local community user groups) **2.1.2:** Training conducted for mangrove and integrated farming User Groups including: i) nursery management; ii) planting; iii) climate-resilient and multi-use mangrove species; iv) maintaining restored areas under climate change impacts; and v) mixed farming system development. **2.1.3:** Tailor-made reforestation techniques and restoration guidelines developed for coastal mangrove areas using a participatory approach with local communities concerned. **2.1.4:** Tailor-made integrated farming systems developed for piloting within coastal forest areas using a participatory approach with local communities. **2.1.5:** Local communities trained on diversifying income streams through sustainable alternative livelihood strategies.
Component 3: Demonstrations that reduce vulnerability to climate change impacts	**3.1:** Increased resilience of local communities and ecosystems through large-scale mangrove restoration and integrated farming systems.	**2.1.1:** Mangrove forest restoration guidelines implemented using a participatory approach with local communities and relevant departments for enhancing the supply of ecosystem services in the face of climate change. **2.1.2:** Community-managed mangrove nursery established for providing propagules and seed for restoration activities. **2.1.3:** Mixed farming systems (aquaculture, livestock and crops) piloted to increase/diversify the income of local farmers and to reduce agricultural failure as a result climate extremes.

Agencies Involved: Executing Agency: Forest Department. Partner/Cooperating agencies: Department of Fisheries, Ministry of Livestock and Fisheries; Ministry of Tourism; local Authorities; Biodiversity and Nature Conservation Association (BANCA); and local communities.

Baseline information: As result of the recent devastating cyclone events affecting the Ayeyarwady Delta and its coastal forests, there have been considerable reforestation activities occurring in this region including projects such as *inter alia*: i) Integrated mangrove rehabilitation and management through community participation in the Ayeyarwady Delta by JICA (2007-2013) ii) Community plantations with mangrove species in some parts of Pyindaye and Kadonkani reserved forests, Ayeyarwady delta by FREDA (on-going); and iii) Ecological Mangrove Restoration Programme in the Ayeyarwaddy Delta by Action Aid Project (Australian Government). The only restoration activities that are intensively focused on the Rakhine State are being implemented by the UNDP with MERN. As a result of the location of the Rakhine coastal zone, it is prone to natural calamities such as flood, cyclones, storm surges and tsunamis. The area contains diverse ecosystems such as coral reef, seagrass beds and mangroves, and therefore has potential for ecotourism operations. The coastal forest systems in these areas are currently being over-utilised and are severely degraded. At present, BANCA and Oikos are in the process of setting up a project on biodiversity surveys at the Gwa Township areas.

Climate Change Adaptation Rationale: Climate change threatens to severely hamper local communities in the Rakhine area as a result of an increase in coastal floods and storm surges. In terms of adaptation to climate change, the main benefit of mangrove restoration for local communities is the reduction of incoming waves and tidal variation in the intertidal zone. For example, mangroves dissipate the energy of approaching waves because they exist as a rough and irregular surface on which waves can break. This reduces coastal flood risk and decreases the height of storm surges. Integrated farming systems contribute to climate change adaptation as the diversification of crops, livestock and aquaculture (including the use of more than one variety/species of each) ensures a safety net of numerous livelihood options in the face of uncertain weather conditions. For example, integrated farming systems increase stability and resilience of production. This is because if one crop fails, another may survive, or if all crops fail, livestock and aquaculture resources will compensate. Although this project will focus on increasing the climate change resilience of local communities and coastal forests to climate change, there will also be mitigation spin-offs. This is because mangroves have been shown to sequester carbon at high rates and sometimes even more effectively than terrestrial forests. This "blue carbon" approach could be used to provide renewable financing for the project to ensure sustainability beyond the project's lifespan.

Third Priority Project: Community based eco-friendly aquaculture systems (e.g. mudcrab, clam, shrimp and tilapia) for enhancing the climate change resilience of rural livelihoods and supporting the recovery of mangrove forest ecosystems.

Project Objective: To reduce the vulnerability of coastal livelihoods to climate change affects such as salt-water intrusion and flooding through integrated eco/mangrove-friendly aquaculture systems (including *inter alia* mudcrab, clam, shrimp and Tilapia).

Project Area/Location: Pulaw Township, Tanintharyi Region

Beneficiaries: i) Local communities; ii) Fisheries Sector; and iii) Forestry Sector

Period: 3 years

Estimated Budget: US$ 600,000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Research for maximising the climate change resilience of integrated aquaculture systems and mangrove forest recovery	**1.1:** Technical expertise developed for integrated aquaculture systems that are resilient to climate change impacts.	**1.1.1:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.2:** The climate change impacts (e.g. salt-water intrusion, flooding, sea-level rise, changes in precipitation) to local aquaculture livelihoods as well as mangrove systems analysed in-depth. **1.1.3:** Multi-species crab, shrimp, clam, and fish systems (freshwater, brackish and marine) appropriate for aquaculture under future climate change conditions identified and costed. **1.1.4:** Innovative techniques and eco/mangrove-friendly methods for aquaculture systems developed using a participatory approach. **1.1.5:** Pilot sites identified for engaging local communities and departments. **1.1.6:** User Groups, Community Based Organisations and other participants identified for implementing and coordinating integrated eco-friendly aquaculture systems.
Component 2: Local capacity development to plan and implement integrated	**2.1:** Increased options given uncertain weather conditions through integrated aquaculture systems	**2.1.1:** A series of hands-on training sessions, seminars and workshops conducted with relevant stakeholders on the importance of mangrove restoration and integrated aquaculture systems in the face of climate change conducted. **2.1.2:** Training for mangrove and integrated farming User

aquaculture systems	and restored (passive) mangrove forests.	Groups including: i) aquaculture technologies and methods; ii) benefits of climate-resilient (brackish/marine) and multi-species (mud-crab, shrimp, fish, clam) systems; iii) benefits of eco-friendly aquaculture systems; iv) maintaining aquaculture systems under climate change conditions; and v) benefits of mangrove buffers. **2.1.3:** Tailor-made integrated and climate-resilient aquaculture systems developed for piloting within coastal forest areas using a participatory approach with local communities.
Component 3: Demonstrations that reduce vulnerability to climate change impacts.	**3.1:** Increased resilience of local livelihoods to salt-water intrusion and flooding as well as other climate change impacts through piloting integrated aquaculture systems.	**3.1.1:** Integrated eco-friendly aquaculture guidelines implemented using a participatory approach with local communities and relevant departments for enhancing the supply of ecosystems services in the face of climate change. **3.1.2:** Local communities trained on diversifying income and employment opportunities through sustainable alternative livelihood strategies.

Agencies Involved: Executing agency: Department of Fisheries; Partner/Cooperating agencies: Local authorities, and local communities.

Baseline information: Currently there are no projects focused on eco-friendly integrated aquaculture systems using a variety of marine, brackish and freshwater species including mudcrab, shrimp, clam and fish species (e.g. Tilapia) within the coastal zone. However, there has been rapid growth of unsustainable marine shrimp culture throughout the region, resulting in large-scale clearing of mangroves, conversion of agricultural lands to shrimp ponds, pumping of seawater into freshwater areas (leading to salinisation of soils and groundwater), extraction of ground water and discharge of pollution and pond effluents. This has lead to severe environmental degradation as well as social conflicts between shrimp farmers, other land users and water users. At present, there are often no legal requirements for EIAs (Environmental Impact Assessments) for implementing shrimp farming in coastal areas. In cases where legal standards exist, the EIA is not effective. This is because there are no clear guidelines for eco-friendly aquaculture systems.

Climate Change Adaptation Rationale: Climate change threatens to severely hamper local communities in the Tanintharyi area as a result of an increase in floods, intense rains and storm surges. Eco-friendly aquaculture systems will reduce the pressure that current aquaculture is placing on Myanmar's mangrove coastal ecosystems. The main benefit of mangrove recovery (i.e. passive restoration) in combination with integrated aquaculture systems (including fresh, brackish and salt-water species) will be increased resilience of livelihoods to climate change impacts such as flooding, salt-water intrusion, storm surges and intense rains. Integrated aquaculture systems will ensure that local communities are using a variety of species appropriate for a range of climatic conditions. Although, this project will focus on climate change adaptation through integrated aquaculture systems, it will also contribute to providing a set of clear guidelines for implementing eco-friendly aquaculture practices. Furthermore, mangrove regeneration/passive restoration has the potential to generate large amounts of "blue carbon credits" within the target area, as mangroves are extremely effective at sequestering carbon. This is a potential additional source of income.

Fourth Priority Project: Small-scale aquaculture and mangrove buffers demonstration sites for transferring adaptation technologies to Mon and Tanintharyi coastal communities.

Project Objective: To build the capacity of local communities for planning and implementing adaptation options for small-scale aquaculture.

Project Area/Location: Thanphyuzayat, Chaungzone and Paung Townships, Mon State

Beneficiaries: i) Local communities; ii) Fisheries Sector; and iii) Forestry Sector

Period: 3 years

Estimated Budget: US$ 600,000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Biophysical, ecological and socio-economic assessments of Mon State's coastal communities and ecosystems	**1.1:** Technical expertise developed for designing climate-resilient and eco-friendly aquaculture using a combination of traditional and scientific approaches.	**1.1.1:** Ecological, social and climate change vulnerability assessments conducted at project sites. **1.1.2:** The climate change impacts (e.g. salt-water intrusion, flooding, sea-level rise, changes in precipitation) to local livelihoods and mangrove systems analysed. **1.1.3:** Innovative techniques and eco/mangrove-friendly methods for aquaculture systems developed using a participatory approach. **1.1.4:** Pilot sites identified for assembling small-scale aquaculture eco-friendly demonstrations. **1.1.5:** User Groups, Community Based Organisations and other participants identified for participating in training local communities.
Component 2: Small-scale demonstrations for training and transferring adaptation technology "know how"	**2.1:** Increased adoption of eco-friendly aquaculture practices through improved implementation capacity of local communities.	**2.1.1:** Small-scale aquaculture systems developed as demonstration sites within coastal forest areas using a participatory approach. **2.1.2:** A series of hands-on training sessions, seminars and workshops on the importance of mangrove restoration conducted with local community user groups using the aquaculture research centre at the University of Mawlamyine as well as demonstration sites. **2.1.3:** Hands-on training for local communities conducted on: i) aquaculture technologies and methods; ii) benefits of climate-resilient (brackish and marine) and multi-species aquaculture systems; iii) benefits of eco-friendly aquaculture systems; iv) maintaining aquaculture systems under climate change impacts; and v) benefits of mangrove buffers and restoration.

