State of Eritrea

Ministry of Land, Water and Environment

Department of Environment

National Adaptation Programme of Action

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Preface

Eritrea is a Least Developed Country situated in an arid and semi-arid region of Sahalian Africa. The country has low adaptive capacity relative to constraints in wealth, technology, education, institutions, information, infrastructure and social capital. This renders Eritrea highly vulnerable to climate variability, extreme weather events, and long-term climate change.

Eritrea has special needs regarding adaptation to climate change. With low-lying coastal regions, arid and semi-arid areas, areas liable to drought and desertification, areas with fragile ecosystems including mountainous ecosystems, and an economy highly dependent on consumption of fossil fuels and associated energy-intensive products, Eritrea is particularly vulnerable. An overriding need is for developed country parties to the Convention to take full account of these circumstances in order to facilitate the transfer of needed technology and resources so that effective adaptation can continue to take place.

Climatic hazards such as temperature increases, reduced precipitation, chronic drought, flash flooding, heat stress, El Niño effects, and sea level rise are expected to adversely affect food security, water supply, public health, wildlife, coastal resources and fragile ecosystems are raising serious concerns in Eritrea about a changing climate. Those of its citizens most likely to be affected are also those least able to cope. These include subsistence farmers, spate and irrigated well farmers, pastoralists, the rural poor, small-scale traders, urban and semi-urban poor, artisanal fishermen and island inhabitants. These groups are already finding it difficult to cope with increasing climatic variability. Women, children, and elderly people are particularly vulnerable.

The NAPA process in Eritrea was designed to be consistent with ongoing national strategies, plans, and frameworks for sustainable development. The resulting prioritized adaptation projects are closely linked with national plans regarding poverty reduction, improving food security, disaster preparedness and prevention strategies, and promoting sustainable development. At the policy level, the NAPA process in Eritrea has been actively seeking to identify ways to mainstream adaptation to climate change into national development processes by inclusion of climate and vulnerability in sectoral and development policies.

As the climate change Focal Point in Eritrea, I believe the priority adaptation projects identified through the consultative process possess great potential to help vulnerable groups through relieving hardship, safeguarding livelihoods, improving food security, and strengthening education. The experience gathered in developing the NAPA also lays important groundwork for long-term climate change adaptation activities in Eritrea.

Eritrea's NAPA document is not an end in itself, but a way for us to present to the international community our highest priority actions that are urgently needed to adapt to climate change. Each priority project will need strong donor support coupled with effective local project implementation, monitoring and evaluation programmes. I take great pride in the work accomplished thus far and eagerly look forward to seeing priority adaptation projects successfully implemented in Eritrea.

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List of Acronyms

CC	Climate Change
CBA	Cost Benefit Analysis
CBOs	Community Based Organizations
CCD	Convention to Combat Desertification
CEA	Cost Effectiveness Analysis
CO_2	Carbon Dioxide
COP	Conference of the Parties of UNFCCC / UNCBD / UNCCD
EINC	Eritrean Initial National Communication
FAO	Food and Agriculture Organization of the United Nations
GCM	General Circulation Model
GEF	Global Environment Facility
GDP	Gross Domestic Product
IDPs	Internally Displaced People
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Countries
LDCF	Least Developed Countries Fund
LEG	Least Developed Countries Experts Group
MCA	Multi Criteria Analysis
MDGs	Millennium Development Goals
M&E	Monitoring and Evaluation
MEAs	Multilateral Environmental Agreements
MIAT	Multidisciplinary Integrated Assessment Team
MLWE	Ministry of Land, Water & Environment
MOA	Ministry of Agriculture
MOF	Ministry of Fisheries
MOEM	Ministry of Energy & Mines
MOH	Ministry of Health
MOTC	Ministry of Transport & Communication
MOTI	Ministry of Trade & Industry
NAPA	National Adaptation Programme of Action
NBSAP	National Biodiversity and Strategy Action Plan
NCCC	National Climate Change Committee
NRDS	Northern Red Sea
RBM	Roll Back Malaria
SNC	Second National Communication
SRDS	Southern Red Sea
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
V & A	Vulnerability and Adaptation
WHO	World Health Organization

1. Introduction and Setting

The National Adaptation Program of Action (NAPA) of Eritrea has been developed based on a review of existing studies and extensive stakeholder input. Climatic shocks have already produced serious negative impacts on rural and urban livelihoods in Eritrea. Unless addressed, Eritrea is likely to become increasingly susceptible to impacts from climate variability and climate change.

Population and Geography

Eritrea is located at the northern part of the Horn of Africa, between latitudes 12° 40? and 18° 02I North of equator and longitudes 36° 30? and 43⁰ 20? east of Greenwich. It has a landmass area of, about 125,700 km^2 inclusive of the islands, and a coastline spanning some 1,720 kilometres. It shares borders with Sudan in the north and west, with Ethiopia in the south, and with Djibouti in the southeast (see Figure 1 below).

Figure 1-1: Map of Eritrea

Source:www.lib.utexas.edu/maps/africa/eritrea_pol86.jpg

Eritrea's physical features are characterized by central and northern highlands extending for about 350 km north to south; flat coastal plains of the eastern lowlands; and flat plains of western lowlands interspersed with hills. The altitude across the country varies considerably, from 1,500 to 2,400 meters above sea level in the highland area; from 0 to 500 meters in the eastern lowland areas; and from about 700 to 1,400 meters in the western lowlands.

The population of Eritrea is estimated at 3.56 million as of 2003 National Statistics with an annual growth rate of about 2.7 percent. Much of the population is clustered in the cooler climates of the central highlands. More than 80% of the population live in rural areas.

Climatic Patterns

Eritrea's climate regime is highly variable, being influenced by the expanding Sahel-Saharan desert, the proximity to the Red Sea and the land's physical features. Altitude and topography play major roles in determining climate in general and temperature in particular. Typically, mean annual temperature declines by 1°C for each 200-meter rise in elevation. Ambient average temperatures vary considerably, with the eastern lowland having an annual mean of 31 °C reaching as high as 48 °C; while in the highland areas the annual mean is 21 °C with a maximum of 25 °C. In the western lowland areas, the annual mean is 29 °C with a maximum of 36 °C.

The whole country is divided into six agro-ecological zones representing two rainfall regimes, summer and winter, whose patterns and amounts are affected by the difference of physiognomic regions. The summer rains are brought by south-westerly monsoon winds and are concentrated mainly in the months of July and August. They affect the central highland and the western lowland areas. The winter rains typically occur from November to March and are influenced by the north-easterly continental winds. These rains affect coastal areas and the eastern and southern escarpments.

Eritrea has a mostly arid climate with about 70% of its land area classified as hot and arid and receiving average annual rainfall of less than 350 mm. The main rainy season in

most parts of the country is from June to September. There is also a short rainy season involving a small number of highland areas which occurs between March and May. In the eastern coastal areas and parts of the adjacent escarpment, the rainy season is between December and February. The eastern lowland has an average annual rainfall between 50 and 200 mm; while northern areas, given that they fall within the eastern limit of Sahelian Africa, receive less than 200 mm/year of rain. Southern areas experience average annual precipitation of 600 mm, with the central highland areas receiving about 400-500 mm per year.

A main feature of rainfall patterns in Eritrea is the *extreme variability within and between years*, and *spatial variation over very short distances*. The southwest monsoon winds are responsible for the main and small summer rains in Eritrea. The northern and north-eastern continental air streams are responsible for the winter rains along the coast and in southern part of the escarpment of the central highlands. The northern and north-eastern winds are dry in their nature but take moisture while crossing the narrow Red Sea water body.

Infrastructure

Eritrea is currently confronted with major infrastructural challenges. Since the end of the war for independence with Ethiopia (1961-1993), significant strides have been made in the development of critical infrastructure.

Although the extent and the quality of infrastructure are still inadequate to attract private investment, Eritrea has made significant progress in rehabilitating and expanding its basic infrastructure. Power generation has been critical to investment opportunities in the past but with the commissioning of the Hirgigo project, Eritrea's power generating capacity has been boosted from 35 MW in 1991 to more than 135 MW in 2002.

Road transport has been very much damaged by the 30-year war of independence. The Government has made considerable progress to rehabilitate old roads and to construct new ones, particularly linking the productive regions to major consumption canters. Nonetheless, with the road density of only 0.6 Km per square Km and 2 Km per 1000 people, many challenges still remain.

Efforts are also being made to improve the seaports at Massawa and Assab. Eritrea has a steadily improving education, health facilities, telecommunication and postal services throughout the country.

Economy

The 30-year liberation war for independence has resulted in the destruction of economic and social infrastructures. Immediately after independence in 1994, however the Government formulated economic policy in a Macro-Policy Paper. This policy document encouraged, *inter alia*, private investment in various sectors and the establishment of an efficient, outward looking private sector-led market economy.

Eritrea is a poor country with an estimated annual GDP of about US$ 180 per capita according to World Development Report of 2003. Agriculture, fisheries, industries, tourism and mining, *inter alia*, play an important role in the economic development of the country.

Agriculture accounted for about 21 % of the GDP as of 2003. Over 80% of the population depend on traditional subsistence agriculture, including crop production and livestock husbandry. However, agricultural production is affected by a host of factors including high rainfall variability with recurrent and long drought periods, continuous degradation of the soil, frequent pest outbreaks and lack of research and extension services. About 66% of population was below the poverty line in 2003 according to national Statistics Office.

Poverty is concentrated in rural areas, and is most severe in arid highland areas.

Marine and coastal resources, particularly fisheries, are recognized as one of the very important areas, which could have a very crucial role in the economic development of the country. Eritrea has the potential to sustainably harvest around 70,000 tones of fish annually, but nonetheless the current fish catch is known to be around 13,000 metric tones per year. Having 1900 km of coastline, Eritrea has a very high potential not only to exploit its fish and other marine resources but also has an excellent opportunity to develop its tourist industry.

Eritrea is also believed to have good potential of minerals including gold, copper, potash, silver, marble, oil and natural gas. The potential of gold, petroleum and gas is believed to be high. Mining is believed to have good prospects in contributing to the economic development of the country. Mining and Quarrying on the average accounted for about 1.5% of GDP for the period 1992-1997.

Industry accounts for about 22% of GDP and the balance of national income is accounted for by the service sector, which was 58% of GDP in 2002.

Eritrea's long-term development objective is to attain rapid and widely shared economic growth with macroeconomic stability and a steady and sustainable reduction in poverty. The transitional medium-term (2004-06) objectives sought to promote economic growth and development including developing exports, increasing agricultural productivity, attracting investment in fisheries, tourism, construction, manufacturing, developing strong financial sector, and expanding and modernizing the country's basic infrastructure. During this transition period, Eritrea's immediate development priorities have been to meet the basic needs of the population, achieving macroeconomic stability, managing the public debt, rehabilitating and expanding infrastructure and resettlement and reintegration.

Institutions

Eritrea did not inherit a sound institutional set up from the previous regime. All administrative, legal, commercial, judiciary and regulatory institutions started to be established after 1991. Although considerable progress has been made in this respect much remains to be done to achieve a standard that can help to facilitate the integration of adaptation concerns into national policy making.

The Department of Environment (DOE) in the Ministry of Land, Water & Environment is the major institution responsible for coordinating environmental actions in Eritrea. In addition, there are several Ministries that deal with environmental issues in their areas of mandate such as the Ministry of Energy & Mines, the Ministry of Agriculture, the Ministry of Trade & Industry, the Ministry of Fisheries, the Ministry of Transport & Communication, University of Asmara, the Ministry of Public works, and the Ministry of Health.

The National Environmental Management Plan for Eritrea was adopted in 1995 and provides the basic policy document for action in the environmental sector and lays out a strategy for action for conservation activities. Its guiding principles include recognition of the strategic importance of conserving natural resources and maintaining environmental quality as a part of national economic growth and development processes, to develop integrated and multiple uses of natural resource use strategies at the same time ensuring local involvement and equity in environmental.

