Climate Change Adaptation: Options and Good Practices for the Arab Region

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Acronyms and Abbreviations

AFED: Arab Forum for Environment and Development

AHDR: Arab Human Development Report

AIACC: Assessments of Impacts and Adaptations to Climate Change

AOAD: Arab Organization for Agricultural Development

CAMRE: Council of Arab Ministers Responsible for Environment

CBA: Community-based Adaptation

CCAA: Climate Change Adaptation for Africa

CDM: Clean Development Mechanism

CFR: The Cape Floristic Region

CFUGs: Community Forest User Groups

CGIAR: Consultative Group on International Agricultural Research

CRASTE-LF: African Regional Centre for Space Science and Technology in the French Language

DRR: Disaster Risk Reduction

ESCWA: Economic and Social Commission for Western Asia

FAO: Food and Agriculture Organization

GCC: States of the Gulf Cooperation Council

GEF: Global Environment Facility

HFA: Hyogo Framework for Action 2005-2015

ICZM: Integrated Coastal Zone Management

IDRC: International Development Research Centre

IPCC: Intergovernmental Panel on Climate Change

IUCN: International Union for Conservation of Nature

IWRM: Integrated Water Resource Management

LCA: Linking Climate Adaptation network

LDCs: Least Developed Countries

LEG: Least Developed Countries Expert Group

MENA: The Middle East and North Africa

METAP: Mediterranean Environmental Technical Assistance Program

NAPA: National Adaptation Programme of Action

NASA: National Aeronautics and Space Administration

NC: National Communications

NEPAD: New Partnership for Africa's Development

OSS: Sahara and Sahel Observatory

PDSI: Palmer Drought Severity Index

ROAS: Regional Office for Arab States

SCCF: The Special Climate Change Fund

SLR: Sea Level Rise

SPA: Strategic Priority for Adaptation

UAE: United Arab Emirates

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

USCSP: United States Country Study Program

UNISDR: United Nations International Strategy for Disaster Reduction

WB: World Bank

WHO: World Health Organization

WRI: World Resources Institute

WUAs: Water Users' Associations

I. Introduction

This work is commissioned by the United Nations Development Programme - Regional Bureau for Arab States. The study examines current evidence provided by earlier studies and research in order to provide the UNDP-Arab Region Office with an improved understanding of the potential adaptation to climate change impacts for the Arab region. It provides an overview of the options for adaptation in order to minimize potential negative effects. The report starts with a brief introduction, which summarizes the objectives, methods and contents of the report. Next, it provides the background knowledge related to climate change and its impacts on the region, and then the potential adaptation options for increasing resilience of different sectors in the region in view of the projected impacts of climate change. Some of the main issues related to adaptation planning integration and funding are then discussed, followed by a complete list of scientific and technical studies that provide background information and support the evaluation. Finally, a glossary of terms and concepts, in addition to three annexes, complements the results provided in the main chapters of the report.

II. Background

Climate change is a huge threat to all aspects of human development and achievement of the Millennium Development Goals for poverty reduction. Although the Arab region does not contribute more than 5% of total emissions, the climate change impact on the region is expected to be huge. The region is already vulnerable given its scarce water resources, high levels of aridity and long stretch of coastline threatened by rises in sea level. Potential climate change impacts on the region include drought, decline of water quality, floods, changes in soil erosion and desertification, storms, coastal erosion, changes in seawater temperature and salinity, and biodiversity reduction.

Adaptation to climate change is therefore an economic and social imperative for the region. Actions are needed now, and adaptation and risk management should be a central element in the development planning strategies for the countries in the region. One of the most important constraints on the assessment of vulnerability and adaptation is the lack of capacities to conduct the type of vulnerability and adaptation assessments that would generate reliable results for incorporation into national development planning processes (Leary et al, 2007).

The Intergovernmental Panel on Climate Change (IPCC) has played a key role in reviewing and synthesizing information about climate change, its impacts, and potential adaptation measures, with a view to informing the United Nations Framework Convention on Climate Change (UNFCCC) negotiations. This knowledge needs to be made more accessible to decision makers, development agencies, and civil society in

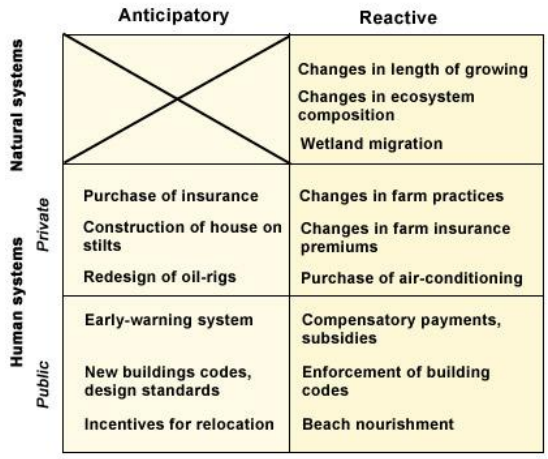
order to enable them to use it to inform their own work. The IPCC defines adaptation as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects." Resilience is "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self organization, and the capacity to adapt to stress and change" and is a subset of adaptation that represents less change from the status quo compared to other adaptation options. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in behavior, resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005). Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism. This study looks at existing cases of adaptation in different sectors to identify lessons that will help societies and governments in the Arab region adapt better to the impacts of climate change.

1. The adaptation concept

Adaptation refers to all those responses to climate change that may be used to reduce vulnerability, or to actions designed to take advantage of new opportunities that may arise as a result of climate change (Burton, 2009). The focus of these actions is on managing risk. Investments in risk-based actions are fundamental to reducing the environmental, social and economic costs of climate change. In its Fourth Assessment Report, the IPCC (2007) recognizes that some adaptation is occurring, but on a very limited basis, and affirms the need for extensive adaptation across nations and economic sectors to address impacts and reduce vulnerability. Vulnerability to climate change may be defined as: "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (Leary et al, 2007). Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity."