Agencies Involved: Executing agency: Department of Marine Science, University of Mawlamyine. Partner/Cooperating agencies: Local authorities and local communities.

Baseline Information: The University of Mawlamyine is the leading university with aquaculture experience in Myanmar. An aquaculture research centre has been established at the University within the Department of Marine Science. This centre will be used for holding training sessions and workshops for the project. At present, there are no projects on eco-friendly aquaculture systems within the coastal zone. However, there has been rapid growth of unsustainable marine shrimp culture throughout the region, resulting in large-scale clearing of mangroves, conversion of agricultural lands to shrimp ponds, pumping of seawater into freshwater areas (leading to salinisation of soils and groundwater), extraction of ground water and discharge of pollution and pond effluents. This has lead to severe environmental degradation as well as social conflicts between shrimp farmers, other land users and water users.

Climate Change Adaptation Rationale: Mangrove habitats play essential roles in climate change adaptation, such as i) buffering communities from coastal flooding; ii) reducing erosion and trapping sediment; iii) increasing the land available for diversified local livelihoods; and iv) providing habitats for local animals/plants. Restoration in conjunction with sustainable small-scale aquaculture approaches are necessary as Myanmar's mangrove ecosystems have become increasingly degraded through both natural and human activities. As a result of a lack of local community awareness and resulting unsustainable aquaculture practices, mangroves are depleted in Myanmar's coastal regions. Therefore, education and training on sustainable eco-friendly aquaculture practices are urgently

needed within these communities to increase the resilience of livelihoods and ecosystems to climate change.

Energy: Priority Adaptation Project Profiles

First Priority Project: Enhancing the resilience of water supplies in the face of climate change for rural communities through solar powered water purification and irrigation pumping systems.

Project Objective: To ensure cleaner and safer water for drinking as well as sustained water supplies for irrigation under a changing climate through solar power.

Project Area/Location: The target area is the Central Dry Zone; however, the project could also include townships in the Ayeyarwady Region. Villages in the Central Dry Zone will be selected in collaboration with Department of Development Affairs (DDA) in the Nyaung-U and Kyaukpadaung Townships of the Mandalay Region as well as the Chauk Township of Magway Region.

Beneficiaries: i) Rural communities; and ii) local farmers (livestock and fishery).

Period: 1 year

Estimated Budget: US$ 3 Million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Interventions that reduce the vulnerability of water supplies to climate change.	**1.1:** Resilience of water supply (quality and quantity) increased for drinking purposes and ensuring health standards.	**1.1.1:** Ground and surface water resources at project areas assessed and profiled for determining pilot sites. **1.1.2:** Appropriate cost-effective solar powered technologies identified for implementation. **1.1.3:** Solar powered water pumping and purification systems assembled for increasing water quality and quantity at project sites while decreasing energy demands.
	1.2: Increased climate-resilience of water supplies for irrigation, for maintaining crop production and reducing input costs.	**1.2.1:** Advanced solar powered water supply facilities constructed for pumping water from rivers, streams or ponds for irrigation. **1.2.2:** Deep tube-wells rehabilitated using advanced solar powered technologies.
Component 2: Strengthened capacity of local communities for operating and maintaining renewable energy systems.	**2.1:** Systems developed that will enable the maintenance of renewable energy water purification and pumping systems beyond the implementation phase of the project.	**2.1.1:** Local representatives trained to use, repair and maintain systems established at project sites. **2.1.2:** Training workshops conducted with local communities in order to increase their awareness regarding the agricultural and health benefits that energy efficient water pumping systems can provide. **2.1.3:** Local communities trained on water saving practices for reducing water usage and waste to complement solar powered adaptation technologies.
Component 3: Mainstreaming renewable energy technologies into policy for increasing the resilience of water supplies.	**3.1:** An enabling policy environment created to promote/support solar powered water supply adaptation technologies.	**3.1.1:** Policy briefs generated to describe the benefits of the project. **3.1.2:** A proposal formulated and submitted to relevant departments and ministries focused on describing the potential role of government for promoting and supporting solar powered water purification and pumping systems for rural communities. **3.1.3:** A seminar conducted to mainstream the above into policies, plans and strategies at the national and regional level.

Agencies Involved: Executing agency: Rural Energy Development Committee; Partner/Cooperating agencies: Ministry of Industry, Ministry of Agriculture/ Livestock and Fishery, Department of

Development Affairs (DDA, under the Ministry of Progress of Border Areas and National Races and Development Affairs), UN Organizations, NGOs and INGOs.

Baseline information: The Government of Myanmar has supported various rural water supply projects including the Ten Year Project for Rural Water Supply by the Development Committees of Sagaing, Magway and Mandalay Divisions (2000-2010) which was implemented by the DDA, Ministry of Progress of Border Areas and National Races and Development Affairs. The Japan International Cooperation Agency (JICA) provided the DDA's engineers with technical assistance during the project. In total, 72 electric pump stations and 42 medium electric-pump stations were established. Pumping systems for accessing groundwater resources were established at 36 sites. In addition to this project, Bridge Asia Japan and UNICEF have assisted with sinking tube-wells in the Central Dry Zone. Various UN organizations, INGOs and NGOs have been implementing potable water supply projects across Myanmar to improve living conditions in remote areas. After the devastation of Cyclone Nargis (2008), a number of international aid agencies (e.g. Munich Re Foundation, Arche Nova, Aktion Deutschland Hilft), local organisations and volunteers focussed on restoring drinking water by cleaning and repairing wells in 60 villages (Kungyangon and Amar districts) and providing toolkits, pumps and plastic sheeting ($1m^2$ – catching ~200 litres rainwater/day). The World Health Organisation, in collaboration with the Norwegian Government, donated four large and twenty small Portable Water Purification Systems. Training for staff within the Myaung Mya Township hospital was provided for installing and using the purification systems. Examples of technologies that have previously been used in rural water supply projects include: shallow tube-wells with hand pumps, deep tube-wells with tara pumps, deep tube-wells with India Mark ii pumps, gravity fed systems, improved hand dug wells and rainwater collection jars. Solar power is not currently being used in these rural water supply projects.

Climate Change Adaptation Rationale: At present, Myanmar is facing shortages in water supply as a result of limited quality and quantity of water. Future climate change will exacerbate this situation, particularly for villages in the Central Dry Zone and Inle Lake area where access to water is likely to decrease as a result of increased intensity and frequency of droughts, floods and extreme high temperatures. Within Myanmar's Coastal Zone, salt-water intrusion and increased flooding will contaminate water supplies, leaving many villages without safe drinking water. Solar water purification systems integrate solar electricity and water purification. Solar panels generate power for a battery that pumps the water through a filtration and purification system. A large water unit can produce ~4000 litres of purified water/hour, while the small unit provides ~50-70 litres of water/day. Pumping water for irrigation using solar power will increase the resilience of the water supply in the face of climate change, while reducing high water pumping costs, and thus sustaining agriculture production. Solar technology for ensuring the resilience of water supply for rural communities is urgently needed to sustain livelihoods and improve health and living standards in Myanmar.

Second Priority Project: Enhancing the resilience of sanitation in the Shan Region to climate change impacts through solar powered aerobic septic tanks.

Project Objective: To improve sanitation in the Shan Region through sustainable solutions for reducing health risks (water-borne diseases) and increasing drinking water supplies in the face of climate change.

Project Area/Location: Inle Lake area in the Southern Shan State.

Beneficiaries: i) Rural households/communities; and ii) tourism (hotels and restaurant owners).

Period: 1 year

Estimated Budget: US$ 2 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Interventions to promote sustainable sanitation solutions for villages, hotels and restaurants at the Inle Lake.	**1.1:** Environmentally sound management of waste to safeguard water supplies, improve health and decrease non-renewable energy demands.	**1.1.1:** Sanitation and water quality surveys conducted in project areas to determine appropriate and cost-effective solar-powered technologies for implementation. **1.1.2:** Solar-powered aerobic septic tank systems as well as other appropriate sanitation technologies assembled for improving public health, ensuring climate change resilience of water supplies and decreasing energy demands.
Component 2: Strengthened capacity of local communities for operating and maintaining solar powered sanitation technologies.	**2.1:** Solar-powered sanitation systems maintained and operational beyond the implementation phase of the project.	**3.1.1:** Local representatives trained to use, repair and maintain solar-powered sanitation systems. **3.1.2:** Training workshops conducted with local communities in order to increase their awareness on the health benefits of sustainable sanitation technologies. **3.1.3:** Local communities trained on best water-related health practices as well as waste water treatment practices for reducing residential wastes and to complement solar powered sanitation technologies.
Component 3: Up-scaling of project activities within the tourism industry and mainstreaming into policy and planning at the national and regional level.	**3.1:** Interest and uptake of solar-powered sanitation technologies enhanced within the Inle Lake's tourism industry.	**3.1.1:** Awareness raising campaigns conducted in non-project sites to stimulate the uptake of project activities outside target areas e.g. site visits and local demonstrations.
	3.2: Enabling policy environment created to support solar powered water supply adaptation technologies.	**3.2.1:** Policy briefs generated that focuss on describing the benefits of the project. **3.2.2:** A proposal formulated and submitted to relevant departments and ministries focused on describing the potential role of government for promoting and supporting solar powered sanitation systems for rural communities. **3.2.3:** A seminar conducted to mainstream the above into policy, plans and strategies at a national and regional level.