The Ministry of Agriculture (MOA) develops agricultural strategies and policies. Regarding improvements of existing crops, technologies and traditional knowledge systems, the National Agricultural Research Institute (NARI) has been conducting

research on different agronomic crops including breeding for drought and diseases resistant cultivars. Regarding forestry policy, the MOA, in consultation with all stakeholders, has prepared a draft policy. This draft has sought to integrate many climate change adaptation issues.

To facilitate the implementation of "National Integrated Water resources Planning development and Management Strategy", a set of management tools, policies and legislative guidelines, taking into account of climate change concerns, have been prepared.

To safeguard the sustainability of marine resource and protect the country's marine and coastal biodiversity, the Government has adopted two proclamations and thirteen legal notices. There is also an ongoing project entitled Eritrean Coastal, Marine and Island Biodiversity (ECMIB) Project aimed to address the environmental and marine biodiversity concerns of Eritrea in the Red Sea Region.

Finally, every institution both governmental and NGO is required to conduct ***Environmental Impact Assessment*** before implementing any development project using the "National Environmental Impact Assessment Procedures and Guidelines". Some institutions are developing their own procedures and guidelines in consultation with relevant stakeholders, mainly the Department of Environment.

Development Challenges and Vulnerability to Climatic Variability

As indicated above, traditional subsistence agriculture dominates the Eritrean economy, with the overwhelming majority of the population dependent upon crop production and/or livestock husbandry to support their livelihoods.

Over 66% of the population lives below the poverty line. The average Eritrean household lives on approximately US$ 15 per capita per month, with slightly wealthier families living on US$ 317 per capita per month Currently, 80% of those living in rural areas support themselves through subsistence farming.

Small-scale farmers dominate the agricultural sector. Typically, such farmers are living in conditions of persistent poverty and rely on rain-fed and traditional practices. This combination renders them highly vulnerable to climate variability. The eradication of poverty through improved agricultural production is among Eritrea's primary development objectives. Poverty is deeply entrenched in rural areas, home to a majority of the population living on less than US$1 per day.

Numerous other development challenges are taking place simultaneously with increasing climate risks. For example, depletion of forests – primarily for household fuel use – threatens biological diversity, human communities, and reduces other valuable services forests provide.

2. Framework for Adaptation Programme

The vulnerability of communities and economic sectors in Eritrea to climate-related impacts is primarily associated with weather fluctuations in the near term (i.e., climate variability), as well as fluctuations in weather patterns over the long term (i.e., climate change). Current major climate hazards are discussed in the sections below relative to the nature of the hazard and the serious threats they pose to local livelihoods, ecosystems, and economic sectors.

Key Climatic Hazards

The main climatic hazards identified in the course of the desktop and participatory vulnerability assessments are as follows:

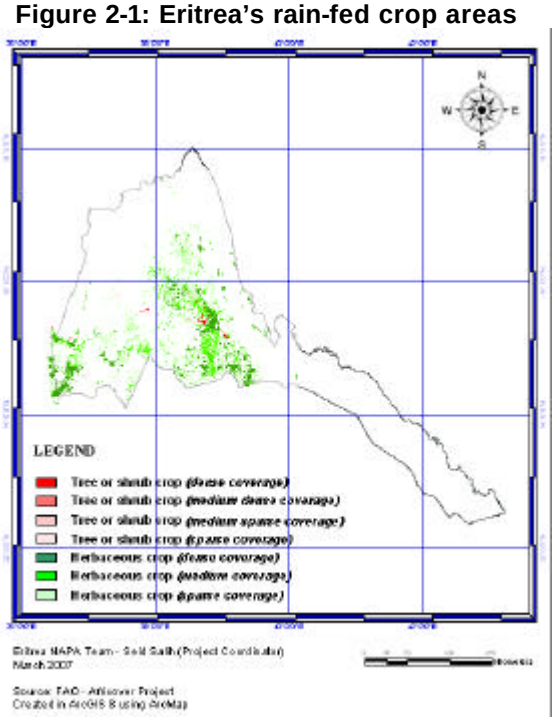
- *Increased climatic variability:* Relative to baseline conditions, there have been observed changes in average, range, and variability of temperature and precipitation throughout the country;
- *Recurring drought:* The occurrences of dry spells, seasonal droughts and multi-year droughts are more frequent than in the past;
- *Flash flooding:* there has been a perceived increase in episodes of torrential rainfall with heavy runoff and flooding; and
- *Sea level rise:* Coastal areas and the hundreds of Eritrean islands in the Red Sea are susceptible to rising sea levels associated with climate change.

Key Vulnerabilities

Eritrea's Initial National Communication (INC) showed that a doubling of carbon dioxide concentrations would lead to an average temperature increase 4.1 ^{o}C. Rainfall is also expected to be seriously affected by climate change, varying by a ratio ranging from 0.1 in 0.15. Such long-term changes in climate will have serious adverse impacts on agriculture, water resources, forestry, coastal environments, and human health. Moreover, impacts are already being observed in each of these sectors, as briefly outlined below:

- *Agriculture:* Relative to total surface area, Eritrea has modest land resources for rain-fed cultivation (see Figure 2-1). Small rains that usually occurred during April/May have all but disappeared. In recent years, the main rainy season starts later and finishes earlier than the historical pattern resulting in some wheat and millet varieties, as well as some native cultivars, disappearing from production, due to recurring rain-fed crop failures. New crops pests are appearing that have been previously unknown or uncommon. Irrigated crops are also adversely affected due to depletion and drying of water wells on which irrigation depends, as well as unusually heavy flooding during the rainy season. These circumstances are increasing the heavy toll on subsistence farmers.

Figure 2-1: Eritrea's rain-fed crop areas



- *Livestock:* Frequent droughts between 1992 and 2004 have led to the deaths of thousands of cattle and camels. In

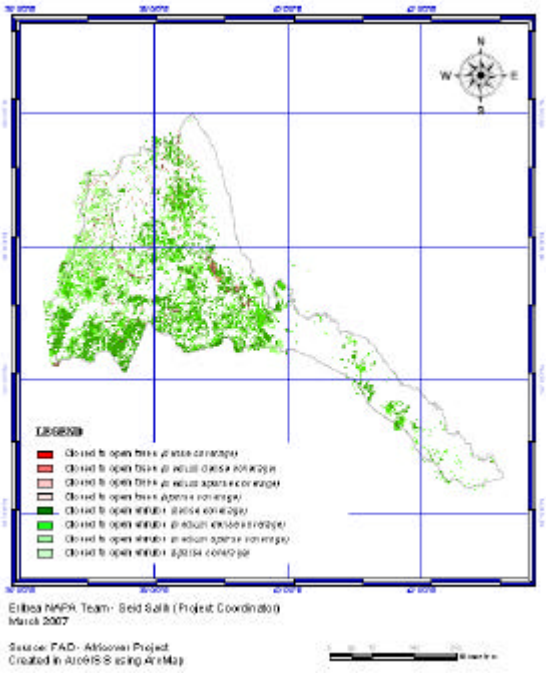
addition, thermal stress is increasingly exceeding thresholds that animals can tolerate, leading to decreased feed intake, interference with animal productive and reproductive functions, requiring a shortening of grazing hours, and increasing exposure to pathogens. Pastoralists in the eastern lowlands and north-western rangelands are the most vulnerable to these patterns.

- *Forestry:* Most of Eritrea's land areas are characterized by sparse to medium coverage of shrubs with almost not areas covered with trees (see Figure 2-2). Climate variability impacts soil moisture and adversely affects the growth of shrubs and trees. As temperature increases, it has been observed that there are increasing shortages of biomass both for energy and local house construction, as well as declines of biomass products such as frankincense, gum Arabic, doum palm leaves, wild fruit, wild medicine and fodder. The most vulnerable species are those shallow rooted with narrow temperature tolerance including *Dodonaea angustifolia, Psiadia punctulata, Meriandra bengalensis* and *Otostegia integrifolia* in the eastern and western escarpments of the country and those with slow growing habits such as *Olea africana and Juniperus procera.*

- *Water Resources:* Eritrea has an extensive river system with seasonal flow pattern (see Figure 2-3). However, recurrent drought, warmer temperature and high evaporation pattern are resulting in smaller stream flows, lower groundwater level, deterioration in water quality, and disappearance of base flows which are the sources of water supply for urban, rural, livestock and industry. All towns located in the upper part of the major drainage basins (Mendefera and Dekemehare) or at the water shade dividing ridges (Adikeyih and Barentu) are particularly vulnerable. On the other hand, most of the coastal villages are located with in less than 15 km distance from the sea. Fresh and scarce groundwater is found mostly underneath the larger ephemeral rivers and is extracted using very shallow open wells. Because of these sources proximity to the sea and its arid climate, the coastal village's water supplies are very sensitive for salt-water intrusion and flooding.

- *Coastal and Marine Environment:* the distress of coral reefs in the Red Sea as a result of temperature *rise* has had a devastating effect both on Eritrean fisheries as well as the reefs themselves. Temperature changes affect through impacts on food and nutrient supply, growth, survival, reproduction, prey-predator dynamics and habitat. Similarly, temperature increase causes toxic algal blooms (such as red tide) that threaten the shellfish population through lethal and chronic impacts. Climate change is likely impacting mangroves and sea grasses through altered sediment budgets.

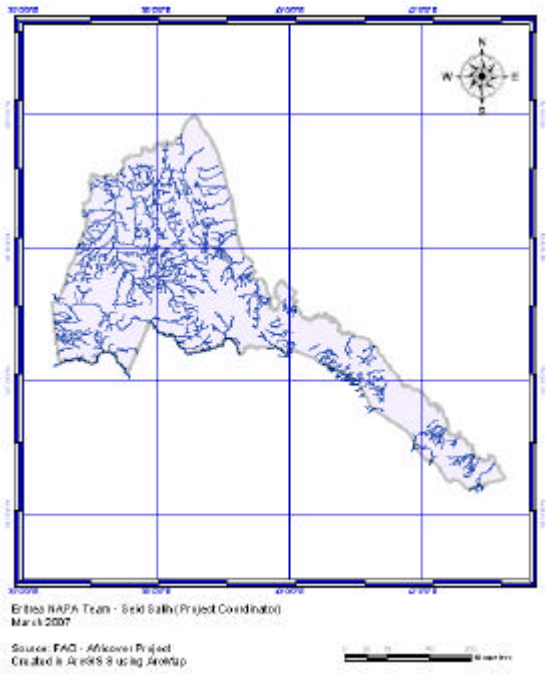
Figure 2-2 Eritrea's biomass coverage



- *Public Health:* Malaria has now been observed at altitudes close to 2,000 metres in Eritrea, a new phenomenon that is attributed to climate change.

Increasing climate variability will exacerbate food security and lead to malnutrition, impaired child development and decreased adult activity. Also, diarrhea is being manifested from flooding and drought events. During floods, the spread of infective micro-organisms and parasites increase contamination particularly of waste. During drought, water supply is decreased creating difficulties in maintaining hygiene.

Figure 2-3: Eritrea's river systems



National Goals, Plans, and Frameworks

The NAPA process in Eritrea was designed to be consistent with ongoing national strategies, plans, and frameworks. In particular, the NAPA process is closely linked and highly complementary with existing national development plans regarding food security, poverty reduction and sustainable development.

Strong linkages have been established under the NAPA framework with a number of key national initiatives. These include Eritrea's Poverty Reduction Strategy, the National Environmental Management Plan (NEMP), Eritrean Initial National Communication (EINC), Multilateral Environmental Agreements (MEAs), United Nations Development Assistance Framework (UNDAF), disaster preparedness and prevention strategies, and various sectoral ongoing and formulated projects and policies.

Moreover, the NAPA process in Eritrea has been actively seeking to identify ways to mainstream adaptation to climate change into national development processes, by inclusion of climate and vulnerability in sectoral and development policies that are complementary to climate change. In particular, there are several national policy processes that have parallel aims to climate change adaptation have been the focus of scrutiny. Some of them are listed below.