Adaptation measures or options vary depending on many factors. For example, adaptation measures can be classified based on the sectors considered. Alternatively, adaptation measures can be classified based on the timing, goal and motive of their implementation. Accordingly, adaptation can include reactive or anticipatory actions, or can be planned or autonomous (UNFCCC, 2006, IPCC, 2007). See Figure (1):

Figure (1) Anticipatory and reactive adaptations



Source: IPCC, 2001

Planned adaptation is the result of deliberate policy decisions, based on the awareness that conditions have changed or are expected to change, and that some form of action is required to maintain a desired state. Such anticipatory adaptation would progress from the top-down approach, through regulations, standards and investment schemes.

Such an anticipatory approach is particularly important for decisions that have long-term implications, such as the design and citing of long-lived infrastructure. Considerations of climate change in the National Water Plan of Bangladesh would be an example of this approach.

Autonomous adaptation refers to those actions that are taken by individual institutions, enterprises and communities independently to adjust to their perceptions of climate risk. Such autonomous actions may be short-term adjustments and are often considered as a reactive or bottom-up approach.

Adaptation could also be reactive or anticipatory depending on the timing, goal and motive of its implementation**.**

Reactive adaptation occurs after the initial impacts of climate change become evident.
Anticipatory adaptation occurs before the impacts are obvious. For example, adaptation in a natural system is reactive by nature, while in a human system it can be both reactive as well as anticipatory. See Table (1):

Table (1) Summary of approaches to adaptation

Types of adaptation	Characteristics	Examples
Autonomous adaptation	Adaptation that takes place naturally or not as a conscientious response to climate change	Natural responses of plant species to e.g. drought or to seasonal changes (earlier spring) Autonomous farming practices (changes to sowing dates)
Building adaptive capacity	Creating the information and regulatory, institutional and managerial conditions that enable adaptation to be undertaken Education and capacity-building	Climate change research funding Awareness creation among farmers Development of policy support tools
Adaptive measures	Taking actions that help reduce vulnerability to climate risk or exploit opportunities	Creating water collection and storage facilities Introducing new crop varieties Resource management tools and infrastructure

Source: author, adapted from IPCC, 2001

It may be that the agricultural sector is one in which autonomous adaptation is a particularly important category because farmers have traditionally adapted their methods in response to changes and variability. In contrast, planned or policy driven adaptation is the result of a deliberate policy decision planning process such as National Adaptation Programmes of Action (NAPAs), that have been prepared by Least Developed Countries (LDCs) (UNFCCC 2008). In the water sector, planned interventions involve both the supply and demand side. While supply side adaptation options involve increases in storage capacity or abstraction from water courses, demand side options, such as increasing the efficiency of water to ensure that economic and social benefits are maximized through use in higher-value sectors, aim to increase the value per volume used and to ensure that quality is maintained.

Assessing adaptation to climate change:

Various international and national organizations have developed guidelines for climate impact and adaptation assessment. Widely applied generic guidelines include the IPCC Technical Guidelines (Carter et al, 1994; Parry and Carter, 1998), the United States Country Study Program (USCSP) International Handbook (USCSP, 1994; Benio et al,

1996), the United Nations Environment Programme (UNEP) Handbook (Feenstra et al, 1998), the United Nations Development Programme-Global Environment Facility (UNDP-GEF) Adaptation Policy Framework (Burton et al, 2005). The two prototypical approaches applied in guidelines for climate impact and adaptation assessment are the hazards-based approach and the vulnerability-based approach (Burton et al, 2005). The hazards-based approach focuses on the incremental impacts of climate change. Assessments start from model-based climate change projections and generally have a limited consideration of non-climatic factors. Several reviews have concluded that hazards-based assessments have been crucial for identifying risks of climate change but that their results generally have not been immediately useful for the purposes of adaptation policy design (Klein et al, 1999; O'Brien, 2000; M.) Important limitations of hazards-based assessments are their strong reliance on model-based climate and climate impact projections, which may not be available at the spatial scale relevant for the decision-maker, and the long time frame of climate change projections that has little practical relevance for many adaptation actors. The vulnerability-based approach assesses future climate change in the context of current climate risks. It has a strong focus on the social factors that determine the ability to cope with climatic hazards. Vulnerability-based assessments start from the experience with managing climate risks in the past, and they involve stakeholders from the outset, linking adaptation to climate change directly to their activities.

Four broad approaches of adaptation assessment are outlined in the Adaptation Policy Framework (Lim and Siegfried, 2004), as summarized in Table (2):

Table (2) General adaptation framework

Approach	Aims	Tools
Hazards-based approach	To reduce climate induced risks. This approach assesses the current risk to which a system is exposed and then uses climate scenarios to estimate future vulnerability.	Building physical infrastructure, such as sea walls, dykes and river bunds. Disaster Risk Reduction and Preparedness planning.
Vulnerability-based approach	To ensure that critical thresholds of vulnerability in socio-ecological systems are not exceeded under climate change. This approach takes into account both development conditions and sensitivity to climate change.	Safety net programs. Strengthening livelihood asset availability. Adaptive-capacity approach. Insurance. Improving technological know-how.
Policy-based approach	To ensure that policy is robust under climate change.	Mainstreaming within sectors. Climate proofing.

Source: (Lim and Siegfried, 2004)

2. How can communities adapt to climate change?

The ability of communities to adapt to climate change is determined by their levels of development, their access to resources and their scientific and technical capacities. The impacts of climate variability create challenges for the world's poorest communities, as their livelihoods are likely to be more sensitive to climate change. These impacts may be related to more intense and frequent extreme events, like hurricanes or floods, and more long-term stresses, such as water scarcity and increased recurrence of drought (World Bank, 2006).

Adaptation can take different forms, such as better education, training and awareness of climate change, or it can take the form of more technical measures, such as drought-resistant seeds and better coastal protection. For many communities, the direction of climate change remains uncertain, so focus is also placed on increasing their adaptive capacity in relation to key sectors, such as agriculture and health.