Agencies Involved: Executing agency: Rural Energy Development Committee; Partner/Cooperating agencies: Ministry of Industry, Ministry of Health/ Ministry of Hotel and Tourism, DDA (Ministry of Progress of Border Areas and National Races and Development Affairs), UN organizations, NGOs and INGOs.

Baseline information: The Environmental Sanitation Division (ESD) of the Department of Health (DOH) under the Ministry of Health (MOH) has been carrying out institutional water sanitation activities, drinking water quality surveillance and pilot project monitoring. Many water agencies, particularly the DDA, have been working to improve the supply of water to urban and rural communities. One of the guidelines of the National Health Policy (1993) is to intensify and expand environmental health activities, including prevention and control of air and water pollution. The Annual National Sanitation Week initiated in 1998, was the most effective advocacy campaign throughout the country and had great success in increasing community awareness and sanitation coverage.

Climate Change Adaptation Rationale: In the past, Inle Lake system existed as the sole source of drinking water for local communities. However, at present human and household wastes are deposited directly into the lake (i.e. direct latrine systems), causing health problems for the locals who use the water for drinking. Furthermore, septic systems that are functional in the area are leaking waste into the lake during high water periods as a result of poor design and position in the landscape. Recent surveys of the faecal coliform bacteria levels in the lake indicate that the water is unfit for human consumption, and as a result, many of the communities that can afford to do so have turned to

using tube-wells or bottled water instead. High nutrient loads and contamination are also negatively affecting local livelihood practices including floating agriculture gardens and fish production and catches. Excessive weed and algae growth in the lake is reducing fish growth and population numbers. Furthermore, the poor environmental state of the lake is negatively affecting recreational activities that make this area the top tourism destination in the country. Under climate change impacts, living conditions at Inle Lake will worsen. Decreased water supplies, increased conditions for the spread of water-borne diseases as well as flooding will exacerbate health risks currently being experience by communities living near the lake. There is an urgent need for sustainable sanitation solutions, and appropriate water and wastewater management to increase the resilience of sanitation systems at Inle Lake in the face of climate change. Solar powered aerobic septic systems, for example, are appropriate for achieving sustainable sanitation, particularly in rural communities that do not have water infrastructure and generally do not have access to electricity. Furthermore, aerobic systems (as opposed to conventional systems) require less space, cause less groundwater pollution and work faster than anaerobic systems. This means that they can dispose of effluent in less time.

Third Priority Project: Increasing climate change resilience of rural communities in the Sagaing, Mandalay and Ayeyarwady Regions by increasing livelihood opportunities through renewable solar electricity systems.

Project Objective: To increase community access to energy for supporting job creation, employment, education and channels for communicating early warnings to villages vulnerable to extreme weather events.

Project Area/Location: Three project sites within the Sagaing, Mandalay and Ayeyarwady Regions.

Beneficiaries: Rural communities.

Period: 2 years

Estimated Budget: US$ 5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Solar Home System for rural community electrification.	**1.1:** Kerosene and candles replaced with solar powered electricity in rural villages to provide power for a range of devices (e.g. lighting, fans, television, radio, cell phone chargers), and to increase dissemination potential of weather warnings.	**1.1.1:** Energy requirements of project sites assessed for determining appropriate and cost-effective Solar Home Systems. **1.1.2:** Solar Home Systems assembled for increasing access to energy and improving living conditions of community members while reducing non-renewable energy needs.
Component 2: Solar power technologies for agro-based industries, rural farm electrification and home-based industries.	**2.1:** Diesel oil replaced with solar power energy for providing agro-based as well as home-based industries with renewable energy.	**2.1.1:** Project areas assessed for site selection as well as design and construction parameters for implementing Solar Farms and transmission facilities. **2.1.2:** Solar Farms and transmission facilities implemented for providing energy for agro-based industries and home-based industries.
	2.2: Resilience of water supply for irrigation enhanced for rural farmers.	**2.2.1:** Deep tube-wells rehabilitated using advanced solar powered technology for increasing water supply from ground sources for irrigation.

Component 3: Strengthened capacity for operating and maintaining renewable energy systems.	**3.1:** Long-term sustainability of Solar Home Systems and Solar Farms.	**3.1.1:** Local representatives trained to use, repair and maintain solar powered systems. **3.1.2:** Training workshops conducted with local communities to increase their awareness on the health benefits of using sustainable sanitation technologies. **3.1.3:** Local communities trained in energy conservation and efficiency practices for reducing energy consumption and fossil fuel usage to complement Solar Home Systems and Solar Farms.
Component 4: Mainstreaming renewable energy for increasing climate change resilience of livelihoods.	**4.1:** Political will enhanced to support Solar Home Systems and Solar Farms.	**4.1.1:** Policy briefs generated focussing on describing the benefits of the project for increasing the climate resilience of livelihoods as well as the cost-effectiveness of solar powered systems for reducing poverty under climate change impacts. **4.1.2:** A proposal formulated and submitted to relevant departments and ministries focused on describing the potential role of government for promoting and supporting Solar Home Systems and Solar Farms. **4.1.3:** A seminar conducted to mainstream the above at a national and regional level.
	4.2: Private sector buy-in and support increased for communities.	**4.2.1:** Meetings held to set up agreements between local communities and private sectors focussed on the potential importance of loans for supporting local community investment in solar technologies.

Agencies Involved: Executing agency: Rural Energy Development Committee; Partner/Cooperating agencies, departments or private sector companies: Ministry of Industry, Ministry of Cooperative, Small and Medium Enterprise, Ministry of Agriculture/ Livestock and Fishery and DDA (Ministry of Progress of Border Areas and National Races and Development Affairs).

Baseline Information: The potential availability of solar energy in Myanmar is ~51973.8 Terra Watt hour/year. The Central Dry Zone, in particular, has abundant solar energy resources available - surveys indicate the radiation intensity during the dry season at 5KW/m^2/day[110]. Harnessing Myanmar's abundant solar energy, however, is still in the initial stages. This is mainly a result of the initial (start up) costs, which are particularly expensive when considering the incomes of rural communities. Some equipment has been installed for villages in remote areas (to demonstrate the effectiveness of Photovoltaic Power Systems) under the Technical Cooperation among the Developing Countries Programme. Furthermore, a number of pilot projects have been carried out under the Solar Photovoltaic Battery Charging Community Enterprise which is financed by Energy Services and Income Generating Opportunities for the Poor (ENSIGN) in collaboration with: i) Yoma Bank; ii) Energy Planning Department (EPD) of the Ministry of Energy and Research (Demonstrative Research on a Photovoltaic Power Generation System in Myanmar); iii) New Energy and Industrial Technology Development Organization (NEDO) of Japan; and iv) Department of Electric Power of Ministry of Electric Power. In addition, a Solar Power Village Electrification Scheme has been implemented by the Myanmar Scientific and Technological Research Department (MSTRD) and the Department of Physics of the Yangon University. Furthermore, universities (e.g. Yangon University) are conducting on-going research into the development of prototypes of solar equipment. Current research is focussed on using solar energy for: i) cooking and other household purposes; ii) water pumps; iii) solar drying for grain and fish products; and iv) salt extraction from seawater.

Climate Change Adaptation Rationale: Increasing the use of renewable energy will stimulate job creation, employment and education as well as increase the effectiveness with which remote communities can receive warnings of extreme weather events. Introducing renewable energy will create an enabling environment for work, studying as well as recreation. This is because at present many vulnerable communities rely on kerosene, candles or diesel oil for lighting and power. Solar energy is a reliable source of "free" renewable energy and has the potential to improve the socio-economic status of rural communities in the face of climate change through: i) providing emergency

[110] Khin May Myint. 2009. Energy Planning Department, Ministry of Energy. Energy Policy Report. Country report also see: http://eneken.ieej.or.jp/data/2594.pdf; and http://www.iim.uni-flensburg.de/sesam/upload/Asiana_Alumni/MyatMon.pdf

lighting; ii) providing purified drinking water; iii) enhancing the effectiveness of national forecasting and early warning systems through providing 24 hours of power supply; iv) creating jobs e.g. agro-based and rural farms; v) boosting village economies through sustainable electrification; vi) facilitating education in remote areas situated away from the national grid; vii) improving health and living standards of rural communities; viii) providing recreational activities and access to information (e.g. television, radio and cell phones) for people living in poverty; ix) maintaining well-lit and secure main roads and streets in remote areas; x) enhancing income through livestock and fisheries; and xi) increasing the effectiveness of health facilities to provide well preserved medicines (e.g. solar freezer power). Solar energy is the cheapest form of energy and the use of Solar Home Systems will reduce the burden of electricity bills on local communities. Although initial upfront payments on the systems are expensive, the payback period is ~5-12 years and the systems last an average of 25 years.

Fourth Priority Project: Increasing climate-resilience of harvested seed/grains through heated-air mechanical drying technologies.

Project Objective: To improve seed/grain storage techniques in the face of climate change to reduce product and associated financial losses.

Project Area/Location: Three project sites in the Sagaing, Mandalay and Ayeyarwady Regions.

Beneficiaries: Small- and medium-scale farmers and rural communities.

Period: 2 years

Estimated Budget: US$ 3 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Mechanical heated-air dryer systems constructed for increasing seed and grain quality and quantity.	**1.1:** Increased resilience of grain/seed drying practices to intense rain and other climate-induced risks.	**1.1.1:** Socio-economic surveys conducted on traditional and conventional seed/grain drying methods used by rural farmers for informing design specification for heated-air and mechanical dryer prototypes. **1.1.2:** Minimum energy requirements determined for effective and thorough drying of grain and seed supplies. **1.1.3:** Drier systems constructed at project sites for increasing the quality and quantity of seed/grain as well as prolonging storage time through: i) more rapid drying times; ii) greater control of temperatures during drying (i.e. reduced overheating); and iii) reducing fungal growth.
Component 2: Technical capacity to develop, use and maintain new drying techniques.	**2.1:** Reduced dependence on sun-drying (on roads) through knowledge transfer on heated-air drying systems.	**2.1.1:** Local representatives trained to use, repair and maintain drier systems established in project sites. **2.1.2:** Workshops conducted with local communities on: i) the agricultural and economic benefits of heated-air drying systems; ii) transferring technical skills for developing/establishing heated-air drying systems; and iii) alternative storage methods to complement heated-air systems to control temperature, moisture, light, pests and hygiene.
Component 3: Awareness raising campaign on the cost-effectiveness of heated-air systems as well as other efficient seed and grain storage methods.	**3.1:** Awareness of the economic benefits of heated-air systems as well as other storage methods increased.	**3.1.1:** Awareness raising campaigns conducted in non-project sites to stimulate the uptake of project activities, e.g. site visits and local demonstrations. **3.1.2:** Guidelines developed for climate-resilient seed/grain storage methods and disseminated to relevant departmental and community representatives.