- *Poverty reduction strategy:* Major portions of Eritrea's interim Poverty Reduction Strategy Paper (2007) focuses on an overview of the nature of poverty in Eritrea and a statement of the Government's commitment to poverty reduction. It lays out the Government's macroeconomic framework and steps to create the conditions for resuming rapid economic growth, and policies and programs for poverty reduction. It represents an initial articulation of a national strategy that aims at directly impacting on poverty through broad based economic growth and targeted interventions. The strategy and the processes followed in its formulation are country-owned and reflect national priorities and local realities.
- *Environment Management Plan:* The plan comprises four parts, each consisting of several sections. The first part considers environmental and developmental prospects for Eritrea within a broader (i.e., international) context, including the United Nations Conference on Environment and Development (UNCED). The second part addresses the major environmental and development issues confronting Eritrea. The third part defines major steps and responses involved in an

integrated environmental and development planning process. The last part examines in detail the requirements for implementation of the plan and its associated project activities, institutional prerequisites, and financial/human resources.

- *Initial National Communications:* As part of its obligation under the UNFCCC, Eritrea communicated a range of information to the COP through its initial national communication submitted in 2001. There is close linkage between the initial national communication and the NAPA process, particularly as related to vulnerability and adaptation assessments with key findings from the NAPA process to be integrated into Eritrea's Second National Communication (SNC). Most members of the NAPA team have been retained for the vulnerability and adaptation assessment to be undertaken as part of the SNC. Many of the issues, concerns and needs identified in the NAPA process will be further explored in the SNC while taking advantage of stakeholder networks established.
- *National Capacity Self-Assessment:* The NCSA has already identified the major capacity requirements of Eritrea in the three main environmental agreements including CBD, UNCCD and UNFCCC. Adaptation and capacity building are considered in NCSA project as being cross cutting issues that would promote synergy between and among the UNFCCC, CBD and UNCCD. NCSA helps identify key deficits in institutional capacity and institutional linkages and aids the process of creating synergies. The experience gained by the Eritrean NCSA team during the preparation of NCSA will also enable Eritrea to implement its SNC.
- *Sustainable Development Summit:* Eritrea's assessment of national progress on sustainable development is highly relevant to NAPA, particularly in that it creates an informative snapshot of the country's policy and programmatic successes, upon which an adaptation strategy might be built, as well as its persistent and emerging areas of unsustainable development and vulnerability.
- *Development Assistance Framework:* The UNDAF is intended to represent "collaboration and coherence in the UN Programmes of assistance", an endeavor which includes a range of climate change adaptation and adaptation-relevant activities. In achieving its overarching goal of contribution to the reduction in absolute poverty in Eritrea, UNDAF will pursue activities in six major areas including the highly relevant areas of food security and sustainable agricultural development.
- *Multilateral Environmental Agreements:* The United Nations Convention on Biological Diversity (UNCBD) has many direct, potential linkages to adaptation to climate change, including its topical foci (e.g., ecosystem vulnerability), its policy recommendations (e.g., maintaining ecosystem resilience and adaptive capacity), and its participating institutions at the national and international level. For each of these areas, there are strong potential synergies with the adaptation recommendations identified in the NAPA and EINC. Similarly, the United Nations Convention to Combat Desertification and Mitigate the effects of Drought (UNCCD) has many potential linkages to adaptation to climate change, including its topical foci (e.g., ecosystem vulnerability), its policy recommendation (e.g., improved natural resource management), and the overlap in participating institutions. For each of these areas, there are strong potential synergies with the adaptation recommendations identified in the NAPA and EINC.

Barriers to the Implementation of NAPA Results

Eritrea faces numerous challenges and barriers when it comes to the implementation of urgent and immediate activities identified by the NAPA process. Some of the major barriers that will need to be overcome can be summarized as follows:

- *Institutional Organization.* Institutional coordination is lacking in the implementation of development projects and Multilateral Environmental Agreements (MEA). Due to the lack of a clear and transparent legal framework, institutional organization is sometimes inappropriate and has overlapping mandates and responsibilities that create conflicts of interest among stakeholders;
- *Capacity:* There is also a chronic shortage of human resources and skills essential for the implementation of potential adaptation initiatives;
- *Policy gaps:* While Eritrea has macro policies in place, there is a lack of regional and/or micro policies for the various socio-economic sectors. Where regional/macro policies are in place, they suffer from important gaps that inhibit effective action toward sustainable development. There is also a lack of regulatory mechanisms for existing legislation and sectoral policy. Lack of approved laws and regulations that are directly linked with CC like environmental law, water law, and maritime code have not being approved.
- *Lack of clear institutional mandates:* There is no clear mandate and responsibility among institutions as a result there is duplication and overlap of activities; and
- *Funding:* There is concern that inadequate funding both at the national and international levels may limit the level of implementation of all measures identified in the Eritrea NAPA.

3. Identification of Key Adaptation Needs

Eritrea is a country of rich resource potential, richly varied geography, and dedicated human capability. It has made significant development strides as it emerges from a long-running war in promoting sustainable development policies, engaging in international environmental processes, and seeking to strengthen its human and institutional capacity.

Climatic risks pose a serious challenge to Eritrea's emerging development priorites for agricultural development, livestock raising, forestry conservation, water resource management, coastal and marine environmental protection and safeguarding public health. For each of these sectors, adaptation options have been identified on the basis of desk-based assessments coupled with ground-truthing through extensive stakeholder consultations, including individuals from governmental agencies, non-governmental organizations, and grass roots communities across the country.

In the subsections below, major adaptation needs and initiatives are summarized relative to the key vulnerable sectors identified during the regional stakeholder consultation processes in the coummities around Masawa, Asmara and Keren. These needs represent the outcome of consultations that addressed climatic hazards, priority vulnerabilities, and existing coping strategies.

Vulnerable Groups in Urgent Need of Adaptation

In Eritrea, the groups that are most vulnerable to climate risks are those that directly depend upon natural resources for their livelihood. Women, children, and elderly people are the most affected in any group. A brief description of each vulnerable group appears below.

- *Subsistence farmers:* These include rain-fed and spate and well-irrigated farmers. Subsistence rain-fed farming is particularly vulnerable to climatic hazards due to the low adaptive capacity and practices that are increasingly incompatible with climatic variability. Small-scale irrigation farmers are also vulnerable because decreased rainfall and drought reduce the availability of irrigation water thus affecting productivity. Flooding also destroys wells and other irrigation infrastructure.
- *Rural dwellers:* Forest or woodland-dependent rural inhabitants are also highly vulnerable. People that harvest gum and incense, as well as women that derive their livelihoods by weaving doum palm leaves and selling wood and other forest products are also vulnerable social groups.
- *Pastoralists:* Pastoralists are most impacted by recurrent drought through reduced livestock production and reduced livestock products such as milk.
- *Urban poor:* The urban poor are vulnerable to thermal stress and sea level rise through destruction of livelihood activities, price increases in local market, increases in diseases burden such as Acute Respiratory Infections (ARIs), shortage of water both in quantity and quality due to drought and salt water intrusion and shortage of fuel wood.
- *Fishermen:* Artisanal fisheries will be vulnerable to sea level rise in a different ways through low harvests that result from erosion and sedimentation of the coral reefs and mangroves which are breeding sites for fisheries.
- *Island residents:* Inhabitants of Eritrean islands in the Red Sea are vulnerable to climatic hazards through growing shortages of freshwater both in quantity and quality due to saltwater intrusion.

While each of the above communities is already adversely affected to some degree, long-term climate change will deepen their vulnerability to a variety of health impacts. The most highly impacted will be people with low immunization, refugees, rural children, pregnant women, pre-school children and people living in camsin areas.

Key Adaptation Activities

In many parts of Eritrea, the vulnerable groups identified above have devised numerous kinds of coping strategies to deal with agricultural production in the face of climatic variability. However, many of these strategies are proving to be no longer effective. Key adaptation activities needed in each of the vulnerable sectors are briefly summarized below.

Agriculture

Major adaptation activities and needs identified for crop production during stakeholder consultations are as follows:

- Improve soil fertility and moisture retention using conservation, fertilization, and alternative cropping techniques;
- Increase water supply through irrigation, water diversion structures, ponds, wells, and the optimization of farming practices;
- Control pests and plant diseases through regular weeding, crop rotation, and planting of appropriate crops;
- Time crop cultivation in direct response to changing patterns of rainfall; and
- Breed drought- and disease-resistant high-yield crops to maintain and/or improve crop production levels.

Livestock

Major adaptation activities and needs that have been identified for livestock production during stakeholder consultations are as follows:

- Implement community-based development and/or rehabilitation of rangelands in specific areas;
- Select animal species and breeds more able to cope with climatic variability;
- Establish dairy production models suitable for specific areas;
- Increase job opportunities in order to diversify household income; and
- Reduce overall livestock numbers, while simultaneously improving productivity livestock retained.

Forestry

Major adaptation activities and needs that have been identified for tree- and shrub-covered areas during stakeholder consultations are as follows:

- Encourage afforestation of degraded landscape/watersheds by constructing terraces, micro basins, and check dams;
- Promote agroforestry practices as a way of diversifying land production systems;
- Plant a mix of drought resistant indigenous and fast growing exotic species through community forestry inititives;
- Encourage natural regeneration through enclosures augmented with enrichment planting in biodiversity protected areas;
- Promote wood energy substitutes (solar, wind, kerosene, liquid propane gas, electricity) and wood consumption efficiency (i.e., improved stoves); and
- Encourage alternatives for wood in traditional house construction

Water Resources

Major adaptation activities and needs that have been identified for water resource management during stakeholder consultations are as follows:

- Improve water use efficiency by introducing water saving irrigation

systems like drip and sprinkler irrigation;

- Enhance groundwater rechariging mechanisms;
- Develop effective soil and water conservation projects;
- Increaser awareness, education and training for farmers, MoA staff and Zoba offices on resource utilization, particularly on soil/water conservation;
- Upgrade the existing national climatological network;
- Increase knowledge of water resources through stream flow gagging stations for major river basins and groundwater monitoring;
- Introduce/expand irrigated agriculture, especially spate-irrigated agriculture for crop/livestock production;
- Promote good water resource management and efficiency through new regulations; and
- Conduct impact and adaptation research on water resources.

Marine and Costal Zones

Major adaptation activities and needs that have been identified for coastal zones and marine ecosystems during stakeholder consultations are as follows:

- Strengthen Integrated Coastal Area Management (ICAM) practices;
- Promote research to bridge existing knowledge gaps regarding sea level rise;
- Implement a management programme for mangroves;
- Introduce marine and coastal infrastructure protected areas;
- Promote traditional adaptation measures such as natural bench nourishment;
- Provided assistance for relocation of island inhabitants; and
- Develop accessible community awareness programmes on climate change and adaptation options.

Public Health

Major adaptation activities and needs that have been identified for the protection of public health during stakeholder consultations are as follows:

- Establish drought early warning systems;
- Improve the quality of water supply and sanitation systems;
- Improve emergency preparedness;
- Encourage supplementary feeding;
- Upgrade health infrastructures (i.e., enhance vaccination, improving housing standards, monitor and raise awareness of vectors and diseases); and
- Develop integrated control approach for vector-borne diseases.

Proposed Adaptation Projects

During regional stakeholder consultations, numerous specific projects were identified for each type of key adaptation need identified above. These projects were considered to have the potential to decrease vulnerability of key groups and sectors relative to climate variability, extreme events, and long-term climate change.

Overall, there were a total of 102 specific adaptation projects across the crop, livestock, forestry, water resource, coastal and marine environments and public health sectors (see Table 3-1 for a summary). A complete listing of these projects is provided in Annex 1 in tabular form, which also includes a listing of current coping strategies and programmes.

Table 3-1: Adaptation projects identified

Vulnerable sector	Number of potential adaptation projects
Agriculture	18
Livestock	9
Forestry	15
Water resources	29
Marine & coastal zones	14
Public health	17
Total	102

4. Criteria for Selecting Priority Projects

The potential adaptation projects listed in Annex 1 had sufficient consensus among stakeholders to warrant their evaluation relative to a set of criteria. This section provides an overview of the process that was used to develop locally-driven evaluation criteria to rank potential adaptation options emerging from the stakeholder consultations.