For adaptation to be effective in addressing country/community-level impacts, it must progress at several levels simultaneously from local to national to global. Primarily, adaptation is local since the most direct impact of climate change is felt locally, and consequently response measures must start at that level taking into consideration local-specific circumstances. However, for local efforts to be more effective, they need to be supported by national policies and regulations – which in turn sometimes should be supported by international agreements. The efforts should support the process of building adaptive capacity through essential elements such as: **a) Information –** Effective adaptation measures must be based on accurate data and information regarding the nature and extent of likely impacts over different timeframes in given locales, and on the cost and efficacy of possible response measures. **b) Capacity –** A priority area should be the strengthening of existing capacities in terms of determining impacts and developing response measures. **c) Financial Resources –** To ensure the provision of hardware and software technology and to build the technical capacity to deal with adaptation. **d) Institutions –** Adaptation responses need to be integrated into national plans and strategies, which cut across a number of institutions and may need the initiation of new institutions to facilitate the coordination of comprehensive strategies and ensure sustainability. **f) Technology – T**echnology for adaptation is equally important as for mitigation. There is an even greater need for adaptive technology that is suited to the specific needs and conditions of different countries and regions, which can lead to improved outcomes and increased coping capacity under a changing climate.

According to the Food and Agriculture Organization (FAO, 2006), climate change adaptation measures need to focus on climate change "hot spots" analysis, early warning systems, disaster risk management, rural investments, crop insurance, and incentives to adopt better agricultural and land use practices, while also building capacity and awareness on climate change adaptation. In addition, the provision of supportive services such as extension and research at national levels, data collection, monitoring, analysis and dissemination are key to preparing for climate change. In many parts of the world, people have always adapted to variations in their climate by using local knowledge, tools and available resources. In the African Sahel, which is characterized by historical variability, people have been forced to react to and recover from climate extremes and surprises, such as drought. A study in Darfur, in western Sudan (Osman-Elasha et al, 2008), indicated that some community–based adaptations have dramatically assisted local communities in surviving extreme drought, and could therefore be build upon in the future. Some scientists argue that communities' past experiences alone can no longer provide a reliable guide to the future, particularly among a myriad of social, demographic and economic factors that impinge on development trajectories and experiences (O'Brien and Leichenko, 2000). Securing the economic and social well-being of vulnerable people will increasingly require

communities, scientists and policy-makers to work together to consider the implications of a changing climate and to identify responses to these changes.

3. Adapting to climate change in different sectors

In the face of climate change and its potential impact, Arab countries need to implement adaptation measures to minimize the adverse effects on their most important socioeconomic sectors. In their national communication reports, most Arab countries identified future programs and adaptation projects that target different sectors. Assessment and research studies (e.g. national communications) have also explored how different sectors may be impacted by climate change and how they may be able to adapt. The reports indicated that water, coasts, agriculture and health are likely to be particularly sensitive to changes in climate, and it is these areas that are of key importance to vulnerable communities who rely heavily on natural resources and ecosystems. Therefore, the focus of much of the adaptation planning to date has been on adaptation strategies covering the agriculture sector, water resources and, to a lesser extent, coastal zone management and health. See Annex (1) on adaptation strategies in the Arab countries. Immediate attention has been focused on raising awareness and capacity building – mostly supported by GEF, UNDP and other organizations. Some countries have undertaken adaptation-focused research activities, often facilitated and complemented by organizations that are outside national governments, e.g. the Assessments of Impacts and Adaptations to Climate Change (AIACC) Project[1] in Sudan and Egypt. Potential climate change risks and consequences are identified together with adaptation options, as summarized in Annex (3). It is important to mention that adaptation measures identified in the annex will depend not only on climate change, but will consider socio-economic conditions and will take into account country/region specific circumstances. A recent report by N. Saab and M.K. Tolba (Eds.), 2009, for the Arab Forum for Environment and Development (AFED) proposed the following adaptation measures to address various climate change impacts:

a. Improve efficiency, especially in irrigation, and develop new water resources including innovative desalination technologies.

b. Develop new varieties of crops that can adapt to higher temperatures and different spans of seasons, that need less water, and that can withstand higher levels of salinity; and establish a regional genetic bank.

[1] www.aiaccproject.org

c. Adapt land use regulations to the potential rise in sea level by increasing the minimum clear distance required between buildings and shoreline.

d. Construction materials and techniques used for buildings, roads, and utility networks should consider the risk of rising temperatures and storm surges to make them more resistant to climate change.

e. Develop mechanisms for coordinating conservation actions across political boundaries and agency jurisdictions to support the survival and resiliency of plant and animal species at a regional scale.

f. Adapt human health systems and prepare them to respond to the consequences of climate change, mainly the spread of disease, alongside allergic and pulmonary ailments caused by increased drought and fiercer sand storms.

g. Explore and promote options for alternative tourism that is less vulnerable to climate variability, such as cultural tourism. Countries with low-lying coastal areas should develop alternative inland tourist destinations.

However, very little information is made available on practical steps for implementation of these adaptation measures or what enabling environments should be put in place. Areas that have been targeted by most of the Arab countries include: water resources, agriculture, health and coastal zones.

Some national communications have also reported on forests, tourism, fisheries, human settlements, biodiversity and wildlife. FAO, 2009 highlighted the importance of policy reforms to achieve water conservation, flood management and construction of dams. The national communications and NAPAs from countries such as Egypt, Sudan and Yemen reported on adaptation options and/or strategies in agriculture; these plans varied from development of drought-tolerant crops to improving early warning systems, enhancing erosion control, and training and assisting farmers. Many highlighted measures related to improving the health care system, enhancing forest management, protecting tourism infrastructure, strengthening environmental legislation and promoting nature conservation. Other countries – such as Djibouti, Saudi Arabia and Lebanon – reported on adaptation measures which could be undertaken in coastal zones, namely integrated coastal zone management. A number of adaptations for addressing a broad range of climate-related hazards are summarized in Annex (3) on adaptation measures identified by Arab countries under national communications and NAPA reports.