Agencies Involved: Executing agency: Ministry of Industry; Partner/Cooperating agencies, departments or private sector companies: Ministry of Industry, Ministry of Co operative, Small and Medium Enterprise, Ministry of Agriculture and Irrigation and Department of Development Affairs (Ministry of Progress of Border Areas and National Races).

Baseline information: Increased cropping intensity has resulted in more farmers utilising mechanical equipment for land preparation and seed/grain harvesting and drying. The Agriculture Mechanisation Department (Ministry of Agriculture and Irrigation), the Ministry of Industry and many small-scale private factories are involved in producing and distributing agricultural machinery and equipment. Twenty-four model-mechanised farm villages have been established to demonstrate the benefits of farm mechanisation to local communities. Despite efforts being made by the Ministry of Agriculture and Irrigation, current seed and/or grain drying practices used by rural farmers are not resilient to climate change impacts. Rural farmers generally use sun-drying techniques on the nearest concrete or tarred surface, for example, roads and road verges. As a result of poor land preparation, harvesting and drying practices, Myanmar exports mostly consist of low quality rice that fetches a price per tonne well below that of neighbouring countries.

Climate Change Adaptation Rationale: Traditional methods of drying seed and grain in Myanmar are simple and low-cost when compared to mechanical and heated-air dryers. However, under future climate change conditions, such as intense, sudden and erratic rainfall events, using mechanical and heated-air dryers will reduce losses, improve quality and ultimately result in increased income for rural farmers. At present, during the rainy season rural farmers are incurring post-harvest losses as a result of harvesting and storing seed/grain with high moisture levels. Without appropriate adaptation methods, these post-harvest losses will be further exacerbated under future climate change conditions. Access to heated-air dryers will enable farmers to harvest paddy at higher moisture contents without incurring losses or decreased quantity resulting from fungal infections. Furthermore, mechanical drying can be carried out at any time of the day or night. Seed and grain security will assist communities to prepare for droughts and thus help to address present food insecurity. Effective drying as part of an overall climate change adaptation strategy will result in safer storage, ensuring that feed is available for livestock and seed stock is available in the event of poor harvests resulting from drought events. Higher seed and grain security in the face of climate change will contribute to alleviating rural poverty and enhanced food security for households in Myanmar.

Biodiversity: Priority Adaptation Project Profiles

First Priority Project: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Sister Group Islands of the Myeik Archipelago.

Project Objective: To manage existing MPA area at the Sister Group Islands of the Myeik Archipelago to maximise the resilience of marine biodiversity, fish populations and local community livelihoods.

Project Area/Location: Sister Group islands, Myeik archipelago, Tanintharyi Coastal area.

Beneficiaries: i) Local communities at the Sister Group Island, ii) local fishers, iii) Department of Fisheries, iv) Forest Department, v) Myanmar Fisheries Federation, vi) local communities within the Tanintharyi Coastal area, and vii) local NGOs.

Period: 2 years

Estimated Budget: US$ 800, 000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for effectively designing and managing MPAs under future climate change.	**1.1:** Technical expertise developed on MPA management and design in the face of climate change.	**1.1.1:** Climate change impacts on the marine biodiversity of the Sister Group Islands of the Myeik Archipelago assessed and mapped. **1.1.2:** Socio-economic assessments conducted to document current fishing practices around the Sister Group Islands. **1.1.3:** Ecosystem-sensitive fishery practices developed appropriate for local communities and appropriate for reducing pressure on fish populations and other marine species under climate change conditions. **1.1.4:** An effective MPA system/network determined for maximizing marine biodiversity and fish populations under climate change conditions. **1.1.5:** A monitoring and surveillance local community team established and trained to participate in MPA management and law enforcement activities.
Component 2: Interventions to reduce the vulnerability of marine ecosystems to climate change.	**2.1:** Increased climate-resilience of marine habitats and fish populations through community based MPA management and ecosystem-sensitive fishery practices.	**2.1.1:** Knowledge on ecosystem-sensitive fishery practices transferred to local communities including fishing gear and equipment. **2.1.2:** Training courses and workshops conducted for local fishers and community representatives on ecosystem-sensitive fishery practices as well as the conservation of endangered marine species. **2.1.3:** Equipment (e.g. binoculars, GPS, offices, computers, boats, digital cameras and engines) supplied to local community teams to ensure MPA protection and management through community based surveillance and monitoring practices.
Component 3: Promoting the importance of MPAs for managing climate change impacts.	**3.1:** Decreased stressors on marine ecosystems and therefore increased climate-resilience through support for MPA management and sustainable fishing	**3.1.1:** Public awareness campaign (media, signboards and local workshops) conducted for promoting the importance of MPAs for buffering local communities and their natural resources against climate change. **3.1.2:** Education initiatives designed and implemented on the importance of biodiversity and ecosystem goods/services for climate-resilient livelihoods.

	practices	

Agencies Involved: Executing agency: Department of Fisheries, Forest Department; Partner/Cooperating agencies: Myanmar Fisheries Federation, Relevant NGOs and Regional Conservation Organization/Institutions.

Baseline information: Over the past decade, Myanmar marine scientists have been collecting data (including sampling of specimens) on the marine species and habitats in this region using a range of coral reef, dugong, shark, cetacean and sea grass surveys. As of 2004, the Myanmar Government (through the Department of Fisheries) established two shark-protected areas north of Lampi Island as well as at Ross Island in the Tanintharyi coastal area. At present, Myanmar is collaborating with Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, and Thailand through the Bay of Bengal Large Marine Ecosystem (BOBLME-2010-2014) Project to improve the livelihoods of their coastal communities and protect biodiversity by improving regional management of the Bay of Bengal environment and its fisheries.

Climate Change Adaptation Rationale: MPAs are an important tool for restoring and sustaining the health of Myanmar's marine biodiversity. It is widely accepted that a network of MPAs can positively affect the biomass, abundance, size and diversity of fish species, and that these benefits result in sustained and increased fish catches outside the MPA boundary. MPAs need to be effectively managed in order to maintain or maximize ecosystem resilience, despite the effects of climate change. This can be achieved by ameliorating stressors such as overfishing and excessive nutrient inputs, as well as implementing and expanding MPAs in such a way that the linkages and connectivity among sites are preserved. It is important to use scientific research as well as on-the-ground monitoring activities to determine how climate change is altering the abilities of species to respond to local stressors and climate extremes. Particular roles for using MPAs as adaptation tools include: i) providing ecosystem buffers for people against sudden climatic events and reducing vulnerability to floods, droughts and other weather-induced problems (e.g. intact mangrove ecosystems); ii) supporting marine species to adapt to changing climate patterns and sudden climate events by providing refuges and migration corridors; iii) maintaining/increasing ecosystem goods/services under a changing climate e.g. food supply and disaster risk reduction; and iv) indirectly supporting local economies to adapt to climate change by reducing the costs of climate-related impacts. Networks of MPAs are valuable management tools in the face of climate because they provide potential refugia for species under multiple stresses. Maintaining healthy and resilient marine ecosystem at the Sister Group Islands of the Myeik Archipelago will promote sustainable fish populations and support the protection of marine ecosystems despite climate change impacts in this region.

Second Priority Project: Mainstreaming ecosystem-based climate change adaptation for buffering rural communities against climate change impacts into policy, planning and relevant projects.

Project Objective: To disseminate information and demonstrate the importance of biodiversity and ecosystem services in buffering local communities against climate change impacts.

Project Area/Location: Ayeyarwady, Sagaing and Mandalay Region.

Beneficiaries: i) Local communities of the project areas, ii) Department of Fisheries, iii) Forest Department, and iv) Water Resources Department.

Period: 2 years

Estimated Budget: US$ 1.5 million

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Education and awareness for increasing adaptive capacity.	**1.1:** Sewage and pollution reaching water resources reduced, thereby resulting in cleaner	**1.1.1:** Materials and methods (e.g. training booklets, pictures, videos, pamphlets and posters) developed for use in education initiatives. **1.1.2:** Information on climate change impacts and the importance of biodiversity and ecosystem

	townships.	goods/services disseminated to local communities. **1.1.3:** Environmental Conservation Associations established at local levels (district, township, and village) for vulnerable areas. **1.1.4:** Local conservation teams established to collect sewage from households and clean township areas.
Component 2: Community climate change and biodiversity demonstration sites.	**2.1:** Adaptive capacity of vulnerable communities to climate change impacts increased.	**2.1.1:** Community demonstration sites developed for raising awareness on the benefits of a range of ecosystem-based adaptation technologies, including: water conservation practices, behavioural changes, climate-resilient trees for providing shade for reducing heat stress and other products.

Agencies Involved: Executing agencies: Department of Fisheries, Forest Department and other Government Institutions, Wildlife Conservation Society (WCS), Wet Land Alliance, Corin-ASIA, IUCN, Koicas, Flora and Fauna, Marine Research Foundation, Ocean Park Foundation (OPF - Hong Kong), JICA; Partner/Cooperating agencies: Relevant NGOs, Myanmar Marine Science Association, and Rakhine Coastal Area Environment Conservation Team.