The criteria were ultimately used in a multi-criteria assessment of potential adaptation options using *NAPAssess*, a tool for multi-criteria assessment that integrates the various components of a multi-criteria assessment (i.e., scoring, weighting, standardization, and project ranking).[1]

Stakeholders and Evaluation Criteria

Throughout the NAPA process in Eritrea, there was an emphasis on the engagement of local stakeholders. This provided a basis for determining appropriate trade-offs between potential adaptations initiatives directly related to the unique concerns of the range of stakeholders engaged.

A list of key types of stakeholders is summarized in Box 1 below. The role of stakeholders in the development of evaluation criteria was focused on providing a better understanding of the key metrics that they would use in judging the performance of adaptation activities. Several regional and national extensive stakeholders discussions were held with the coummities drawn from all regions of Eritrea.

Approach to Developing Criteria

The process for the development of evaluation criteria was threefold. First, the general criteria suggested by the NAPA Annotated Guidelines were reviewed against existing national policies and action plans related to national development priorities. This resulted in an initial set of evaluation criteria that emerged as findings from the initial desk-based assessment of possible criteria.

Second, in order to integrate the needs and concerns of local communities and other segments of vulnerable communities, the NAPA team developed a set of locally-driven evaluation criteria based on specific economic, social, cultural and environmental factors that emerged from stakeholder consultations in the coummities around Masawa, Asmara and Keren.

- Rural heads of households
- Farmers
- Pastoralists
- Fishermen
- Urban and semi urban dwellers
- Government officials
- Academic researchers
- NGO representatives
- CBO representatives
- Community leaders
- Regional officials
- Women's groups
- Agriculture/health extension
- Local school teachers

Box 1: Types of stakeholders consulted

Finally, a high-level expert group drawn from various national stakeholder institutions, as well as the technical committee of NAPA, merged these two sets of evaluation criteria into one final and practical set that was then used for the prioritization of adaptation projects. The stakeholders involved at this level of consultation were all based in Asmara.

As a practical matter, the total number of criteria was kept to a manageable level by combining those criteria that tended to have a high degree of overlap. This helped to reduce the analytical burden associated with the manipulation of the scoring matrices that

[1] The *NAPAssess* model, available from http://130.64.126.18/SEIUS/napassess/index.asp, was tailored to Eritrean conditions.

were developed. The expert group also assigned weights to the final list of criteria based on their understanding of the stakeholder perspectives that emerged during the consultation process.

In all, the final list of evaluation criteria included seven key criteria that emerged from the process described above. These criteria are listed below together with a short description. They are listed in order of highest to lowest weighting. It is important to note that these criteria represent a mix of both quantitative and qualitative indicators and were fully established and approved by stakeholders assembled.

- *Reduction of threats or impacts of climate change:* This refers to the potential of adaptation measures to significantly contribute to a reduction of the adverse impact of extreme events and climate variability. The relative weight of this criterion was 20%.
- *Cost-effectiveness and feasibility:* This refers to the degree of implementation ease, overall cost, potential to overcome barriers, and long-term sustainability relative to the conditions and constraints of the vulnerable groups identified. The relative weight of this criterion was 20%.
- *Impact on vulnerable groups and resources:* This refers to the potential of adaptation measures to relieve hardship, safeguard livelihoods, improve food security, and strengthen education, particularly among the vulnerable groups identified. The relative weight of this criterion was 20%.
- *Synergy with multilateral environmental agreements:* This refers to the compatibility of adaptation measures with existing national action plans that have been developed to combat desertification and preserve biodiversity resources. The relative weight of this criterion was 10%.
- *Synergy with national plans:* This refers to the compatibility of adaptation measures with national sustainable development, poverty reduction, and resource conservation policies and strategies. The relative weight of this criterion was 10%.
- *Contribution to poverty reduction:* This refers to the potential of projects to contribute to the creation of adaptive capacity among the vulnerable groups identified. It is particularly related to how adaptation projects can contribute to income growth of poor people in both urban and rural areas. The relative weight of this criterion was 10%.
- *Equity:* This refers to the potential for the adaptation measures to be equitable regarding gender, income distribution opportunities, empowerment across communities, and risk reduction across livelihoods. The relative weight of this criterion was 10%.

Assigning Scores to Evaluation Criteria

Once the evaluation criteria were fully identified, each of the 102 adaptation projects (see Annex 1) that had been proposed by the stakeholders was assigned a raw score for each of the proposed criteria. The process of assigning raw scores took place one vulnerable sector at a time. That is, adaptation projects were evaluated relative to other projects within the same vulnerable sector. For example, potential adaptation projects in agriculture competed against only those projects that were agriculture-based.

These raw scores were determined on the basis of discussions - sometimes quite extensive – with stakeholders. Where necessary, uncertainty in stakeholder consensus was resolved on the basis of the best judgement as exercised by the NAPA team under the direction of the Project Coordinator.

Standardization and Weighting

Once all raw scores had been assigned, they were standardized using conventional mathematical techniques. Once standardization process was complete, the weight assigned by stakeholders to each criterion was integrated into the analysis and a final weighted score for each of the 102 potential adaptation projects was developed.

These final weighted scores made it possible to rank the projects in the order of their importance, as perceived by the stakeholders affected and relative to the individual vulnerable sector categories. The top 22 of the overall 102 projects appear in Table 4-1, ranked relative to all the other projects in the vulnerable sector in which they were classified.

Table 4-1: Ranked Set of Potential Adaptation Projects for Each Vulnerable Sector

Sector	Key Adaptation Needs/Activities	Sectoral ranking
Agriculture	Breeding Drought and Disease Resistant Crops	**1**
	Biological Soil and Water Conservation (use of vegetative contour hedges)	2
	Construction of Diversion Structures to let in Rain Water in to Spate Fields	3
	Construction of stone and earth bunds	4
Livestock	Introducing community based pilot projects to intensify existing production models, area and species specific in eastern and northwestern lowlands selecting suitable sheep and goat breeds.	**1**
	Introducing community based pilot rangeland improvement and management in selected agro-ecological areas in the eastern and northwestern lowlands rangelands.	2
Forestry	Encourage afforestation and agroforestry through community forestry initiative	**1**
	Encourage natural regeneration through enclosures	2
	Encourage the use of improved wood stoves (Adhanet)	3
	Conservation and management of the highland forest ecosystem	4
Water Resources	Groundwater Recharge for Irrigation Wells	**1**
	Introduction and expansion of irrigated agriculture especially spate irrigated agriculture (for crop and livestock production).	2
	Implement rural and urban water supply project by construction of new dams, ponds and wells.	3
	Construction of livestock watering points	4
Marine & Coastal zones	Strengthening formulation and development of integrated coastal zone management	**1**
	Mangrove afforestation programs	2
	Establishing marine protected area	3
	Constructing protection structures for the most vulnerable coastal infrastructure	4
Public Health	Infant Young Child Feeding (IYCF) including supplementary feeding, therapeutic feeding (severe), and breast feeding	**1**
	Epidemic forecasting, early warning and response (Surveillance)	2
	GMP (Gross Monitoring program) at community level including information, communication & counseling, training and organization, and guidelines on feeding	3
	Integrated vector management including indoor residual spraying, insecticide-treated nets, and breeding site control.	4

5. List of Priority Activities

The process for the final prioritization of adaptation projects across vulnerable sectors was twofold. First, the top-ranked sectoral projects that emerged from the process described in the previous section were identified. This resulted in the 22 projects identified in Table 4-1 in the previous section being put forward as the highest priority adaptation activities for Eritrea.

Then, as a final step, these highest priority projects were themselves ranked by a group of technical experts, subject matter specialist and senior policymakers, most of them are members of the *National Steering Committee*, to produce a final prioritized set of projects across all vulnerable sectors. This represents a final prioritized list of the most needed projects in Eritrea to meet the urgent and immediate needs of vulnerable communities for adaptation to increasing climatic risks.

Highest Priority Adaptation Projects

Each of the highest ranked sectoral adaptation projects aims to support and improve livelihoods in Eritrea relative to the set of vulnerable sector identified earlier, particularly among those living in rural communities.

The development of the final list of priority projects attempted to rank the five highest priority projects. The subject matter specialists, experts and senior policymakers who conducted the final evaluation and project rankings sought to ensure that the final outputs of the NAPA process would be well linked to the government's ongoing strategies to reduce poverty.

The resulting prioritized options as summarized in Table 5-1 below, ranked from highest to lowest priority. Nonetheless, it was agreed that the first raked project which is "Breeding Drought and Disease Resistant Crops" is essentially a research project and as such it seems difficult to harmonize it as an adaptation project that can meet the "urgent and immediate needs" of vulnerable communities in Eritrea. Therefore, it was agreed to replace this project by the second ranked project as the first highest priority project and the third as the second and so on. It was also agreed that the sixth raked project which is "Introduction and expansion of irrigated agriculture especially spate irrigated agriculture (for crop and livestock production)" to be included in the final list of priority adaptation projects for Eritrea. Full project profiles are provided for each of these options in Annex 2. After the process of selection and prioritization of adaptation projects was completed, the NAPA consultation process gave considerable emphasis to the analysis of existing policies and institutional framework so as to assess their suitability for integration and implementation of the NAPA in national development context.

Table 5-1: Final list of priority adaptation projects for Eritrea

Sector	Key Adaptation Needs/Activities	Final ranking
Agriculture	Breeding Drought and Disease Resistant Crops	**1**
Livestock	Introducing community based pilot rangeland improvement and management in selected agro-ecological areas in the eastern and northwestern lowlands rangelands.	**2**
	Introducing community based pilot projects to intensify existing production models, area and species specific in eastern and northwestern lowlands selecting suitable sheep and goat breeds.	**3**
Forestry	Encourage afforestation and agroforestry through community forestry initiative	**4**
Water Resources	Groundwater Recharge for Irrigation Wells	**5**

6. NAPA Preparation Process

The overall objective of the NAPA process in Eritrea was to build awareness about climate risks, solicit feedback on urgent and immediate needs, and synthesize a wide range of information to decide on the highest priority adaptation projects to put forward.

By necessity, this process involved contributions from a wide range of stakeholders which were solicited through consultations, workshops, meetings, and roundtable discussions. The overall process was guided by the approach recommended in the LEG Annotated Guidelines. A brief overview of the process is provided below.

Organizational Structure

A participatory process, involving multiple stakeholders and national consultants, guided the implementation of the NAPA document in Eritrea. This process began with the establishment of an administrative structure, which included the entities described below. An organizational diagram is provided in Figure 6-1.

- *National Steering Committee:* this unit consisted of senior policymakers who provided strategic oversight and guidance to the overall activities involved in the NAPA process;
- *Multidisciplinary Integrated Assessment Team:* this team was organized into a set of task force units that consisted of experts and specialists who reviewed and synthesized pertinent studies and assessments;
- *Technical Committee:* this group was consisted of experts and specialists who provided a periodic review and evaluation of technical materials prepared during the NAPA process;
- *Project Management Team:* this unit consisted of personnel from the Department of Environment who were responsible day-to-day administration of the project both at the national and regional levels;

Activities

Following the establishment of the administrative structure, the NAPA process in Eritrea was launched with a kick-off workshop. The objectives of this workshop were to publicize the program activities of the NAPA Project and to cultivate public awareness of the adverse effects of climate change to Eritrea.

A major activity in the NAPA process was carrying out the participatory vulnerability assessment, which identified climate change related problems as well as traditional coping mechanisms and strategies. Hence, both a desktop research component and a consultative component were included in the vulnerability assessment.

The vulnerability assessment was followed by meetings of expert committees and a national stakeholders' consultation. In addition to summarizing the climate change related issues and traditional coping strategies, the consultation identified requisite adaptation needs of Eritrea as well as barriers to proposed adaptation measures. The end-of-project workshop concluded the NAPA process with the identification of ranked adaptation projects.