The following sections will discuss sector-specific adaptations to the impacts of climate change.

3.1 Adaptation of water resources to climate change

Specific to the water sector, the IPCC Technical Paper on Water (Bates, B.C., Kundzewicz, Z.W. Wu, S. and Palutikof, J.P. (eds) (2008)) outlines three approaches that can be used to address climate change adaptation planning in light of uncertainty in future hydrological conditions. These include: 1. Scenario-based approaches to planning to develop plausible future storylines that facilitate decision-making in the context of uncertainty. Scenario development is based on a set of assumptions of the key relationships and driving forces of change. These include predictable and unpredictable features of changes in climate, the environment and socio-economic factors; 2. Adaptive management that involves increased use of water management measures that are robust enough to withstand uncertainty; 3. Integrated Water Resource Management (IWRM) – taking on diverse stakeholders, reshaping planning processes, coordinating land and water resources management, recognizing water quantity and quality linkages, conjunctive use of surface water and groundwater, and protecting and restoring natural systems (see Box (1) on Tanzania's experience with water conservation). Climate change is not the only factor that drives changes in water resources. A number of drivers are already changing patterns of demand. These drivers include population growth, land use change, economic growth and technological change (Pahl-Wostl et al). For instance, irrigation demand is projected to increase by 0.4%-0.6% per year up to 2030 and 2080, according to projections from the Food and Agriculture Organization (FAO, 2009). But if the anticipated impacts of climate change are added, the projected demand will lead to an increase of between 5-20% by 2080. On the other hand, the projected increase in household water demand and industrial water demand due to climate change is likely to be small – less than 5% by the 2050s in some locations (Bates et al, 2008).

Box (1) Water Conservation of Tanzania's Great Ruaha River

This case study [2]evaluates adaptive capacity by examining improvements in resilience to climate change, livelihood changes, and conservation of biodiversity. The Great Ruaha River in Tanzania is a major tributary of the Rufiji River, and is nearly 600 km long. The 84,000 km2 basin is home to 6 million people. Since 1957 rainfall in the lowland portion of the catchment has been in decline, a trend that many fear will be exacerbated by climate change. Increasing degradation of the catchment was also evident, which had major impacts on the livelihoods of local people and on the riparian environment, and raises concerns for tourism and hydropower generation.

[2] http://assets.panda.org/downloads/50_12_wwf_climate_change_v2_full_report.pdf

A WWF program was launched to restore flows in the Great Ruaha River. It commenced in 2003, working with communities in eight of 16 districts in the basin, focusing mainly on better catchment management and poverty reduction. Local Water Users' Associations (WUAs) were established to restore catchments and better manage water by restoring the source catchments, through agreements with major agricultural users to better schedule their water diversions, and through enforcement of water laws to shut down illegal diversions. Headwaters and riparian zones were restored by reducing vinyungu (valley-bottom) farming, removing thirsty, exotic trees, restoring indigenous vegetation, including by reducing felling for charcoal production, protecting riparian zones from grazing, and relocating houses from river banks (80 of 150 have been relocated so far). Agreements with irrigators have reduced transmission losses through coordinated water deliveries, and reduced dry season water use. A 49,000 m3 dam was constructed to secure a water supply for livestock.

One of the important requirements for successful adaptation identified from the program is the need for motivating change through improvements in livelihoods; establishing and strengthening local institutions and links to basin and national institutions makes this change sustainable. Reduced poverty, better livelihoods and stronger local institutions are resulting in more sustainable catchment management. Restored flows and stronger local institutions have reduced the vulnerability of local people to water scarcity. In terms of livelihood outcomes, the strategies have diversified from agriculture, brewing and charcoal production into activities requiring less water, notably retailing, manufacturing clothing, and bee-keeping. Secure water supplies have supported livestock production, and fish farming in water storage areas has proved particularly profitable. Conservation of riparian zones and restoration of springs and river flows is of benefit to biodiversity, particularly as flows have recommenced into the Ihefu wetlands.

The water sector, more than any other sector, requires cooperation across various institutions and systematic updating. This is particularly important for transboundary water resources such as the Nile Basin. Cooperation between the 10 nations of the Nile Basin is critical for sustainable management of water resources. The Nile Basin Initiative[3] aims at strengthening cooperation between the 10 countries so as to develop the river in a mutually beneficial manner, share substantial socioeconomic benefits, and promote regional peace and security. This is expected to largely simplify and harmonize the planning process for all countries in the Nile Basin region. Moreover, a systematic collection of information on water resources and the dissemination of that information are essential for comprehending climate change impacts. This requires a multi-disciplinary approach and involves trans-global cooperation. An institutional framework for sharing information at the global and regional levels, and the dissemination of that information at the local level, is necessary. For instance, the National Aeronautics and Space Administration (NASA) is helping monitor the water cycle in the Arab region using satellite data (NASA, 2008).

[3] http://www.nilebasin.org

Adaptation measures for water resources in Arab countries that are already severely water stressed involves new challenges. Climate change represents a serious threat that policy makers must confront, as it is necessary to plan for this challenge. In addressing this uncertain future, it is critical to draw as much strength as possible from the lessons of the past so as to ensure that the measures chosen – which may vary from country to country – are effective and sustainable. The optimal water allocation for a growing number of competing water management requirements (e.g. agriculture, public consumption, industry, hydro-energy, ecosystems, etc.) under a changing climate system places a heavy burden on water managers. Therefore, it is urgent to plan adaptive strategies at the country and regional levels, and to work towards strengthening national capacities. It is equally important that Arab governments integrate climate risk-based approaches, which address climate variability and climate change, into water policy frameworks.