Climate Change Adaptation Rationale: Adaptation actions to climate change through household level activities include water conservation practices, reducing waste and planting climate-resilient shade trees for reducing heat stress and providing multi-use products. Many villages in Myanmar have no electricity or television, and furthermore newspapers and educational programmes seldom reach these villages. Communities generally have a lack of waste disposal systems and release most of their wastes into rivers and streams, resulting in water contamination and a range of water-related health problems. To reduce the vulnerability of these rural households, disseminating climate change information and the 'know how' to adapt to impacts of climate change is urgently needed. Small-scale activities, such as demonstration sites with shade trees for reducing heat-stress, often have more of an effect on communities at a household level compared with large-scale programs. These demonstration sites will be tailored to provide immediate benefits as well as education to remote villages in Myanmar. Local communities will be encouraged to plant climate-resilient trees, use water resources and discard waste in an appropriate and sustainable manner.

Third Priority Project: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at Wetthay Chaing (bay) coastal area.

Project Objective: To manage the Wetthay Chaing coastal MPA in the Ayeyarwady Region to maximise the resilience of marine biodiversity (including the endangered dugong and various turtle species), fish populations and local community livelihoods.

Project Area/Location: Wetthay Chaing, Gwa Township, Rakhine Coastal Area.

Beneficiaries: i) Local communities, ii) Local fishers, iii) Department of Fisheries, iv) Department of Forestry, v) Myanmar Fisheries Federation.

Period: 2 years

Estimated Budget: US$ 800, 000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for effectively designing and managing MPAs under future climate change.	**1.1:** Technical expertise developed on MPA management and design for maximising resilience of endangered species and fish populations in	**1.1.1:** Climate change impacts on the marine biodiversity including the endangered dugong and various turtle species assessed and mapped. **1.1.2:** Socio-economic assessments conducted to identify current fishing practices as well as associated bycatch (dugong and turtle species) within the coastal areas of Wetthay Chaing.

	the face of climate change.	**1.1.3:** Ecosystem-sensitive fishery practices developed appropriate for local communities and appropriate for reducing dugong and marine turtle by-catch. **1.1.4:** An effective MPA system/network developed for maximizing marine biodiversity and fish populations under climate change conditions. **1.1.5:** A monitoring and surveillance local community team established and trained to participate in MPA management, law enforcement activities as well as research and data collection focused on dugong and turtle conservation.
Component 2: Interventions to reduce the vulnerability of marine ecosystems to climate change.	**2.1:** Increased resilience of marine habitats/nesting areas and fish populations through community based MPA management and ecosystem approved fishery practices.	**2.1.1:** Knowledge on ecosystem-sensitive fishery practices transferred to local communities, including fishing gear and mariculture equipment. **2.1.2:** Training courses and workshops conducted for local fishers and community representatives on ecosystem-sensitive fishery practices as well as conservation of endangered marine species (dugong and turtle species). **2.1.3:** Equipment (e.g. binoculars, GPS, offices, computers, boats, digital camera and engines) supplied to local community teams to ensure MPA protection and management through community based surveillance and monitoring practices.
Component 3: Promoting the importance of MPAs for managing climate change impacts.	**3.1:** Decreased anthropogenic impacts on marine ecosystems through increased support for MPA management and sustainable fishing practices.	**3.1.1:** Public awareness campaign (media, signboards and local workshops) conducted for promoting the importance of MPAs for buffering local communities and their natural resources against climate change. **3.1.2:** Education initiatives designed and implemented on the importance of biodiversity and ecosystem goods/services for climate-resilient livelihoods.

Agencies Involved: Executing Agencies: Department of Fisheries, Forest Department and other Government Institutions, Wildlife Conservation Society (WCS), Wet Land Alliance, Corin-ASIA, IUCN, Koicas, Flora and Fauna, Marine Research Foundation, Ocean Park Foundation, (OPF - Hong Kong), JICA; Partner/Cooperating agencies: Relevant NGOs, Myanmar Marine Science Association, and Rakhine Coastal Area Environment Conservation Team, Agencies.

Baseline information: Myanmar marine scientists at the Department of Fisheries conduct surveys and various activities on conserving the endangered dugong as well as turtle species along Myanmar's coast. This work is undertaken in collaboration with international scientists and funded by Wildlife Conservation Society (WCS, USA), Whale and Dugong Conservation Society (WDCS), Ocean Park Foundation OCF (Hong Kong) and Marine Research Foundation (Malaysia). At present, Myanmar is collaborating with Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, and Thailand through the Bay of Bengal Large Marine Ecosystem (BOBLME, 2010-2014) Project to improve the livelihoods of their coastal communities and protect biodiversity by improving regional management of the Bay of Bengal environment and its fisheries.

Climate Change Adaptation Rationale: MPAs are an important tool for restoring and sustaining the health of Myanmar's marine biodiversity. It is now well known that a network of MPAs can positively affect the biomass, abundance, size and diversity of fish species, and these benefits result in sustained and increased fish catches outside the MPA boundary. MPAs need to be effectively managed to maintain or maximize ecosystem resilience, despite the impacts of climate change. This can be achieved by ameliorating stressors such as overfishing and excessive nutrient inputs, as well as implementing and expanding MPAs such that the linkages and connectivity among sites are preserved. It is important to use scientific research as well as on-the-ground monitoring activities to determine how climate change alters the abilities of species to respond to local stressors and climate extremes. Particular roles for using MPAs as adaptation tools include: i) providing ecosystem buffers

for people against sudden climatic events and reducing vulnerability to floods, droughts and other weather-induced problems (e.g. intact mangrove ecosystems); ii) supporting marine species to adapt to changing climate patterns and sudden climate events by providing refuges and migration corridors; iii) maintaining/increasing ecosystem goods/services under a changing climate e.g. food supply and disaster risk reduction; and iv) indirectly supporting local economies to adapt to climate change by reducing the costs of climate-related impacts. Networks of MPAs are valuable management tools in the face of climate because they provide potential refugia for species under multiple stresses. Maintaining a healthy and resilient marine ecosystem at the Wetthay Chaing (bay) coastal area will promote sustainable fish populations and support the protection of marine ecosystems despite climate change impacts in this region.

Fourth Priority Project: Buffering marine habitats and sustaining fish populations under climate change conditions through community-based MPA management and ecosystem sensitive fishery practices at the Thameehla Island, Ayeyarwady Region.

Project Objective: To manage the Thameehla Island coastal MPA in the Ayeyarwady Region to maximise the resilience of marine biodiversity (including endangered turtle species), fish populations and local community livelihoods.

Project Area/Location: Thameehla Island, Ngaputaw Township, Ayeyarwady Region.

Beneficiaries: i) Local communities, ii) local fishers, iii) Department of Fisheries, iv) Forest Department, and v) Myanmar Fisheries Federation.

Period: 2 years

Estimated Budget: US $ 800, 000

Project's Main Components, Outcomes and Outputs:

Main Components	Main Outcomes	Main Outputs
Component 1: Scientific research for effectively designing and managing MPAs under future climate change.	**1.1:** Technical expertise developed on MPA management and design for maximising resilience of endangered marine turtles and fish populations in the face of climate change.	**1.1.1:** Ecological assessments conducted to determine marine turtle nesting areas. **1.1.2:** Climate change impacts on marine biodiversity including endangered turtle species assessed and mapped. **1.1.3:** Socio-economic assessments conducted to identify current fishing practices as well as associated marine turtle bycatch. **1.1.4:** Ecosystem-sensitive fishery practices developed appropriate for local communities and appropriate for reducing marine turtle bycatch. **1.1.5:** An effective MPA system/network developed for maximizing marine biodiversity, turtle conservation and fish populations under climate change conditions. **1.1.6:** A monitoring and surveillance local community team established and trained to participate in MPA management, law enforcement activities as well as research and data collection focused on turtle conservation.
Component 2: Interventions to reduce the vulnerability of marine ecosystems to climate change.	**2.1:** Increased resilience of marine habitats/nesting areas and fish populations through community based MPA management and ecosystem approved fishery practices.	**2.1.1:** Knowledge on ecosystem-sensitive fishery practices transferred to local communities including fishing gear and mariculture equipment. **2.1.2:** Training courses and workshops conducted for local fishers and community representatives on ecosystem-sensitive fishery practices as well as conservation of endangered turtle species. **2.1.3:** Equipment (e.g. binoculars, GPS, offices, computers, boats, digital camera and engines) supplied to local community teams to ensure MPA

		protection and management through community based surveillance and monitoring practices.
Component 3: Promoting the importance of MPAs for managing climate change impacts.	**3.1:** Decreased impacts on marine ecosystems through increased support for MPA management and sustainable fishing practices.	**3.1.1:** Public awareness campaign (media, signboards and local workshops) conducted for promoting the importance of MPAs for buffering local communities and their natural resources against climate change. **3.1.2:** Education initiatives designed and implemented, on the importance of biodiversity and ecosystem services for climate-resilient livelihoods.

Agencies Involved: Lead implementing agency: Department of Fisheries, Forest Department and other Government Institutions, Wild life Conservation Society (WCS), Wet Land Alliance, Corin-ASIA, IUCN, Koicas, Flora and Fauna, Marine Research Foundation, Ocean Park Foundation, OPF (Hong Kong), JICA; Partner/Cooperating agencies: Relevant NGOs, Myanmar Marine Science Association, and Rakhine Coastal Area Environment Conservation Team.

Baseline information: Myanmar marine scientists at the Department of Fisheries conduct surveys and various activities on conserving the endangered dugong as well as turtle species along Myanmar's coast. This work is undertaken in collaboration with international scientists and funded by Wildlife Conservation Society (WCS, USA), Whale and Dugong Conservation Society (WDCS), Ocean Park Foundation OCF (Hong Kong) and Marine Research Foundation (Malaysia). At present, Myanmar is collaborating with Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, and Thailand through the Bay of Bengal Large Marine Ecosystem (BOBLME, 2010-2014) Project to improve the livelihoods of their coastal communities and protect biodiversity by improving regional management of the Bay of Bengal environment and its fisheries.