Development of Interim Technical Reports

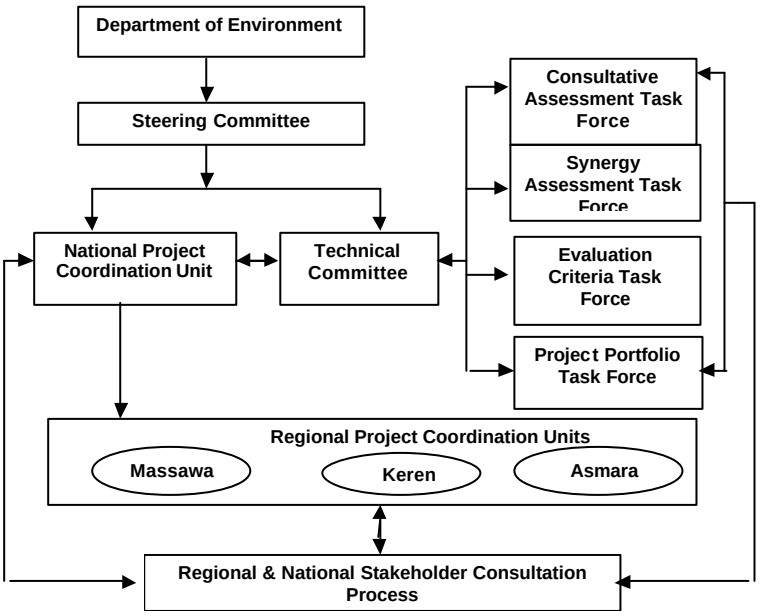
Expert groups were formed to synthesize available information, undertake synergy assessments, and prepare a variety of interim technical reports. These reports had the result of consolidating emerging knowledge and represent a library of permanent material at the climate change Secretariat at the DOE. The following topical reports were prepared by expert groups:

- *Stakeholder Assessment:* The purpose of this report was to identify key stakeholders, based on priority vulnerabilities, whose participation in

the NAPA process would provide critical experience and perspective

- *Stakeholder Consultation Methodology:* The purpose of this report was to conceptualize a consultation process through which participatory assessments of both vulnerability and adaptation options could be achieved.
- *Participatory Assessment:* The purpose of this report was to document stakeholder perceptions and areas of agreement on priority vulnerabilities.
- *Synthesis of Vulnerability Information:* The purpose of this report was to collate, review and synthesize available information on adverse effects of climate change in order to provide a baseline of climate information, and help sharpen understanding of critical vulnerabilities to which adaptation decisions should respond.
- *Synergy and Barriers to Adaptation to Climate Change:* The purpose of this report was to collate, review and synthesize available information on existing national policy linkages with climate adaptation, in order to clarify synergies and provide an overview of the relevant policy context within which adaptation decisions must be made.
- *Identification of Coping Strategies and Adaptation options:* The purpose of this report was to collate, review and synthesize available information on existing strategies and measures for coping with the adverse effects of climatic variability in order to orient the NAPA process toward tested, effective approaches, and help make the process of selecting adaptation projects as informed and strategic as possible.
- *Identification of Adaptation Projects:* The purpose of this report was to identify and elaborate potential adaptation activities for consideration in the final project selection process.
- *Country-Driven Evaluation Criteria:* The purpose of this report was to identify, assess and prioritize evaluation criteria suitable for use in the selection of adaptation activities that address immediate and urgent needs in the Eritrean context.
- *Selecting Adaptation Projects:* The purpose of this report was to select and propose adaptation activities for implementation, through the application of agreed criteria.

Figure 6-1 Organizational Chart of Eritrean NAPA Process



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Annex 1: Coping Strategies and Potential Adaptation Projects identified by stakeholders

Agricultural Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
▪ Diversion of small streams and run off to fields ▪ Stone and earth bund terraces ▪ Check dams ▪ Crop rotation ▪ Fallow systems ▪ Contour farming ▪ Mixed cropping ▪ Late planting and early maturing crops ▪ Cash for work ▪ Off farm labour ▪ Remittance from family ▪ Accumulation of food in good rain years ▪ Growing expensive products ▪ Integrating crop/livestock ▪ Constructing wells, dams, ponds ▪ Using water conservation oriented irrigation system (e.g. drip irrigation) ▪ Using early maturing vegetable plants ▪ Reduction of irrigated field size during drought ▪ Replacing perennial plants by annuals ▪ Increasing depth of water wells during drought ▪ Growing expensive products ▪ Integrating crop/livestock ▪ Sell of fire wood and charcoal ▪ Produce vegetables, fruits forage/fodder which require less water ▪ Growing expensive products ▪ Integrating crop/livestock ▪ Safety net for food ▪ Family remittance ▪ Seed selection ▪ Crop rotation ▪ Crop diversion ▪ Developing wells, ponds & dams ▪ Water supply from spring & river beds ▪ Mulching ▪ Drill planting (chulika) ▪ Deep seeding	▪ Research in drought resistance crops ▪ Multiplication and distribution of drought resistant crops ▪ Food safety nets for needy households during disasters such as drought ▪ Promoting diversion of streams and run off to fields ▪ Preparing integrated production models ▪ Water use management and regulation ▪ Developing water conserving irrigation techniques ▪ Enhance spate irrigation ▪ Applied research on crop resistant vegetables ▪ Promoting self-reliance programmes for women headed families	▪ Stone and earth bund terraces on farmlands to conserve soil and moisture. ▪ Breeding of drought and disease resistant high yielding crops to promote crop production ▪ Implementation of diversion structures to supplement water to rain-fed agriculture ▪ Application of fertilizer (both organic and inorganic) to improve soil nutrients an increase water holding capacity of soil ▪ Conservation tillage through application of crop residue to reduce evaporation and accordingly retain moisture. ▪ Planting moisture efficient crops such as pearl millet and water melon on river beds ▪ Crop rotation (rotating legume and non leguminous crops) to improve soil nutrients, soil mois ture and decrease soil born pests and disease. ▪ Selection of healthy and vigorous seeds to increase resistance to drought, pests and diseases and to increase productivity ▪ Improve farm management technology such as row planting depth of planting etc. to increase production. ▪ Use late planting and early maturing crops to secure crop production at times of low and variability of rains ▪ Contour farming to retain soil and moisture on cultivated fields. ▪ Weeding to reduce competition of weeds against plants for soil nutrients and moisture ▪ Mulching using crop residue to retain soil moisture from evaporation ▪ Increase irrigation through construction of dams, ponds, and water wells for increased crop production ▪ Mixed cropping such as barley and wheat, sorghum and finger millet, sorghum and sesame etc. to secure production if one type of crop fails. ▪ Soaking of seeds into water prior to planting to hasten and secure germination. ▪ Biological soil conservation (strip cropping, planting grasses and leguminous plants on edges of plots) to strengthen physical soil conservation structures so as to retain moisture and soils in the cultivated fields. ▪ Introduction/ expansion of irrigated agriculture especially spate irrigated for crop and livestock production.

Livestock Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
▪ Seasonal extensive movement, distance depends on severity ▪ Concentration in riverine area ▪ Increase digging shallow wells in riverbeds ▪ Forage conservation ▪ Crop residue conservation, purchase ▪ Digging deep wells by communities ▪ Moving animals to villages with better water sources ▪ Selling animals except for breeding ▪ Movement to cooler uplands ▪ Movement to raised grounds ▪ Keeping herds isolated ▪ Decreasing grazers (cattle) ▪ Increasing browsers (goat, camel) ▪ Overall reduction of herds ▪ Selling of animals even breeders ▪ Casual work in towns or permanent displacement of young people ▪ Fuel wood sale ▪ Trade (within and across boundaries) e.g. western lowland area with Sudan, eastern area with Yemen. ▪ Fishing (eastern lowlands) ▪ Remittance from relatives (within and from outside) ▪ Riverbed planting with pearl-millet ▪ Loan from friends, relatives, merchants ▪ Elimination of animals or substitution of cattle (except ox) by goat/sheep ▪ Reducing number of oxen ▪ Selling oxen at the end of cultivation season and buying at the onset of next cultivation season ▪ Casual work in towns ▪ Food/cash for work ▪ Remittance from relatives ▪ Substitution of ox by hiring tractor service ▪ Loan from friends, relatives, merchants ▪ Importing of animals (eastern Sudan, northern Ethiopia) ▪ Changing to other trade ▪ Reduction of meet, milk consumption ▪ The poor substitute beef, mutton/goat meat with chicken meat and pulses ▪ Restriction of milk only to young children ▪ The poorest families substitute meat with pulses ▪ Substitute forage scarcity with low energy level feeds and imported feeds but limited by supply availability and cost ▪ Reduction of herd size ▪ Sales of male calves at early age	▪ Range development (reseeding, spate irrigation, terracing, etc.) ▪ Provision of ponds, deep wells, motorized ▪ Early warning ▪ Restocking of breeding animals and oxen for the very needy households ▪ Provision of health services ▪ Early warning ▪ Rural sustainable development programmes ▪ Food aid ▪ Food or cash for work ▪ School feeding ▪ Supplemental feeding for child and mother ▪ Food aid ▪ Food or cash for work ▪ School feeding ▪ Early warning ▪ Food aid dried milk ▪ Price control on milk and meat ▪ Supplemental feeding ▪ Early warning ▪ Priority for dairy the industrial by-product feed	▪ Range development by community in specific area ▪ Local institutional capacity building ▪ Rangeland management ▪ Selecting animal species and breeds ▪ Reduction of livestock numbers, but improve productivity of individual ▪ Establish production models ▪ Increase job opportunities ▪ Substitute cattle with small ruminants ▪ Establish dairy models suitable for specific areas

Forestry Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
▪ Promoting community forestry/Agro- forestry (multipurpose trees planting at home stead, individual plots, etc) ▪ Off farm job; formal or informal employment locally or in urban areas ▪ Remittance from family members or relatives from urban areas or abroad ▪ Planting drought resistant trees or shrub species ▪ Mixed planting (indigenous and exotic) in rows, one after the other or in blocks to minimize risk of failure, ▪ Establishment and management of permanent and temporary enclosures ▪ Collaborative management (community and government joint management, under the principle of cost benefit sharing) ▪ Planting fast growing species recommended by government ▪ Promoting fuel wood conserving stoves *(Adhanet*); use animal dung and crop residues ▪ Wood energy substitute (solar, wind, electrical, kerosene, liquid propane gas etc ▪ Planting fast growing species recommended by government ▪ Substitute house roofs with corrugated iron sheets and other roofing materials ▪ Afforestation and enclosures with rotational taping ▪ Enclosure with rotational cutting ▪ Planting fodder trees and shrubs, enclosure, rotational grazing, rotational pollarding, Reseeding, cut and carry	▪ Promoting community forestry/Agro- forestry ▪ Constructing hillside terraces, check dams, micro-basins and different bunds, to enhance plant survival and growth ▪ Selection and multiplication of drought resistant plants ▪ Raising seedlings on polythene tubes to develop compacted fibrous roots prior to planting ▪ Institutional capacity building ▪ Organizing community based committees to manage local forestry ▪ Selecting fast growing tree species ▪ Research on energy substitutes and distribution at economic cost; promotion of the private sector to develop substitutes ▪ Developing fast growing tree species ▪ Developing afforestation technologies for different regions ▪ Research on fodder trees and shrubs	▪ Promote climate change research relating to forestry and disseminate scientific information ▪ Conservation and management of the highland forest ecosystem ▪ Conservation and management of the woodland ecosystem of the south western lowland and promote the sustainable utilization of none wood forest products such as gum and incense ▪ Strengthening institutional and legal aspects of the sector ▪ Conduct woody biomass survey and introduce proper utilization of wood resources ▪ Encourage Afforestation of degraded landscapes/watersheds and promote agro forestry, by constructing terraces, micro basins, check dams and using a mix of drought resistant indigenous and fast growing exotic species, through community forestry initiatives. These will help in producing diversified production of food, wood and fodder in line with other environmental protection ▪ Encourage natural regeneration through enclosures and augment with enrichment planting with indigenous plants to fill gaps ▪ Establish biodiversity protected areas ▪ Introduce collaborative forest resources management in the riverine forest and promote proper utilization of the Doum Palm leaves (*Laka)* ▪ Encourage alternatives for traditional house construction ▪ Delineate some forest land in Semienawi and Debubwi Bahri for genetic resource conservation ▪ Encourage the use of improved wood stoves (Adhanet) ▪ Promote wood energy substitutes (solar, wind, kerosene, liquid propane gas, electricity) ▪ Encourage proper livestock management (rotational grazing, rotational pollarding, cut and carry, reseeding grasses, planting fodder trees and shrubs) to reduce overgrazing ▪ Promote fire protection mechanisms