Some countries or sub regions are expected to experience more impacts than others. For example, the Arab region is particularly vulnerable to climate change because it is one of the world's most water-scarce and dry regions. It is already witnessing water–related problems and is going to face more serious climate-related situations in the future. According to the latest IPCC assessment, the climate is predicted to become even hotter and drier in most of the Arab region. Higher temperatures and reduced precipitation will increase the occurrence of droughts, an effect that is already materializing in many countries of the region. It is further estimated that an additional 80–100 million people will be exposed by 2025 to water stress, which is likely to result in increased pressure on groundwater resources that are currently being extracted in most areas beyond the aquifers' recharge potential. In addition, heat waves, an increased "heat island effect," water scarcity, decreasing water quality, worsening air quality, and ground ozone formation are likely to affect public health, and more generally lead to challenging living conditions (World Bank, 2006).

An assessment in Lebanon indicated that a maximum 15% decrease in available water and 6% increase in agricultural demand were projected by the year 2020 (H. A. Amery, 2000). Adaptation measures are necessary in view of increased water demand and a potential decrease in available water. Most adaptation measures identified are no-regret options that attempt to develop nonconventional sources of water that can be exploited in the future, including the use of surplus winter runoff, wastewater reclamation, seawater and brackish water desalination, rainfall enhancement by seeding clouds with silver iodide crystals, and exploitation of submarine springs. Conservation measures, as well as institutional reforms and capacity building, are also needed.

The Moroccan government is working with the World Bank to design ways to make irrigation in the Oum Er-Rbia River basin more sustainable, more profitable, and more resilient to climate change. This basin, which is currently facing lower-than-predicted rainfall patterns, contains half of Morocco's public irrigated agriculture and produces 60 percent of its sugar beets, 40 percent of its olives, and 40 percent of its milk (World Bank, 2007). Moroccan authorities will commit to providing a fixed amount of water to the farmers on an on-demand basis so that they have confidence that water will be available at exactly the times they require it. The project will subsidize localized irrigation equipment (drip, micro-sprinklers, etc.), promote private investment in post-harvest infrastructure, and help farmers link to domestic and international markets. The farmers, in turn, will have to commit to not exceeding a fixed quantity of water consumption and will be sanctioned if they exceed the limit.

Some of the adaptation measures related to water resources in Lebanon are summarized in Table (3). The table summarizes all the potential water-related adaptation measures that can be exploited in the future. However, adoption of any adaptation measure will need capital investment, institutional reforms, and capacity building. Institutional reforms should aim at strengthening institutions, removing market distortions, correcting market failure to reflect environmental damage or resource depletion, and promoting public awareness and involvement. Capacity building would be of crucial importance for monitoring and mitigating impacts on water quality.

Table (3) Technical Adaptation Measures and Nonconventional Water Resources (E. Bou-Zeid and M. El-Fadel (2002))

Adaptation measure	**Potential benefit**	**Best uses**
Conservation	Curbs water demand increase	Domestic, industrial, agricultural demand reduction
Use of surplus winter runoff	Collectable runoff can constitute up to 10% of rainfall	Irrigation, aquifer recharge
Wastewater reclamation	All collected wastewater can be reused	Irrigation, aquifer recharge
Seawater/brackish water desalination	Unlimited water supply	Domestic, industrial
Rainfall enhancement by seeding clouds with silver iodide crystals	Can increase precipitation by up to 15% in arid regions	Domestic, industrial irrigation, aquifer recharge

Use of submarine springs	Submarine springs with significant flows are located along Lebanese coastal waters	Domestic, industrial, agricultural use, aquifer recharge

3.2 Agriculture and food security

The Intergovernmental Panel on Climate Change (IPCC) predicts that during the next decades, billions of people, particularly those in developing countries, will face changes in rainfall patterns that will contribute to severe water shortages or flooding, and that rising temperatures will cause shifts in crop growing seasons. This will increase food shortages and the distribution of disease, putting populations at greater health and life risks. The predicted temperature rise of 1 to 2.5-degrees Celsius by 2030 will have serious effects, including reduced crop yields in tropical areas. The impact of a single climate-, water- or weather-related disaster can wipe out years of gains in economic development (FAO, 2008).

Challenges to agriculture are many. Generally agriculture can be affected by too much rain or too little rain. As too much rain will increase flood events, damage crops, erode fertile soil and possibly increase pest and disease problems, too little rain will result in reduced water availability that may lead to crops suffering from heat and drought stress. Depending on the impacts, different agro-climatic zones must have different adaptation options and adaptive capacity (Arab Organization for Agricultural Development, 2007).

It is imperative to identify and institutionalize mechanisms that enable the most vulnerable to cope with climate change impacts. Historically, people whose livelihoods depend on agriculture have developed ways to cope with climate variability autonomously. However, the current speed of climate change may be faster than the capacity of people to adapt, and therefore they may be confronted with situations they are not equipped to handle. Thus, anticipatory and planned adaptation is an immediate concern. Small-scale rain-fed farming systems, pastoralist systems, inland and coastal fishing and aquaculture communities, and forest-based systems are particularly vulnerable to climate change (IPCC, 2007). Generally, the impacts of climate change are greatest on smallholder and subsistence farmers and pastoralists because of their low adaptive capacity; therefore, these small-scale farmers and pastoralists will likely bear additional adverse impacts (World Resources Institute, 2005).