Climate Change Adaptation Rationale: MPAs are an important tool for restoring and sustaining the health of Myanmar's marine biodiversity. It is widely accepted that a network of MPAs can positively affect the biomass, abundance, size and diversity of fish species, and that these benefits result in sustained and increased fish catches outside the MPA boundary. MPAs need to be effectively managed in order to maintain or maximize ecosystem resilience, despite the impacts of climate change. This can be achieved by ameliorating stressors such as overfishing and excessive nutrient inputs, as well as implementing and expanding MPAs such that the linkages and connectivity among sites are preserved. It is important to use scientific research as well as on-the-ground monitoring activities to determine how climate change alters the abilities of species to respond to local stressors and climate extremes. Particular roles for using MPAs as adaptation tools include: i) providing ecosystem buffers for people against sudden climatic events and reducing vulnerability to floods, droughts and other weather-induced problems (e.g. intact mangrove ecosystems); ii) supporting marine species to adapt to changing climate patterns and sudden climate events by providing refuges and migration corridors; iii) maintaining/increasing ecosystem goods/services under a changing climate e.g. food supply and disaster risk reduction; and iv) indirectly supporting local economies to adapt to climate change by reducing the costs of climate-related impacts. Networks of MPAs are valuable management tools in the face of climate because they provide potential refugia for species under multiple stresses. Maintaining healthy and resilient marine ecosystem at the Thameehla Island, will promote sustainable fish populations and support the protection of marine ecosystems despite climate change impacts in this region.

Annex 2: Summary of Myanmar's Participatory Rural Appraisal

Outline of the PRA Process

Participatory Rural Appraisals (PRAs) were one of the methods used to identify climate change vulnerabilities and adaptation needs during the development of the Myanmar National Adaptation Programme of Action (NAPA). The PRAs were conducted in July-August 2010 at three townships selected mainly for their distinct hazard levels and socio-ecological representativeness. The selected townships were: i) Nyaungshwe in Shan State (Hilly Region, temperate climate, Shan ethnic group); ii) Kyaukpadaung in Mandalay Region (Central Dry Zone, tropical climate, Bama ethnic group); and iii) Bogale in Ayeyarwaddy Region (Delta and Coastal Zones, monsoon climate, Karen and Mon ethnic groups).

Participants in the PRAs were drawn from stakeholders at village and township levels. Six village communities were identified for each township to participate in the assessment. Equal numbers of villagers were selected through UNDP - Integrated Community Development Project (UNDP/ICDP) networks in each village as participants. The UNDP/ICDP is one of the non-governmental organizations involved in community development in Myanmar. Their network of township offices provided access to communities in remote areas during the PRA processes. In addition, the networks provided national PRA teams with a supporting cadre of locally-based and well organised community development volunteers and key informants. Village level representatives were drawn from different socio-economic groups (Table 17) while township level representatives comprised personnel from line departments, local authorities and development agencies (mainly UNDP) who had a stake in food security and sustainable environment. Particular effort was taken to ensure representation of the most marginalized groups and gender equity.

Table 17. Example of villages and village representatives from different socio-economic groups included in the PRA assessment approaches per township surveyed.

Township	Villages and village representatives
Nyaungshwe	• Hill top villages – farmers (shifting cultivation), wood cutters and migrant workers; • Watershed villages – fishermen, individuals involved with handicrafts and migrant workers; and • Lake area villages – fishermen, vegetable growers, weavers and black smiths.
Kyaukpadaung	• Marginalized villages – mining workers, wood cutters and flower collectors; • Villages near Mount Poppa – fruit gardeners, charcoal bakers and seasonal migrant workers; • Villages near urban areas – farmland workers, livestock keepers, potters and palm producers.
Bogale (Ayeyarwady Delta)	• Coastal villages – fishermen, casual labourers • Riverside villages – farmers, fishermen, farm labourers and wood cutters. • Mangrove villages – farmers, fishermen, farm laboureres and wood cutters.

PRAs were conducted over two day periods in each of the townships using a variety of tools and methods[111]. The PRA involved active participation, which enabled all communities to contribute to the identification of adaptation needs. The assessments were mainly driven by local participants and were only facilitated by visiting PRA teams.

Table 18. The variety of participatory tools and methods used by the PRA teams for collecting information and data from vulnerable communities.

PRA Tools and Methods	Issues highlighted
Focus group discussion and individual questionnaires for general assessment of	Vulnerability, community coping strategies and gaps needing to be addressed.

[111] Myrada Group, India 1990. Papers from Participatory Rural Appraisal - Participatory Learning Methods/Experiences (PRA-PALM) Series, http: // www.myrada.org/myrada publication

community vulnerability to climate change/ climate variability.	
Seasonal calendar for assessment of climate change.	Most frequent and important observed seasonal climate changes (from 2001 – 2011) which require immediate adaptation.
Seasonal calendar for assessment of climate variability.	Seasonal variability in frequency and intensity of extreme weather events (from 2001-2011).
Historical trend lines for the assessment of impacts of climate changes and climate variability on different sectors.	Information on decade-wise climate change affects regional environment, agriculture, forestry, biodiversity, energy and industry and water resources (1980-2010).
Matrix ranking for assessing vulnerability of people's lives, properties, assets, livelihood and opportunities to climate change/variability.	Climate effects on people's lives, properties, assets, livelihood and opportunities.
Consensus seeking on selection of criteria for prioritizing adaptation measures.	Criteria for prioritizing adaptation measures.
Consensus seeking on identification of adaptation measures.	Adaptation measures identified.
Prioritization of adaptation measures by using agreed criteria (including pair-wise ranking to break ties).	Priority list of adaptation measures.

Summary of PRA Results

Nyaungshwe Township, Shan State (Hilly Region)

Socio-ecological Setting

The Shan Plateau in eastern Myanmar is an extensive, mountainous upland ranging from 1,000 to 2,300 m in height. The area covers the watersheds of four of Myanmar's most important reservoirs: Kinda, Inle, Paung Laung and Zawgyi. The land rises and falls in gentle slopes. Areas that have been stripped of their natural forest are subject to severe erosion. Erosion from the uplands threatens to clog these reservoirs with silt, endangering much of the country's hydropower production and irrigation water supplies for the lowlands. The main staple crop is rice, but many other crops are also grown, including wheat, maize, chilli, cotton, potatoes, groundnuts, sesame, pulses, tea, tobacco and cabbages. The rainy season lasts from mid-April to mid-November.

Farmers in Shan State face numerous problems. The soils are generally infertile, and crop and livestock yields are low. The area's isolation and lack of infrastructure make it difficult for farmers to sell any surplus produce at a profit. Landholdings are small, and population growth forces farmers to overexploit the natural resources. This includes cutting trees for fuel wood and clearing land on steep slopes for cultivation. This environmental degradation further reduces yields, reinforcing a vicious cycle of poverty.

Nyaungshwe is one of the 52 townships in the Shan State with an average elevation of ~899 m above sea-level. Inle Lake, which is situated in the lowest part of the Nyaungshwe basin, is the main water source for Lawpita and Baluchaung Hydro-electricity Stations. Average annual rainfall is about ~940 mm. The maximum temperature is 31.5 ^{o}C and minimum temperature is 16.9 ^{o}C.

Inle Lake which is the natural heritage site of the Inn Tha and Shan is facing serious environmental problems. The annual siltation rate determined by the Irrigation Department is reported to be 10 t ha^{-1} year^{-1}. As a result the lake is shrinking in size and its water holding capacity is reduced every year. Further, excessive use of pesticides in the floating garden and use of chemical dyes by weaving communities have contributed to serious chemical pollution in the lake. The people around the lake are already feeling the impacts as: i) the availability of fish in the lake is declining; ii) water level for irrigation and transportation is shrinking; iii) water quality for drinking and cleaning is degrading; and iv) outbreaks of skin and other water borne diseases are common.

The following is a list of the: i) observed climate change/variability; ii) observed impacts of climate change/variability; and iii) identified adaptations interventions as indicated by the Nyaungshwe township communities.

Observed Climate Change and Climate Variability

- warmer summers and colder winters;
- less rain, untimely rain, more frequent heavy rain/ inundation;
- increased temperature extremes and droughts;
- stronger winds; and
- More erratic changes of temperature.

Observed Impacts of Climate Change and Climate Variability

- destruction of crops by hoarfrost;
- inundation of plantation and human settlements by torrential rain in mountain valleys;
- loss and damage to agricultural crops;
- damage to livestock breeding;
- damage to fishery works;
- decrease in the quality and quantity of locally produced crops;
- deterioration of markets;
- low economic activity related to local products;
- transport difficulties caused by damaged roads and bridges;
- damage to settlements and bridges by strong winds;
- development activities hampered by poor transport and communications;
- unsettled social attitudes resulting from decreased job opportunities;
- migration of workers to other areas (with the possibility of human trafficking) as a result of job shortages;
- low investment in health care and education as a result of insufficient family incomes;
- drying up of river channels/creeks as a result of scarce rain;
- decreased income from fish sales as a result of increased dryness and droughts;
- reduced availability of water for domestic use as a result of increased dryness;
- reduced availability of wood fuel for domestic cooking as result of drought and intense rain;
- settlements destroyed by forest fires as a result of increased dryness;
- production in betel plantations affected by increased dryness and fires;
- damage to crops and increased exposure of human beings and livestock to diseases as a result of untimely rains;
- higher operational costs as a result of increased use of pesticides and fertilizers;
- insufficient incomes and difficult living conditions;
- increases in health problems such as cough, cold, flu, diarrhea; and
- reduced availability of safe drinking water and spread of water borne diseases as a result of flooding.

Identified Adaptations Interventions

- preservation of natural plants;
- reforestation;
- maintenance of dams, irrigation network and dykes;
- sustainable extraction of wood for fuel using proper forest management practices;
- village owned wood forests;
- health education;
- breeding climate-resilient livestock and crops;
- maintaining bridges and roads;
- developing climate-resilient income streams and livelihoods;
- systematically maintaining wells and ponds to meet health standards;
- solving the problem of fuel wood moistening by unseasonal and intense rain; and
- solving the problem of fuel wood scarcity as a result of drought.

Kyaukpadaung Township, Mandalay Region (Central Dry Zone)

Socio-ecological Setting

The Dry Zone of Myanmar is located in the central part of the country and is characterised by an acute scarcity of water, infertile soils and severe soil erosion. Almost all of the annual 500-750 mm of rain falls in the monsoon period from May to October. Rainfall is erratic and droughts are common.