Water Resource Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
▪ Rainwater harvesting from roofs and hillsides ▪ Introduction of water rationing, water tariff and water trucking ▪ Establish village level water committees ▪ Soil and Water Conservation measures ▪ Change in land use ▪ Construction of stream diversions in the lowlands ▪ Construct shallow wells ▪ Construction of shallow and deep wells, dams and ponds and increasing the capacity of existing dams by raising their heights ▪ Reduce irrigated land size and grow mainly short maturing vegetables ▪ Establish village level water and irrigation committees ▪ River bank protection ▪ Construction of shallow wells, ponds and small dams for human and livestock watering ▪ Rainwater harvesting from roofs and hillsides ▪ Introduction and expansion of spate irrigated agriculture ▪ Introduction of water tariff and water trucking ▪ -Livestock movement depending on the availability of grazing and water point Reduce livestock population ▪ -Introduction of water tariff	▪ Construction of new dams and ponds and increasing the capacity of existing dams ▪ Increase availability of water supply by digging of new wells and shifting from shallow aquifers to deeper rock aquifers ▪ Awareness, education and training of farmers on resources utilization, ▪ Soil and Water Conservation measures ▪ -Capacity Building Awareness, education and training of farmers, MoA staff and zoba offices on resources utilization, particularly on soil and water conservation ▪ -Introduction of irrigated agriculture ▪ -Digging of new wells and shifting from shallow aquifers to deeper rock aquifers ▪ -Construction of new dams, ponds and increasing the capacity of existing dams ▪ -Improve/upgrade urban groundwater supply systems ▪ -Introduction of regulations to enhance water management ▪ -Enhance groundwater recharging mechanisms like Soil and Water Conservation measures and forestation ▪ -Construction of shallow/deep wells, dams and ponds and increasing capacity of existing dams by raising heights ▪ -Improve on farm level water use efficiency ▪ -Improve water use efficiency by developing and introducing water saving irrigation system like drip and sprinkler irrigation ▪ -Construction of wells, ponds and small dams for human and livestock watering ▪ -Improve/upgrade existing coastal fresh water sources ▪ -Introduction and expansion of spate irrigated agriculture ▪ -Improve design/construction procedures of water works ▪ -Awareness, education and training on resources utilization ▪ -Construction of ponds, wells and dams for livestock watering	▪ Upgrading the existing national climatologically network . ▪ Upgrading Massawa water supply sources and distribution. ▪ Upgrade existing dams to increase their reservoir storage capacity. ▪ River bank protection. ▪ Research low cost water treatment ▪ Reduce irrigated land size and grow mainly short maturing vegetables. ▪ Rainwater harvesting from roofs/hillsides. ▪ Prepare drought management plan for all major cities and towns. ▪ Introduction of water rationing, water tariff and water trucking. ▪ Introduction of regulations to enhance good water management and improve water use efficiency. ▪ Ground water recharge for irrigation wells ▪ Implement rural/urban water supply of new dams and ponds and wells. ▪ Improving and upgrading existing coastal fresh water sources. ▪ Improve water use efficiency by developing and introducing irrigation systems like drip/sprinkler irrigation ▪ Improve the design and construction procedures of water works. ▪ Improve the design and construction of existing traditional spate irrigation system. ▪ Improve farm level water use efficiency. ▪ Groundwater recharge for Harsille well fields (Asseb) . ▪ Establishing groundwater monitoring. ▪ Establish village level water and irrigation committees ▪ Establish a stream flow gagging station for major river basins. ▪ Enhance groundwater recharging mechanisms ▪ Develope better system of information flow about climate change impact. ▪ Develop an effective Soil and Water Conservation projects. ▪ Construction of livestock watering points ▪ Conduct impact and adaptation research. ▪ Capacity Building to Water Resources Department, Zoba offices and MoA on groundwater assessment and development. ▪ Capacity building for city and town water supply administration bodies. ▪ Awareness, education and training of farmers, MoA staff and Zoba offices on resources utilization, particularly on soil and water conservation.

Marine and Coastal Zone Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
▪ Migrate to highlands ▪ Use wooden houses ▪ Planting trees around their houses ▪ Shifting of their daily activities when the sun is setting ▪ Spend their time in the shore (swim) during day time when there is extreme thermal stress ▪ Proclamation of land ▪ Temporary protect the coast with stones and other barriers such as dikes ▪ Shifting to uplifted land of the coast to avoid flooding ▪ Closed seasons and areas (take rest) ▪ Shift to other livelihood, small traders ▪ Migrate to relatively suitable and cold area ▪ Stock dried fish before the change take place ▪ Pelagic fish migrate to other less stressed place ▪ Avoid spawning ▪ Loss activity during the day to store energy	▪ Prepare insulated housing made of fiber plastic and easily constructed ▪ Minimize working hour to avoid thermal stress. ▪ Mobilize community ▪ Provide tents and other necessary materials ▪ Distribute mosquito protecting net ▪ Financial support from fisheries cooperatives ▪ Community based marine resource management programme ▪ Food aid ▪ Small scale aquaculture useful as a vehicle to stabilize food supplier and employment ▪ ECBIM project ▪ National Biodiversity Strategy and Action Plan ▪ Manazanar project (mangrove planting) ▪ Enforcing community by laws, e.g. regulations where fine is imposed if a person uses banned fishing methods ▪ Closed season and close area, i.e. restocking depleted species ▪ NBSAP	▪ Integrated Coastal Area Management ▪ Capacity building for village social groups, and assistance to improve existing coping capacity ▪ Community awareness programme to raise awareness on climate change and adaptation options ▪ Promote research studies to bridge the existing gap of knowledge of climatic change ▪ Promote traditional adaptation measures such as natural bench nourishment ▪ Coastal infrastructure protection ▪ Assistance for relocation of island inhabitants ▪ Emergency contingency pan ▪ Introducing low-tech community based coastal aquaculture and management ▪ Encourage communities to diversify their livelihood in response to the multi-dimensional impact of climate change ▪ Marine protected area ▪ Management programme for mangroves ▪ Mangrove afforestation programme and establishment of nursery grounds ▪ Fisheries management

Public Health Sector

Current coping strategies		Potential Adaptation Activities
Autonomous	**Projects/programmes**	
• Constructing houses with materials of poor heat conductivity • Using ventilators, air conditioners • Dressing style: light, white, loose fitting with the body • Planting trees for shade around the house • Frequent washing of the body • Adjusting work time to late afternoon, early morning, nights • Avoiding to take drinking water from flood pools • Boiling of water before drinking • Avoiding water contamination with human faeces • Digging of water well for adequate and clean water source • Water conservation by collecting rain water from roof • Avoiding washing in stagnant water which is contaminated • Cooking food thoroughly and eating it without storing • Using bed nets impregnated with the chemicals • Taking prophylactic medication against malaria during risk season • Controlling insect breeding sites around the house • Taking awareness information • Constructing latrines • Conserving food for periods of shortage • Avoiding swimming in pond or stagnant water in riverbeds • Irrigation system that is not suitable for vector breeding (e.g. snails) • Taking prophylactic medicaments against malaria before moving to malaria endemic areas • Avoiding swimming in pond or stagnant water in riverbeds • Controlling insect breeding sites around the house (water pools) • Digging water wells for clean water source, water treat • Water conservation by collecting rain water from roof • Install mosquito proof mesh or window screens • Organizing households in managing refugee camps • Preparing households for returning to their villages • Participating in refugee camp sanitation	• Multi-targeted health programmes • Vaccination of children • Supplementary feeding for children and mothers • Food aid • Awareness on health and disease • Improved health infrastructure • Increasing clean water sources • Distribution of drugs and bed nets for malaria • Early warning on weather changes • Draining wet areas • Insecticide application • Eliminating breeding site • Create disaster preparedness programmes • Land use planning to reduce flash floods • Destroy unfit residences • Fortify sanitation systems • Surveillance for disease, vectors • Constructing sanitary facilities • Integrated control approach for vector-borne diseases • Housing programmes (sanitary, wire mesh fitting strong) • Emergency food aid until resettlement • Provision of temporary health facilities, equipment, drugs • Emergency cooking materials • Provision of emergency water supply • Provision of sanitary facilities • Health education	• Upgrading health infrastructure • Building awareness on diseases and causes • Establishing early warning systems • Improving water and sanitation systems • Emergency preparedness for disasters • Improving housing standards • Land use planning • Town and village planning • Coastal protection from storms • Supplementary feeding • Vaccination • Developing bed nets and accessories at economic prices so that people have access in already malaria endemic areas • Surveillance of vectors and diseases, drug/insecticide resistance (malaria risk areas) • Programmes for destruction of vector breeding sites • Developing integrated control approach for vector-borne diseases • Preparing programmes for resettlement involving socioeconomic infrastructure • Provision of initial requirements that lead to self-sufficiency

Annex 2: Project Profiles

This Annex presents a total of five projects that have emerged from the complete NAPA consultative process in Eritrea. They represent the highest priority interventions as determined through a structured the Multi-Criteria Analysis (MCA) process that involved a broad range of stakeholders (see Section 6 for a discussion of the NAPA stakeholder consultation process). Each project is briefly described regarding its rationale, objectives, activities, expected outcomes, implementation arrangements, and budget.

Project Profile 1:

Introducing community based pilot rangeland improvement and management in selected agro-ecological areas in the north western lowlands rangeland

Project area: The north-western lowland, a hot arid region with extreme rainfall variability and frequent drought years, is the geographic focus for this project. The vegetation is of the savannah type and the topography is flat plain crossed by major ephemeral rivers flowing from the central highland area. The populations are pastoralists, hence their livelihood is almost exclusively dependent on livestock. The production system is featured with extensive seasonal movement to cope with shortage of feed and water. However, the system is becoming less sustainable and as a result the pastoralists are impacted by the low animal productivity and because many animals are lost due to starvation and lack of drinking water. The rangeland, the pastoral system and the livelihoods of the pastoralists in the project area are highly vulnerable to climate variability, extreme events such as drought and climate change. The most vulnerable populations in the project area are those thriving in the Kerkebet area. In general, 6 villages, 200 HH/village and 20,000 ha of rangeland will be covered by this project.

Rationale: The pastoralists in the project area are dependent on livestock for their livelihood. The extensive livestock production system has however failed to sustain their livelihood because the productive and reproductive efficiencies have been declining progressively and direct losses of animals due to lack of feed and water during the dry season and drought years have been increasing. The rangeland has been negatively affected by climate variability, drought and climate change where the total biomass has been decreasing sharply and the nutritive plant species have been replaced by plant species and associations of less nutritive value. The traditional coping practice of animal movement in search of water and feed has been disturbed by land use change and climate variability. As a sequel to this, the rangeland is currently unable to sustain profitable livestock production and because of this the system is not capable to sustain the livelihood of the pastoralists. This project has been designed to adapt the livestock system into the new conditions produced by climate variability and frequent droughts. The strategy is to increase feed and water supply for the long dry season and establish community based rangeland management system. This is expected to improve the productive efficiencies of the livestock and decrease the direct losses of animals due to starvation and thirst. In this way, the pastoral system will be intensified, avoiding long distance movement, to become more sustainable allowing also the pastoral households more time for other activities.