The majority of the Arab region will face a reduced amount of available water due to climatic and non-climatic factors. Rainfall is predicted to decrease while

evapotranspiration is expected to increase, and so water supply is likely to diminish. Increasing temperatures are likely to increase demand by other sectors, potentially leading to conflicting demands for a diminishing resource. Responding to water scarcity stress and the threat of declines in crop and pasture yields requires farm level intervention, such as rainwater harvesting and establishing small-scale water reservoirs on farmland while improving the efficiency with which irrigation water is used, such as by changing land use in areas that are more susceptible to drought, e.g. from crops to rangeland (Osman-Elahsa et al, 2006) or changing crops by switching to less water intensive crops, and by investing in rain water harvesting equipment (Tompkins et al, 2005). There will be a need for farmers in this region to adapt to an environment in which the risk of drought is increased and the supply of water is reduced. Farming communities must, therefore, protect themselves against the potential impacts of climate change on agriculture and subsequent impact on food security through the appropriate use of resources in order to preserve livelihoods as well as lives and property. For example, farm communities might adopt new crop varieties which are more tolerant of drought, together with more heat and drought resistant cultivars of current crops (see Annex (1)). Earlier planting and early maturing crops are also an option. Diversified crop rotations and activities will help further. Extension campaigns are essential to raise farmers' awareness and acquaint them with these options. For animal herders, the reduced productivity of traditional forages such as grass may lead to the use of supplements. Medany et al (2007) concluded that designing an adaptation strategy for the agriculture sector should consider the simple and low cost adaptation measures that may be inspired from traditional knowledge to meet local conditions and to be compatible with sustainable development requirements (see Box (2) on adaptation of farmers in drought prone area of western Sudan). It is not preferable to use imported solutions based on high levels of technology and high initial costs.

While many parts of the Arab region, and particularly the Middle East and North Africa (MENA), will be facing more frequent drought conditions (Brooks, 2007), parts of the region – such as Sudan and Yemen – are projected to receive an increasing amount of rainfall and potential floods. In order for agriculture to adapt to an increased risk of floods, farm-level actions are needed to improve soil drainage and reduce waterlogging. An early warning system should be established to ensure the timely dissemination of information and minimize flood impacts by warning farmers and making them aware of the hazards.

The Food and Agriculture Organization (2009) promotes the use of indigenous and locally-adapted plants and animals as well as the selection and multiplication of crop varieties and autochthonous races adapted or resistant to adverse conditions. The

selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperature, drought, flooding, high salt content in soil, pest and disease resistance) allows for the harnessing of genetic variability in new crop varieties if national programs have the required capacity and long-term support to use them (FAO, 2006). In the Yemen highlands, farmers have long traditions of agrobiodiversity farming practices and traditional knowledge. The World Bank is currently supporting, with Global Environment Facility (GEF) resources, the identification and implementation of coping strategies for adaptation to climate change for highland farmers who rely on rain-fed agriculture. These strategies include the conservation and utilization of biodiversity important to agriculture, particularly the plant varieties and associated local traditional knowledge. The project will emphasize the conservation of agrobiodiversity and development of a range of coping mechanisms using predictive climate modeling (World Bank, 2006).

With projected changes in the pattern and distribution of rainfall, agriculture in the Arab region will also face the threat of increasing pests and diseases, e.g. locusts. In order for farmers to adapt to increasing pest and disease pressures, research and extension agencies will need to identify potential problems and develop strategies to minimize the impact of these problems. This may include the promotion of more resistant varieties and/or a pest control program (FAO, 2008).

Box (2): Farmers shifting to rangeland management and controlled herding in arid lands of Sudan[4].

Farmers in the Sahel have experienced a dramatic change in climate. Over the last five decades, especially between the 1950s and early 1980s, rainfall has gradually decreased in the region. This has resulted in the movement of people and animals southwards, especially after the devastating drought in 1983. Farmers have to cope with even more erratic rainfall and more frequent droughts. The Bara Province lies in drought-prone Western Sudan, North Kordofan state, and typifies the semi-arid and desert scrub of the African Sahel region. The area is characterized by harsh climatic conditions and erratic seasonal rainfall. The predominant socioeconomic grouping consists of a mix of agro-pastoralists and herders that are extremely vulnerable to drought. In response to the drought of the 1980s, a GEF-UNDP project (Community-Based Rangeland Rehabilitation Project) was implemented in the area. Before the project, local people used to keep less than 30% of their lands for grazing and over 70% for cropping. The project intervention managed to approximately reverse the ratio, which became 28% and 82% for cropping and grazing, respectively. The project adopted an institution-building approach where implementation committees and coordination committees were created among the village communities. Several training events were held to enhance community development and improve natural resource management, pest management, diversification of income, and cottage industries. Although the participation from the

[4] http://www.aiaccproject.org/working_papers/Working%20Papers/AIACC_WP_20_Ziervogel.pdf

community was voluntary, the involvement of women in all these activities was largely encouraged. The application of a sustainable grazing system represented by grazing allotments was also introduced by the project at both individual and public levels. This system was found to improve the quality and diversity of grazing land, in spite of the fact that it is practiced on relatively small areas. Range land quality and availability of desirable species did improve significantly, due to the project intervention. The presence of diverse activities was one of the most important factors for increasing the resilience of the community. Strong positive indicators are observed regarding the recovery of local fauna and flora, reduction of sand dune formation, improved productivity and rangeland carrying capacity – which presumably stands for the success of the project in achieving one of its major objectives, biodiversity conservation. There were also good indicators of changes in thinking within the community under study. A good example was the modernization of the traditional women's garden (the Jubraka or backyard farm) into the modern women-irrigated garden. These combined interventions enabled the local communities to stand against the major cause of their vulnerability, drought, and brought about a general increase in their adaptive capacity amid harsh climatic conditions that could act as a baseline foundation for building future climate change adaptation strategies.

3.3 Forestry and biodiversity

Adaptation in the forestry sector will require risk and vulnerability assessments of forests and forest dependent people, adjustments to forest policies and management practices, new research, additional training and capacity strengthening. This will require additional financial investments in the sector. No comprehensive picture exists of the status of the countries' risk and vulnerability assessments and adaptation plans for forests in the Arab region. The Nineteenth Session of the Near East Forestry Commission was held in Tunisia 5-9 April, 2010 under the theme, "Forests and range: adapting to global changes for sustainable development." Participants highlighted the need for countries to initiate or accelerate efforts in adaptation and stressed the need to harness forest potential for improving the adaptive capacity of forest dependent people and to strengthen not just the mitigation role of forests, but also their adaptation role. It further highlighted that regional mechanisms and cooperation can be instrumental in enhancing national action in forestry for climate change adaptation and should be strengthened (see Box (3) on conservation in the Cape Floristic Region).