The landscape of the Dry Zone is undulating, and soils are mainly sandy with some clay and sandy loam in the valley bottoms. Soils are generally nutrient poor and shallow, and are easily eroded by intense rains and strong winds. The main crops are sesame, pigeon pea, green gram, groundnut, cotton and sorghum. Yields are low, and crops often fail because of the irregular rainfall. The population density is relatively high, and there is a trend towards fragmentation of landholdings. In order to survive, farmers are forced to cut trees for fuel wood, cultivate marginal soils, and graze cattle and small ruminants on the remaining scant natural vegetation. All these practices encourage further erosion resulting in gullies forming in the remaining farmland, which turns potentially valuable land into wasteland.

An estimated 290,000 families (1997) throughout the area are landless and are forced to survive by migrating to other parts of the country in search of employment. Poor accessibility restricts access to markets. Formal credit sources are scarce and informal sources are expensive.

The following is a list of the: i) observed climate change/variability; ii) observed impacts of climate change/variability; and iii) identified adaptations interventions as indicated by the Kyaukpadaung township communities.

Observed Climate Change and Climate Variability

- more variable monsoon periods (i.e. increased or decreased duration and late or early onset); and
- higher temperatures and more frequent droughts.

Observed Impacts of Climate Change and Climate Variability

- increasing incidences of poor health among humans and animals;
- reduced crop yields as a result of fluctuating crop cultivation seasons and increased pest infestation;
- increase in pig (e.g. Porcine Respiratory and Reproductive Syndrome) and cattle diseases;
- crop failures and yield losses as a result of drought (e.g. in 2006);
- excessive sweating, fatigue and loss of energy as a result of intensive heat;
- drought and water shortages;
- destruction of trees by strong winds;
- flooding and breakage of pond embankments as a result of heavy rains;
- migration of labour force;
- crop cultivation seasons delayed by lingering droughts resulting in low crop yields and poor livelihoods;
- lack of economic opportunities resulting in people being unable to educate their children effectively;
- reduced water levels in village ponds, creeks and streams causing water shortages and insufficient drinking water for cattle;
- late onset of monsoon delays grass growth which results in insufficient fodder for animals;
- parents with limited economic resources remove their children from school prematurely to assist with work at home;
- poor incomes deprive poor people of adequate and timely health care;
- increased vulnerability of domestic animals to seasonal diseases;
- difficult living conditions force people to migrate to other places and increase their susceptibility to disease;
- farmers suffer low crop yields;
- diminishing returns from agricultural sectors;
- loss of regular jobs by landless rural labourers and increase in casual wage labour;
- poor health as a result of climate change, especially among children and the elderly;
- difficult living conditions foster character delinquency and low ethical standards within society;

- low regeneration of forests and drying up of creeks and streams as a result of climate change; and
- poor blossoming of long term fruit trees (eg. mango, plum and tamarind).

Identified Adaptation Interventions
- crop cultivation;
- vaccinating livestock and quarantining infected animals;
- avoiding settlement in areas prone to landslides;
- evacuating communities living at the foot of the dam;
- ensuring food security for people;
- formation and operation of fire watch team;
- construction of water collection tanks;
- keeping children and elderly under cooling shade and providing light dresses;
- improving drainage systems;
- providing health education on safe water supplies;
- conducting immunization programmes;
- keeping away from risky buildings;
- reporting to concerned departments e.g. health care at health departments;
- mobilizing work teams to provide assistance; and
- restoring degraded forest areas.

Bogale Township, Ayeyarwaddy Region (Delta and Coastal Zone)

Socio-ecological Setting
The Ayeyarwady Delta is an important river delta in Myanmar. The delta is covered by vast swamp land. Formerly covered with dense mangrove forests, most of the area has been cleared in the last 35 years to grow rice and to produce charcoal for local use. Although the production of charcoal in the Delta was banned in 1993, illegal cutting by landless people desperate to earn a living continues. Little undisturbed forest now remains.

The destruction of the mangroves has had severe effects on the environment. Salt water seeps into groundwater and intrudes into creeks, making well water undrinkable, reducing crop yields, and turning valuable farmland into saline wasteland. Tidal flooding is becoming more severe, and without the absorbing effect of the mangrove trees, the coast and river-banks are being eroded. Traditional forest products, such as timber, building poles, fuel wood, charcoal and nipa-thatch roofing, are becoming scarce and expensive. The mangroves used to act as breeding grounds and nurseries for many important species of fish and prawns. However, as a result of degradation and overfishing activities catches are dwindling.

The Delta has a dense population (6 million in Ayeyarwady Region alone), and many people have no land. Families live on boats, moving from village to village in search of work, and catching fish to eat. Although many bridges have been constructed over the area in the recent decade, transportation in many places of the area is still hampered by criss-crossed creeks and canals.

Over 40% of the coastal population depend on mangroves and fisheries for their livelihood (nearly 60% in the poorest parts). (1997) The overexploitation and decline of these resources trap these people in a cycle of environmental degradation and poverty.

The following is a list of the: i) observed climate change/variability; ii) observed impacts of climate change/variability; and iii) identified adaptations interventions as indicated by the Bogale township communities.

Observed Climate Change and Climate Variability
- increased temperatures;
- more intense rainfall, droughts, and floods;
- more frequent rain storms; and
- fluctuation in the onset of monsoon seasons.

Observed Impacts of Climate Change and Climate Variability

- increasing incidences of diseases;
- diminishing marine stocks (fish and shrimp);
- saline water intrusion;
- decreasing fresh water sources;
- increased hardships for fishermen as result of climate change;
- crop failure as a result of unstable weather;
- increases in crabs and other insect pests in crop fields;
- loss of homes and property due to storms;
- damage to paddy plants due to untimely rain;
- decline in crop yields, living standards and business activity;
- fishing boats destroyed by bad weather and damage to fishing industry;
- people and cattle struck by lightning;
- outbreak of diarrhea and other contagious diseases as a result of flooding;
- increased incidences of heatstroke, especially in children and the elderly;
- increased livestock deaths;
- injuries and deaths suffered by the elderly, women and children;
- increased incidences of fishermen losing their lives and catches after boats capsizing during storms;
- wood cutters crushed under trees felled by strong winds;
- increased problem animals e.g. snakes and crocodiles;
- increased risk of fire imposed by rising temperatures and strong winds;
- people suffering from skin diseases caused by untimely rain;
- people traumatized by impact of disasters;
- children missing classes and their education suffering as a result of climate change;
- people injured or loss of life by fallen trees and debris during earthquakes and tsunamis;
- loss of forest-based business opportunities as a result of decreasing forest products (e.g. *inter alia* firewood, charcoal, timber, bamboo);
- loss of lives and property;
- weakening community development activities and religious activities;
- decreasing incomes and lower living standards;
- increased health problems (diarrhea, malaria, and other contagious diseases);
- health problems (diarrhea, heat stroke, skin diseases, brain haemorrhage) among the elderly, hard laborers and cattle;
- flooding as a result of intense rainfall;
- increased hardships among farming and fishing communities as a result of the effects of floods on agriculture and fisheries;
- drinking water shortages as village ponds dry up;
- river bank erosion;
- loss of land and property for communities living on river banks;
- delayed sowing and transplanting times as well as reduced crop yields as a result of late monsoons;
- crop failure as a result of early monsoons; and
- low incomes and difficult living conditions for casual farm labourers as a result of falling agricultural production.

Identified Adaptation Interventions

- construction of embankments to prevent saline water intrusion;
- establishment of fruit and vegetable gardens for income generation;
- regeneration of mangrove forests along coastal areas to protect marine habitats, mitigate natural disasters and enhance the provision of firewood, construction materials and organic fertilizers;
- growing of improved high yield paddy varieties that are resistant to saline water and drought;
- introduction of new crop varieties (sea sesame) which are adapted to local environments and attract higher prices to replace paddy crops in the event of declining paddy yields and prices;
- establishment of alternative income sources, such as animal/fish raising activities on a manageable scale or confined animal/fish breeding;
- preparation for hazards through planning e.g. bringing sufficient fresh water and dried food on fishing trips;
- regular monitoring of and response to weather broadcasts by fishermen;
- use of radios by fishermen during fishing trips;

- storage of sufficient fresh water to prepare for natural hazards;
- stocking of preventive medicines (western and indigenous) in anticipation of emergencies; and
- organising task force teams as well as transportation (boat drivers, boats and fuel, etc) for transporting emergency case victims to the nearest clinics.

Prioritization and Ranking of Identified Adaptation Interventions

Climate change adaptation options identified during the PRA process were ranked and prioritized in order to narrow down the list of options for consideration by NAPA sector Working Groups. Adaptation needs identified by local communities are summarised below for a number of socio-economic sectors/themes.

Agriculture

- weather resistant seed (including high yield paddy varieties), crops, and livestock;
- early maturing crops;
- small dams and canals for irrigation;
- soil conservation methods such as contour terraces for improving soil fertility and crop yields;
- cultivation of drought-resilient and ecologically adapted perennial trees (e.g. dragon fruit) using horticultural methods;
- drought-resistant local tree varieties (e.g. tamarind, mango, neem, lead tree and cutch tree);
- adaptive agriculture technologies to complement existing agriculture practices;
- technology focused on creating floating farmlands (cultivated gardens) in the Inle Lake areas (Eastern Hilly region); and
- sustainable and enhanced paddy cultivation.

Early Warning Systems

- community based early warning systems including community training on preparing for, responding to and recovering from extreme weather events;
- construction of fire prevention ponds;
- mangrove/shelter belts;
- flood water drainage canals;
- provision of life jackets for flood events;
- formation of disaster risk reduction committees in villages;
- training and public education on disaster awareness and preparedness;
- earlier warnings prior to extreme weather events to allow for improved preparation; and
- disaster risk reduction subjects included in curriculum of primary schools.