Objectives: The immediate objectives are to:

1. improve rangeland productivity;
2. improve livestock productivity (milk and meat);
3. increase incomes of the pastoralists;
4. through these:
5. establish livelihood of the pastoralists on a sustainable basis; and
6. improve nutrition of the population and in particular children.

Activities: Key project activities include the following:

1. preparing detailed strategy design and implementation plan.
2. Construction of soil/water conservation and small stream diversion structures on the rangeland.
3. Reseeding of the rangeland with suitable grass and legume species.
4. Constructing water points and equipping them.
5. Establishing community based rangeland and water management systems.
6. Training of communities in managing their resources.
7. Providing mineral supplement to improve animal nutrition.
8. Providing machinery for forage conservation and rangeland maintenance.
9. Monitoring and evaluation.

Short-term outputs: The following are key short-term outputs expected from the implementation of the project

1. Strategy design prepared.
2. Sustainable forage supply system established.
3. Water supply system present.
4. Forage conservation system established.
5. Community institution for resources management established.
6. Local personnel trained for specific skills available.
7. Monitoring and evaluation system established.

Potential long-term outcomes: The following are key short-term outputs expected from the implementation of the project

1. Pastoral communities will be able to cope with climate change by adapting the conditions of feed and water supply to become sustainable.
2. Establishing improved livestock production model through intensification of the pastoral system.
3. Improve food security and nutrition through increased incomes and food availability.
4. Reduce poverty.

Implementation: The main implementing body will be the Ministry of Agriculture through its regional office and its structure. The communities and the local government will participate in preparing the strategy design, implementing and monitoring and evaluation.

Risks and Barriers: Key risks are associated with Rangeland allocation for specific community use avoiding free access of others, as well as the technical Capacity of the Ministry of Agriculture.

Monitoring and Evaluation: The project will prepare a monitoring and evaluation system and this function will be jointly carried-out by the Ministry of Agriculture, the community and the local government.

Financial Resources: The project will be the main source of finance; however, the Ministry of Agriculture will contribute for certain activities such as extension services and the local government in organizing the communities. A summary of project costs appear in Table 4. The project duration is 3 years starting from the time funds made available.

Table 1. Cost estimates to improve rangeland for sustainable livestock production

Project Components	**Cost (US$)**
Preparation of detail strategy design	120,000
Soil/water conservation on rangeland	2,800,000
Small stream diversion structures	1,300,000
Reseeding	900,000
Padlocking	1,100,000
Machinery	700,000
Construction and equipping water points	240,000
Establishing community institution	40,000
Monitoring and evaluation	30,000
Total	**7,230,000**

Project Profile 2:

Introducing community based pilot projects to intensify existing production models, area and species specific in eastern lowlands selecting suitable sheep and goat breeds

Project area: An eastern coastal lowland area, the most arid in Eritrea, is the geographic focus of this project. Rainfall in this region is generally very low and with extreme variability and frequent droughts. The vegetation type is of the steppe and desert like shrubs; while the topography is flat plain intercepted by some hills. The plain is crossed by several ephemeral rivers and streams flowing from the eastern escarpment and highlands. The pastoralists move towards the escarpments during the dry hot season as a coping mechanism for shortage of feed and water. The population in these coastal areas is basically pastoralist and their livelihood is dependent on livestock. The livestock species raised are mainly browsers such as goats and camels; while the grazers such as cattle are increasingly becoming insignificant source of livelihood. The cause for this is the progressive decline of grasses due to climate variability and drought. The livestock numbers are also continuously decreasing due to lack of feed and drinking water and considerable number of them dying each year. In these areas, livestock productivity is poor and the trend is negative. The rangeland is unable to sustain livestock and as a result the livelihood of the population is very vulnerable to climate change. In the project area, the most vulnerable populations are those communities living between Zula and Tio areas. Generally, six villages, 1200 Households (HHs), 6000 population, 400 ha/village, and 6 spate irrigation sites in the eastern lowlands will be covered by this project.

Rationale: The pastoral system in the project area is failing to sustain the livelihood of the pastoralists. This is because the rangeland is vulnerable to climate variability, drought and climate change. The extensive pastoral system of production in the project area is not any more sustainable and the communities have failed with their coping mechanism which involved seasonal animal movement between their villages in the lowland and the corresponding eastern escarpment. The composition of animal species had been altered where grazers are not produced any more except some desert type sheep breeds. The only animal species that are being able to resist the impacts of climate variability and drought are some varieties of goats and sheep. The exiting extensive livestock system and production models should be intensified to the degree that they are sustainable and have the capacity to become sustainable source of livelihoods. The general coping strategy should be by using the most efficient varieties of goat and sheep, keeping their numbers to correspond the available feed and increasing the individual animal productivity. This project is designed to enable the pastoralists to cope with the impacts of climate variability, drought and climate change by intensifying the pastoral system. The elements of the strategy will be by using selected varieties of small ruminants that are more suitable for the project area that is vulnerable to climate change. The system will be further intensified by producing feed under spate irrigation and providing drinking water sources.

Objectives: The main immediate objectives of the project are to:

1. increase incomes of the population by reducing direct loss of animals due to lack of feed and water and by increasing individual animal production and productivity efficiency through the use of selected breeds and improved management;
2. improve nutrition of the population by producing protein food of high biotic value such as milk and meat; and
3. enable the communities to cope with the current impacts of climate variability and drought and future climate change.

Activities: The main activities will include selection and breeding of suitable varieties of indigenous goat and sheep breed types, evolving suitable breeding males, establishing sustainable animal feed and water supply, and organizing and training of communities.

1. Selecting dual purpose breeding goats.
2. Selecting sheep for higher mutton production.

3. Selecting suitable forage seeds.
4. Providing tools for pasture maintenance.
5. Establishing community based pastures under spate irrigation.
6. Constructing spate irrigation structure.
7. Training farmers on spate irrigation pasture management and overall small ruminant production system.
8. Establishing community based institution and providing with the required infrastructure.

Short-term outputs: The following are key short-term outputs expected from the implementation of the project

1. Goat varieties with high milk and meat production established.
2. Sheep varieties with high meat productivity established.
3. Forage production under spate irrigation system established.
4. Community based institution formed.
5. Farmers have acquired skills in animal production.
6. Farmer have acquired skills in forage production.
7. Farmers trained in milk and meat production.

Potential long-term outcomes: The following are key short-term outputs expected from the implementation of the project

1. Sustainable coping of livelihood with impacts of climate change.
2. Food insecurity and poverty reduced.

Implementation arrangements: Implementation arrangement will be mainly the Ministry of Agriculture branch in Zoba Northern Red Sea, agricultural research, and other participating bodies will be the Zula communities, and local government.

Risks and Barriers: Key risks are associated with land allocation for communities to be spate irrigated, as well as the technical capacity of the agricultural office in Zoba Northern Red Sea.

Monitoring and Evaluation: The project design will contain monitoring and evaluation system. The responsible agency for monitoring and evaluation will be the agricultural office in Zoba Northern Red Sea and the beneficiary communities.

Financial Resources: Table 3 summarizes the costs associated with the implementation of this adaptation project. The project duration is 3 years starting from the time funds made available.

Table 2. Cost estimates for developing and utilizing suitable sheep and goat breed types

Project Component	**Cost (US$)**
Breeding animals (1200 HHs @ 12 animals)	800,000
Spate irrigation structure (5 villages)	3,000,000
Earth moving machinery	400,000
Construction water point (5 wells + equipment)	150,000
Farm tools	12,000
Forage seeds (1200 ha) 4 kg/ha	240,000
Community infrastructure and training	120,000
Monitoring and evaluation	25,000
Detail strategy design	90,000
Project management	240,000
Total	**5,077,000**

Project Profile 3:

Encourage Afforestation and Agroforestry through Community Forestry Initiative

Project area: The whole country is vulnerable to this climate related impact on forests. However, populations in the highland area are already suffering from the shortage of wood for cooking and house construction purposes and for this reason these areas are the geographic focus for this project. Forest goods and services are important sources of livelihood in Eritrea. However, these are made to be vulnerable to climate change mainly through human activities. Most parts of the highland Eritrea are highly degraded due to continuous absence of natural resources management resulting into deforestation, climate variability characterized with low and variable rainfall, as well as extreme events such as droughts and climate change.

The most important trend is desertification, loss of topsoil and lowering water penetration and retention of soils. The livelihoods of the populations in the western lowland area and in particular those in the main river basins (Barka River and tributaries, Gash River) and the south-western lowland are suffering from declining supply of goods and services obtained from forests. Although this is well recognized and that efforts have been made to reforest through cash and food-for-work, students summer campaigns, national development campaign etc…in the last 15 years, the success is minimal as compared to the magnitude of deforestation rate. Therefore, in order to address full participation of the entire communities at individual households/ families/ levels is needed to plant and grow trees in different settings.

Rationale: The impacts of climate change and variability, compounded with distractive human actions on the forest resources, have led to the loss of biodiversity, as well as wood and none wood products and services. Such problems will continue unless wider participation of the individuals, households and the entire rural and urban communities is secured in planting and maintaining trees in their respective areas.

In the Forest policy and legislation, provisions are made to secure trees for the person who has planted and maintain them on areas designated to use the land in accordance to the Eritrean Land Law No 58/1994. Therefore, the plan is that each village will allocate part of the marginal land under community use such land to be holding of individual households of the village. These holdings will be planted and grow trees, and use them accordingly. Similarly planting trees will be promoted by communities along homesteads, roadsides, school compounds, sacred areas, cemeteries, parks, river banks, scenic sites, farm boundaries and the like.

Objectives: The immediate objectives are to:

1. Rehabilitate degraded landscapes through afforestation, and control run-off and loss of arable land on down stream areas through soil erosion.
2. Create healthy and well managed forest plantations so as to withstand impacts of climate change.
3. Encourage individual households in a community to plant and own trees and produce sustainable wood, fruit and fodder.

Activities: The main immediate objectives of the project are to:

1. Strengthen forest extension system and develop a strong relationship with farming communities through frequent visits and interaction

2. Assist communities to determine size and boundary of marginal land and to be allocated to individual households in the community for tree planting

3. Establish new or upgrade existing community forest nurseries
4. Train the communities to integrate tree planting and management in their farming systems

Short-term outputs: The following are key short-term outputs expected from the implementation of the project

1. New forestry nursery established and existing nurseries upgraded.
2. Households have been trained.
3. Individual land holding for afforestation distributed.
4. Marginal land has been afforested.

Expected long-term Outcomes: The following are key short-term outputs expected from the implementation of the project. A table summarizing indicators to measure long-term outcomes follows.

1. Availability of fire wood, construction wood in the rural communities ensured.
2. Production of none wood forest products such fruit, fodder, bee forage etc… enhanced.
3. Degraded catchments protected and rehabilitated.
4. Micro climate of the area improved.
5. Awareness of communities in planting, growing and managing trees increased.

Indicators/Expected Outputs	Potential Long Term Outcomes
-Frontline forest extension agents trained and equipped with training manuals, -Frequent meetings convened with the local communities and forest development committees in each village established, and -Local communities trained on appropriate forestry techniques, use	-Awareness level of communities on forest conservation and use of trees in ameliorating the effects of climate change raised -Tree planting and maintenance at individual household and community level enhanced
-Individual households identify their own plot of lands for tree planting, and -Tree planting sites prepared, planted, and maintained by respective households.	-Accessibility of individual households in the rural community to their own wood and none wood forest plantation products increased, -Degraded watersheds resonated, -Downstream water reservoirs protected, -Micro climate of the area improved.
-Existing forest nurseries upgraded and new forest nurseries established at strategic sites, - Multipurpose tree seedlings raised/distributed.	-Healthy and vigorous trees established, and -Availability of wood and none wood forest products increased.
-Multipurpose trees are integrated with crop and livestock production systems (Agro-forestry).	-Increased production of wood, fruit, fodder -Cumulative household income from wood and none wood components increased

Implementation: The project will be based with in the Ministry of Agriculture and will have its own management team and coordinator. The project team will work in collaboration with Regional MoA Branches. Steering committee will be established from different stakeholders to guide the project management.