Some widely known adaptation measures (Center for International Forestry Research, 2008) include:

- Protecting and enhancing migration corridors to allow species to migrate as the climate changes;
- Identifying management practices that will ensure the successful attainment of conservation and management goals;
- Promoting management practices that confer resilience to the ecosystem.

Box (3) Mediterranean-type conservation in the Cape Floristic Region ecosystems [5]

Some of the most threatened ecosystems globally are Mediterranean-type ecosystems such as those found in the Cape Floral Kingdom, the Mediterranean basin, and southern Chile. The Cape Floristic Region of South Africa is one of the world's biodiversity hotspots, one of the 34 most species-rich regions on earth. Together, these hotspots harbor more than 75 percent of the most threatened mammals, birds and amphibians, yet they have already lost more than 85 percent of their original habitat cover. The Cape Floristic Region (CFR) is the smallest of the world's six floral kingdoms, protecting unique Mediterranean-type vegetation known as fynbos. It covers an area of 90,000 square kilometers and contains 9,600 species of vascular plants, many of them endemic; it has been identified as one of the world's "hottest" biodiversity hotspots. The rich biodiversity of the CFR is under serious threat as a result of the conversion of natural habitat to permanent agriculture and to rangelands for cattle, sheep, and ostriches; inappropriate fire management; rapid and insensitive infrastructure development; overexploitation of marine resources and wild flowers; and infestation by alien species. Climate change will increase the threats to these ecosystems and put increasing pressure on water resources, while increasing vulnerability to fire and the spread of invasive alien species. These critical areas for conservation are also home to millions of people who are highly dependent on healthy ecosystems for their livelihoods. The C.A.P.E. Biodiversity Conservation and Sustainable Development Project is building institutional capacity and collaboration among multiple stakeholders—including government agencies, private landowners, and local communities—to mainstream biodiversity conservation into the area's economic activities and enhance conservation of the Cape Floristic Region. A primary focus is on land management for conservation and sustainable natural resource management in four mega-reserves, corridors from the mountains to the sea. The project supports the design of market-based mechanisms for conservation management, such as payment for environmental services, as well as micro-enterprise opportunities for conservation-related businesses, including small enterprises that improve livelihoods and social conditions for local communities.

3.4 Human Health

Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with consequences. In health terms, coping capacity is a measure of what could be implemented now to minimize the negative health impacts of climate change that may arise in the future and maximize any positives that may occur. An assessment of coping capacity is necessary to determine current vulnerability and to plan appropriate adaptations. Assessment of coping capacity at all levels and for all relevant sectors will provide a thorough understanding of what is needed for management of potential health impacts from climate change. Climate change will affect the health of humans as well as the ecosystems and species on which we depend. Climate change effectively multiplies other stresses on development that developing countries already have more of, such as high rates of population growth, poor health, lack of water and sanitation,

[5] http://siteresources.worldbank.org/INTBIODIVERSITY/Resources/Biodiversity_10-1-08_final.pdf

vulnerable employment and political instability. The World Health Organization (WHO, 2003) stated that "there is growing evidence that changes in the global climate will have profound effects on the health and well-being of citizens in countries throughout the world." Key impacts include:

- Health impacts of extreme events
- Health impacts of temperature increases and related changes
- Water-borne disease and water quality
- Vector-borne diseases
- Air quality and related health impacts
- Food-borne diseases
- Food production
- Social impact/community lifestyle, migration, mental health

The above changes could have direct and indirect impacts. Most directly, health will be affected through temperature extremes of heat or cold that could result in illness and death. As well, extreme weather events such as more frequent and intense rainstorms and windstorms, hurricanes and tornadoes could result in death, injury and other harmful effects. Climate change less directly can affect humans by affecting the environment and ecosystems within which they live. These indirect effects will occur through insect- and rodent-transmitted diseases (e.g. West Nile virus) and waterborne and food-related illnesses (e.g. giardiasis and E. coli infection). Smog and air pollution are also likely to increase. The impacts will be widespread, leading to higher mortality rates. Poorer water and air quality, combined with higher temperatures, will threaten health through increased diarrheal, infectious and cardiovascular diseases. Malaria cases are already at about 250 million per year (WHO, 2008). Public health infrastructure will need to adapt to these changes, with improved early warning mechanisms, modified primary and secondary care facilities and careful scenario planning.

As many as 400 million more people may be at risk of contracting malaria due to climate change, including in regions where it had been eradicated (IPCC, 2007). Up to 80 percent of malaria deaths already occur in sub-Saharan Africa (Worldwatch Institute, 2009), where health systems have been severely weakened by conflict and macroeconomic policy choices that undercut domestic social spending. Extreme weather events are also

deadly. According to the World Meteorological Organization, it is estimated that weather- and climate-related disasters claim nearly 225,000 lives a year globally.

Any increase in the frequency or intensity of extreme weather events would worsen this already serious situation, leading to more deaths and injuries related to weather events. According to McMichael and Kovats (2000), adaptation to climate change in health terms can be broken down into primary, secondary or tertiary measures similar to those used for public health. *Primary adaptive measures* are actions taken to prevent the onset of disease arising from environmental disturbances in an otherwise unaffected population. S*econdary adaptive measures* are preventive actions taken in response to early evidence of health impacts. And *Tertiary adaptive measures* are health-care actions taken to lessen the morbidity or mortality caused by the disease.