Forest

- land ownership agreements focused on decentralization of forest ownership e.g. regionally owned and managed forests and/or village owned and managed forests;
- fuel-wood substitution through sustainable woodlots or other mechanisms;
- capacity building for technologies for restoring degraded forests including, seed collection; cleaning; storage and sowing as well as plant cuttings propagation and planting out;
- fire-breaks within forests and around community villages;
- natural and/or artificial slopes/walls (e.g. small-scale ponds/dams, dykes, natural restoration) to regulate water levels in vulnerable lake areas;
- restoration of mangrove forests (tidal woods); and
- reforestation using multi-use/benefit tree species such as mango, tamarind, lead tree and cutch trees.

Public health

- raising public health funds;
- dissemination of preventive healthcare information and education;
- construction of a maternity and general healthcare centre;
- construction of rural health centres and provision of health staff;
- formation and training of healthcare service teams/organizations (e.g. Red Cross teams);
- provision of medicinal supplies;
- construction of approach bridges to improve accessibility to clinics;
- construction of fly-proof latrines to prevent drought-induced diseases; and

- provision of latrine pans and pipes.

Water Resources
- renovation of village ponds (e.g. raising embankments to improve storage capacity);
- construction of filtration systems at village water ponds;
- construction of gravity-flow water supply systems (by tapping uphill water sources);
- construction of additional tube wells;
- plantation of appropriate trees and shrub species around water sources;
- construction of canal systems between cultivated fields;
- technical and geological expert input for the construction of river embankments and weirs to prevent rivers from bank erosion;
- construction of emergency water tanks for fire fighting; and
- construction of rain water collection and storage tanks to address water shortages during flood and drought events.

Coastal Zone
- plantation of mangrove forests (tidal wood);
- construction of dykes/sea walls for the protection of coastal paddy fields against sea flooding and salt water intrusion; and
- restoration of mangrove forests (tidal wood) in degraded areas (as a result of human activity and extreme weather events) to assist with erosion control.

Energy and Industry
- reduction of the reliance on fuel wood by using coal-dust fuel blocks;
- dissemination of technology (such as appropriate stoves) to enable the use of the stems of paddy and legume plants as an alternative fuel source;
- use of alternative energy sources (e.g. solar energy, biogas, wind power, etc) as a solution to the fuel wood shortage;
- provision of electricity generators and other relevant equipment (e.g. wiring and lighting tubes) for village lighting;
- construction of fly-proof latrines;
- construction of inter-village roads/water ways in Inle lake;
- renovation of weather-damaged roads and village paths; and
- construction and maintenance of roads and small bridges for improved inter-village communication.

Biodiversity
- small-scale aquaculture ponds and equipment/technologies for fish and prawn/shrimp farming
- locally adaptable fish species for small-scale aquaculture practices;
- improve regulations for marine species harvesting and fishing seasons;
- improved measures to communicate regulations to communities;
- improved fish yields for ensuring income for fishermen;
- provision of fishing gear and apparatus; and
- mangrove restoration.

Annex 3: The observed temperature and rainfall from weather stations across Myanmar. Data recorded from 1951 – 2007 (some stations only started recording in 1961, 1971, and 1981).

Represented Physiographic Region	State/ Region	Station	Mean Annual Temperature (mm)	Increase per decade (°C)	Mean Annual Rainfall (mm)	Increase per decade (mm)
Northern Hilly	Kachin	Myitkyina	24.1	0.2	2,195	64.71
	Upper Sagaing	Hkamti	24.1	0.04	3,570	215.2
	Lower Sagaing	Monywa	27.3	0.3	785	-17.4
Central Dry	Mandalay	Mandalay	27.5	0.2	864	13.14
	Magway	Magway	27.2	-0.23	800	57.1
	Chin	Hakha	16.0	0.13	1,742	50.5
Western Rakhine	Rakhine	Sittway	27.0	0.13	4,555	52.06
Eastern Hilly	Northern Shan	Lashio	21.9	0.14	1,381	33.62
	Southern Shan	Taunggyi	19.4	0.16	1,555	-5.48
	Eastern Shan	Kengtung	23.0	0.01	1,297	-2.51
	Bago	Bago	26.9	-0.16	3,798	-81.08
Ayeyarwady Delta	Ayeyarwady	Pathein	27.2	0.08	2,904	36.4
Yangon Deltaic	Yangon	Kaba Aye	27.4	-0.04	2,684	41.74
	Kayah	Loikaw	27.4	-0.04	1,089	-11.17
	Kayin	Hpa-an	27.2	0.32	4,346	-23.6
	Mon State	Mawlamyine	27.1	0.14	4,816	71.57
Southern Coastal	Taninthayi	Dawei	26.6	-0.01	5,499	7.8

Annex 4: Myanmar's predicted temperature and rainfall from seven weather stations according to the Providing Regional Climates for Impacts Studies (PRECIS) model.

Future changes of temperature and precipitation have been estimated for Myanmar using a number of global and regional climate models. For the purpose of this NAPA, the predictions from the model 'Providing Regional Climates for Impacts Studies' (PRECIS) are reported. The model was conducted using 20 km x 20 km resolution, and operated by the South East Asia System Analysis Research and Training Regional Centre (SEA START RC) using an A2 emissions scenario (Table 19.). Modelled data for the period 1971-2000 were used as the baseline information. Data recorded at seven stations were used. These stations were assumed to be representative of the eight physiographic regions (Table 20).

Table 19. Future changes in temperature and precipitation for Myanmar based on a number of global and regional climate models.

Station	1971-2000 (baseline)		2001-2020		2021-2050		2051-2099*	
	Annual Mean Temperature (°C) (SD)	Annual Rainfall (mm) (SD)	Annual Mean Temperature (°C) (SD)	Annual Rainfall (mm) (SD)	Annual Mean Temperature (°C) (SD)	Annual Rainfall (mm) (SD)	Annual Mean Temperature (°C) (SD)	Annual Rainfall (mm) (SD)
Myitkyina	24.3 (0.45)	2203 (197)	24.9 (0.58)	2431 (346)	25.4 (0.52)	2400 (331)	27.8 (1.012)	2870 (400)
Mandalay	27.7 (0.66)	931 (164)	28.1 (0.69)	1037 (202)	28.5 (0.58)	1085 (158)	30.7 (0.948)	1202 (301)
Sittway	24 (0.39)	4117 (891)	24.6 (0.33)	4073 (790)	25.1 (0.35)	4778 (1130)	27.2 (0.888)	5699 (1358)
Kengtung	23.3 (0.44)	1314 (198)	23.7 (0.47)	1340 (218)	24.3 (0.46)	1350 (166)	26.4 (0.794)	1523 (266)
Yangon	27.4 (0.45)	2661 (344)	28.1 (0.28)	2604 (437)	28.8 (0.51)	2805 (367)	30.9 (0.904)	3075 (401)
Pathein	27.2 (0.41)	2960 (497)	27.8 (0.23)	3005 (556)	28.4 (0.42)	3252 (499)	30.5 (0.857)	3593 (485)
Dawei	27.6 (0.34)	3547 (850)	28.1 (0.17)	3489 (692)	28.7 (0.38)	3701 (876)	30.4 (0.727)	4221 (902)

* (PRECIS computes only up to 2099)

Table 20. The weather stations used for the Providing Regional Climates for Impacts Studies (PRECIS) model, detailing the relevant state and physiographic region represented by each station.

Weather Station	Administrative Unit	Represented Physiographic Region	Mean Height Above Sea-Level
Myitkyina	Kachin Division	Northern Hilly	145m
Mandalay	Mandalay Division	Central Dry Zone	93m
Sittwe	Rakhine State	Rakhine Coastal	5m
Kengtung	Shan State	Eastern Hilly	827m
Yangon	Yangon Division	Yangon Deltaic	28m
Pathein	Ayeyarwaddy Division	Ayeyarwaddy Delta	4m
Dawei	Taninthary Division	Southern Coastal	16m

Annex 5: Comprehensive list of Myanmar's national and multilateral treaties and agreements

Name of National and Multilateral Treaty or Agreement
Plant Protection Agreement for the Southeast Asia and Pacific Region
Treaty Banning Nuclear Weapons Tests in the Atmosphere in Outer Space and Under Water
Outer Space Treaty: Treaty on Principles Governing the Activities of States in the Exploitation and Use of Outer Space including the Moon and other Celestial Bodies
Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-Bed and Ocean Floor and in the Subsoil there of (Seabed Treaty)
Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological and Toxin Weapons, and their Destruction
Vienna Convention for the Protection of the Ozone Layer
Montreal Protocol on Substances that Deplete the Ozone Layer
MARPOL: International Convention for the Prevention of Pollution from Ships
MARPOL: International Convention for the Prevention of Pollution from Ships as amended 1978
Agreement on the Networks of Aquaculture Centres in Asia and the Pacific Region
London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer
United Nations Framework Convention on Climate Change (UNFCCC)
Treaty on the Non-Proliferation of Nuclear Weapons
ICAO: ANNEX 16 Annex to the Convention on International Civil Aviation Environmental Protection Vol. I, II, Aircraft Noise
United Nations Convention to Combat Desertification
Vienna Convention for the Protection of Ozone Layer
Montreal Protocol on Substances that Deplete the Ozone Layer
London Amendment to the Montreal Protocol
Convention Concerning the Protection of the World Cultural and Natural Heritage
Convention on Biological Diversity (CBD)
United Nations Convention on the Law of the Sea
International Tropical Timber Agreement (ITTA)
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
ASEAN Agreement on the Conservation of Nature and Natural Resources
Catagena Protocol on Biosafety
ASEAN Agreement on Transboundary Haze Pollution
Kyoto Protocol to the United Nations Framework Convention on Climate Change
Convention on the Prohibition of the Development, Production, and Stockpiling and Use of Chemical Weapons and on their Destruction
Stockholm Convention on Persistent Organic Pollutants
Ramsar Convention on Wetlands
Copenhagen Amendment to Montreal Protocol on Substances that deplete the Ozone Layer
Hyogo Framework for Action
ASEAN Multi-Sectoral Framework on Climate Change