Risks & Barriers: Key risks are associated with the following:

1. A shortage of skilled human power,
2. Conflicting land use (for grazing & tree growing), and the redistribution of arable land to members of the communities every 5-7 years in the highland discourages the development agro-forestry,
3. Insufficient coordination among different stakeholders,

4. Financial capacity to support communities with planting stocks and provision of hand tools, and
5. Lack of enforcement for national and regional action plans and regulatory instruments pertinent to forest conservation and development.

Monitoring and Evaluation: Monitoring and evaluation will be carried out on regular bases and more specifically after rainy season and in the late dry season. Village development committees, forest extension agents and subject matter specialists will conduct frequent monitoring and evaluation. An independent evaluation assessment team will also be selected from the steering committee and conduct evaluation assessment in the middle and final project term

Financial Resources: The total project coast is estimated at USD 5.15 million, out of which US$ 150,000 will be for project office. Government contribution will be made for support activities as indicated in Table 5. The project duration is 5 years starting from the time funds made available.

Table 3. Estimated Cost for Community Forestry Development

Project Components	**Cost (US$)**
Infrastructure/Civil works (construction of roads, office, community forest nurseries)	1,150,000
Equipment and supplies (Field and office equipment, hand tools, water pumps, vehicles etc)	1,000,000
Community development support (forest extension services)	950,000
Silviculture (seedling production and distribution)	1,100,000
Recurrent costs (Staff salaries, allowances, maintenances etc)	850,000
Total	**5,050,000**

Project Profile 4:

Groundwater Recharging for Irrigation wells

Project area: A decline in groundwater is already being experienced in most parts of the country and in particular in the more arid areas of the coastal plains and certain valleys in the highland such as Tsilma, Adi-Keih, Hagaz and Ala. In these areas, wells are drying up and groundwater supply for continuation of irrigation as well as for livestock and human uses has become critical. These areas are very vulnerable to climate variability, drought and climate change and the focus of this adaptation project.

Rationale: Urban and rural communities, irrigated agriculture and industries who rely on ground water resources for their water supply are already suffering from the negative impact of climate variability in particular low and unreliable rainfall, short rainy season, extreme weather events such as drought and climate change. The wells are drying up and the population in some villages are walking long distance to fetch water. Small holder irrigated agriculture from ground water is failing examples are like in Alla and Hagaz are depending on water tracking. Rural inhabitants are paying more than double the price they use to pay costal areas groundwater sources are threatened with seawater intrusion. So far, no projects have been implemented whose main objective is to enhance ground water volumes as coping mechanizes strategies have not been effective. In Eritrea, about one million cubic meters of water flow out of the country as surface flow. If a substantial amount of this water is allowed to be stored in under ground aquifer as ground water, this will enable communities and livelihood resource to better adapt to the negative impact of climate changes. To cope with this problem and sustain the resource activities to enhance groundwater recharging will be required.

Objectives: The immediate objectives are as follows:

1. To enhance ground water recharging.
2. To ensure easily accessible water supply for domestic and agricultural use.
3. To increase spring water supply and protect natural forest and wild animals from extinction.
4. To prevent costal ground water supply from salt water intrusion.
5. To prevent salt water intrusion to costal ground water supply.

Activities: The key activities of the project are as follows:

1. Develop integrated watershed management programme
2. Construct an effective soil and water conservation structures for farm and non-farm lands
3. Establish ground water monitoring
4. Capacity building of *farmer* MOA and WRD

Short-term outputs: The following are key short-term outputs expected from the implementation of the project. A table summarizing indicators which which to measurfe long-terms outcomes follows.

1. Water recharging structures are in place.
2. Community institutions for water use management established.
3. Water supply and demand control legislation present.

Potential long-term Outcomes: The following are key short-term outputs expected from the implementation of the project

1. Increased availability of good quality and quantity of ground water for urban and rural uses.
2. Increased availability of ground water for irrigation.
3. Quality and quantity of coastal water supply improved.

4. Improved wild life habitats through increased water supply availability.
5. Contribution to food security, health, nutrition, and poverty reduction.
6. Sustainable coping strategy to climate change

Expected outputs/ Indicator	Potential long term outcomes
Wild life habitats and natural forests maintained. Community based IWPP establishing and functioning effectively. Sustainable ground water resource.	Good quality and quantity of ground water available to urban and rural communities.
Ground water source improved and sustained. Well-maintained and effective terraces constructed, gullies stabilized erosion and stream and river flow reduced substantially.	Irrigated agriculture make sustainable
Monthly report produced to decision makers well informed. Ground water use regulated accordingly	Ground Water Resources are better understood and well controlled. In addition efficiently managed and utilized.
The Technique of ground water recharging well understood and practiced. Capacity of MOA extension agents improved in constructing effective soil and water conservation structures Capacity of farmers improved in construction and maintaining soil and water conservation structures	Soil moisture increased and land productivity increased; adequate spring water is available for wild animals.

Implementation arrangements: The national implementing agencies would be the MoA and the WRD. The MoA is the most appropriate body to implement this project. This is because it has a widely spread network of extension agents who are quite experienced in working with farmers. The farmers are the implementing bodies of most of the activities of the project. The WRD will be involved in monitoring ground water resource and in preparing appropriate legislation on management and utilization of groundwater resource.

A project management unit will be established to follow the day-to-day activity of the project. Project steering committees will be formed at national and local level and will consist of executive level officials of respective ministries and community representatives and private stakeholders like NGOs. The duty of the steering committees is to make sure that the project is financially and technically implemented according to an agreed project document.

Risks and Barriers: Key risks are associated with shortage of budget to implement this project, lack of existing national legislation on the proper utilization of ground water delays, and the physical structures constructed to enhance ground water recharging are not properly maintained and managed.

Monitoring and Evaluation: The project will be monitored and evaluated regularly every six months. It will also be evaluated by external consultants at the end of its life relative to the matrix shown below.

Financial Resources: The table below summarizes the costs associated with the implementation of this adaptation project. The project duration is 3 years starting from the time funds made available.

Table 4. Cost estimates to Enhance Groundwater Recharging

Project Component	Cost (US$)
Develop integrated watershed management programme	2,000
Construct effective soil & water conservation structures for farm and non-farm lands (6,000 ha)	5,700,000
Establish ground water monitoring programme	1,500,000
Capacity building of *farmer* MOA and WRD	50,000
TOTAL	7,252,000

Project Profile 5:

Introduction and expansion of irrigated agriculture especially spate irrigated agriculture (for crop and livestock production)

Title: Increase Agricultural Production through Spate Irrigation and Range Development

Project Area: The Project site location is in the Northern Western Lowland, which makes part of the lower Barka River Basin, and more specifically it is in the Dighe Sub region of the Gash Barka Region involving villages situated along both side of the funeral Barka River. The area is located between Tekeret and Keru Villages. The area is hot arid featured with low and extremely variable rainfall and high drought frequency. The rangelands-rainfed cropping are highly venerable to climate variability as a sequel to this, livestock production and the populations dependant on these activities are venerable to climate variability, extreme events such as drought, and climate change. In respect to rainfall, the project area falls in the threshold or margin for rainfed-cropping; hence this activity is venerable to the impacts of climate variability and drought.

The populations in the project area consist of Tigre and Hidarbe tribes organized in about five main villages. The average household number in a village is 400, while the average household size is 5persons; while the women headed households make about 30% of the total households. Traditionally, their source of livelihood was Pastoralism; but as the pastoral system has been failing gradually to sustain their livelihood, different autonomous coping mechanisms were practiced. The most important autonomous strategy has been growing drought resistant cereal crops such as Sorghum and Pearl Millet wherever moisture is favourable including riverbeds. In this way, the communities have become agro- pastoralists for the most part. However, frequent crop failure and animal loss are destabilizing their livelihoods.

Rationale: The populations in the project area have been suffering from the low productively of the extensive livestock system, and the failure of rain-fed crop. The rangelands have been under continues human pressure, climate variability and drought, which have led in to seriously degradation and land and water use changes. Due to this, the rangeland productivity has reached its lowest point destabilizing the pastoral system. Rain-fed cropping is also failing due to climate variability and successive drought years with tendency of increased frequency and severity. The fail of the mixed crop-livestock farming system has severely impacted the livelihood of the population and their traditional coping strategies have become ineffective. This existing situation has made the farming system and the populations' dependant on it for their livelihood highly venerable to climate viability, drought and climate change.

This project is designed to adapt this vulnerable community to climate variability and drought immediately and to cope with climate change in the long term. The strategy is by intensifying the present practices of agro-pastoralism. It is expected to improve cereal food production and incomes by avoiding crop failure and low livestock productivity including death due to low and variable rainfall and drought. This will involve increase in soil moisture for cereal crop production and for feed productively of the rangeland. Through this the livelihoods of these communities will be sustainable.

Objectives: The main major objectives are two:

- Increase food crop production by avoiding crop failer due to climate variability and drought;
- Increase cash income and protein food of animal origin by avoiding direct loss of animals and poor productivity due to starvation;

Strategies: The main strategy taken by the project to achieve its objectives is by:

- establishing spate irrigated cereal crop production system;
- improving livestock production through improving rangeland;
- restocking of small ruminants;
- providing machinery and initial agricultural inputs; and
- establishing community based effective institution.

Activities: The main activities are:

- designing detail strategy and implementation plan;
- constructing river diversion and earth embankment structures for spate irrigation;
- providing initial seed, farm tools and machinery for construction and maintenance of spate irrigation and soil and water conservation structures;
    - construction of soil water conservation structures on rangeland;
    - reseeding of rangeland;
    - providing initial good sheep breeding stock for women headed households and the poor in general;
    - constructing water wells and equipping them for human and livestock uses;
- training communities to manage their resources; and
- monitoring and evaluation.

Short-term outputs

- spate irrigated cereal crop production system established;
- improved rangeland for livestock present;
- sheep goat breeding flocks for women headed households and the poor present;
- safe and adequate water supply system established;
- community organization and management systems made available;
- initial agricultural inputs present**;**

Potential long term outcomes

- coping strategy for agro-pasturalists to climate variability, extreme weather events and climate change have been established on a sustainable bases;
- sustainable source of livelihood for the agro-pasturalist developed;
- lesson on adaptation strategies to climate change and climate variability have been learned to enable replication at wide scale; and
- decreasing food insecurity/malnutrion and poverty levels.

Implementation Arrangements

The main implementing body will be the Ministry of Agriculture through its Regional Agricultural Office in Gash-Barka Administrative Region. Other relevant stakeholders will be the target communities, local administration, the Ministry of Land, Water and Environment. The arrangement will be within the organizational structure of the stakeholder bodies.

Risks and Barriers

- capacity of the Ministry of Agriculture for implementation;
- capacity to prepare detail strategy design; and
- land tenure and use for each of the village communities for purposes of spate irrigation and rangeland development.

Monitoring and Evaluation

The monitoring and evaluation system will be designed with the project strategy design. It should be established and implemented to ensure guidance of the project by collection information on problems and deciding on possible modification and adjustment of plan. The regional Agricultural Office in collaboration with the participating farmers will conduct the monitoring and evaluation function.

Financial Resources

The financial contribution will be mainly from the project, however, the Ministry of Agriculture will provide extension services on crop and livestock and in the control of major animal and crop pests. The Local Administration will provide assistance in organizing the agro-pastoral communities. The target communities will provide source of labor, but mostly on cash for work.

Table 5: Activities and Cost Estimates

Activities	Cost estimates (USD)
(a) Construction of Spate Irrigation Structures (at five sites)	4,200,000
(b) Initial Agricultural Inputs	300,000
(c) Construction of soil water conservation structures on rangeland (2500ha)	2.600.000
(d) Livestock breeder stock for women headed households/poor households	400,000
(e) Machinery for construction and maintenance of enhancements	600,000
(f) Community capacity building	160,000
(g) Detail Project design preparation	130,000
(h) Monitoring and Evaluation and related project management	150,000
Total	**8,540,000**