Consideration of the chain of events from the climate parameter to health impact is a useful method to identify opportunities for adaptation. In general, the earlier in the chain of events that adaptations are applied the better. All measures aim to increase adaptive capacity. Adaptive measures may be targeted at the whole population, vulnerable regions or vulnerable subpopulations. Measures focused on vulnerable groups are likely to provide the greatest reductions in risk and therefore the greatest improvements in health outcomes. In Toronto, Canada, vulnerable people are warned of potential heat waves through the Heat/Health Alert system, which was introduced during the summer of 2001. The system forecasts the occurrence of oppressive heat before it happens. The system is adjusted for the local climate and takes into account how people have responded to certain weather conditions in the past. By using historical meteorological data combined with mortality data, experts were able to conclude which weather conditions resulted in above-average “heat-related” deaths. A “heat emergency” is issued when the likelihood of weather-related deaths occurring exceeds 90 percent. The system also involves various outreach activities, including improved access for vulnerable groups to “cooling centres” where bottled water, cots and air-conditioned space are provided (See Box (4) on adaptation to rising temperatures in Europe). Experience from previous programs in developing countries suggests that climate change adaptation policies need to take into account how climate variability impacts vulnerability, and the policies need to be fully integrated into existing programs to relieve poverty and improve health care infrastructure. Training and capacity building for health professionals from developing countries is one way of supporting them in adapting to climate change impacts.

Few examples are found on health adaptation in the Arab region, however, some of the measures identified in the national communications include:

- Public health management reform
- Improved housing and living conditions
- Improved emergency response
- Development of an early warning system
- Better and/or improved disease/vector surveillance and monitoring
- Improvement of environmental quality
- Changes in urban and housing design
- Improved health care through flood shelters and assistance shelters as part of community emergency preparedness programs, better health education, and better access to primary health care such as distribution of treated mosquito nets and better malaria surveillance programs and habitat clearance.

Box (4) Adaptation to rising temperatures in Europe[6]

Heat watch and warning system in France

Following the 2003 European heat wave, a heat watch and warning system, including a national action plan, was implemented in France. The system was based on an analysis of data from 14 cities in France and used temperature alone, rather than the synoptic approach advanced by Kalkstein and others. A heat wave in 2006 afforded the opportunity to assess the effectiveness of the system. This event, the second most severe since 1950 after the 2003 heat wave, led to more than 2,000 extraordinary deaths in France—this was 4,400 fewer deaths than predicted based on the 2003 event. The evaluation indicates that an effective warning system can be rapidly implemented. Housing style and the use of air conditioning can lessen the impact of heat waves. In a number of studies, the availability of air conditioning has been shown to reduce the risk of mortality during a heat wave. As a longer-run strategy, increased use of air conditioning in homes would be expected to protect against heat-associated mortality, although the strategy has associated costs with regard to its implementation and the electric power needed to support the air conditioning.

[6] http://www.rff.org/rff/documents/RFF-Rpt-Adaptation-Samet.pdf

3.5 Coastal zone

Global models predict sea levels rising from about 0.1 to 0.3 meters by the year 2050 and from about 0.1 to 0.9 meters by 2100. The bulk of the Arab region's economic activity, agriculture and population centers are in the coastal zone, which is highly vulnerable to sea level rise. The total length of the coastal zone in the Arab region is 34,000 km, of which 18,000 km is inhabited. Most of the region's major cities and economic activity are in the coastal zones (AFED, 2009). The region has high exposure to both coastal inundation and increasing salinity of soil and available freshwater resources such as aquifers. The social, economic, and ecological impacts of rises in sea level are expected to be relatively higher in the Arab region compared to the rest of the world. Low-lying coastal areas in Tunisia, Qatar, Libya, United Arab Emirates, Kuwait, and particularly Egypt are at high risk. The Gaza coastal aquifer is highly vulnerable, and about 1.5 million Palestinians depend on it for their drinking water (Alatout, S., 2000). This aquifer is particularly vulnerable to seawater intrusion as a result of over-pumping (both inside and outside of Gaza), which has lowered the water table. Any added salinity from a rise in sea level will only further compromise the water quality in the aquifer, which is already quite polluted (Brown O. & Alec C., 2009).

Rising sea levels threaten some of the most productive agricultural areas in the region, such as the Nile Delta in Egypt, where a 1 meter rise would put 12% of the country's agricultural land at risk[7]. Given the high value of the delta land and the ratio of population dependent on it for their livelihoods, consideration might be given to constructing a fence to protect this large and very productive agricultural area. It is equally important to improve early warning systems of flood hazards and to protect agricultural and water supplies from contamination by saltwater.

A number of adaptation measures for coastal zones are identified and highlighted in the AFED report. These measures include:

- Establishing strong monitoring systems for coastal zone indicators and law enforcement
- Establishing an institutional system for risk reduction that integrates and coordinates research and carries out training on the national and regional scales
- Developing a database for national and regional indicators of climate change
- Developing a Regional Circulation Model (RCM) for the impact of climate change on Arab countries and the Red Sea, thereby building capacities and reducing uncertainties of predictions

[7] http://www.adv-sci-res.net/3/123/2009/asr-3-123-2009.pdf

- Adopting an integrated coastal zone management approach to protect coastal resources with special reference to expectations of future severities and increasing frequencies of extreme events
- Adopting a proactive planning approach and developing policies and adaptation programs for no regret planning, protection of the low land areas in the coastal region and coastal cities in the Nile Delta, Tunisia, Mauritania and Gulf region, while also exchanging experiences and success stories
- Upgrading awareness of decision makers on strategic aspects and developing employment opportunities for vulnerable groups
- Developing an early warning system of tsunamis for the Mediterranean and the Gulf regions through satellite systems

3.6 Tourism

Tourism is important for a number of Arab economies. Arab countries present a variety of tourist attractions, ranging from historic and cultural sites to conferences and religious, environmental and recreational tourism. However, like most sectors of economic activity, tourism is vulnerable to the impacts of climate change. Many of the projected climate changes in the Arab region will impact the attractiveness of Arab tourist destinations. Examples of climate-related stresses include hotter summers, droughts, extreme weather events, water scarcity, and ecosystem degradation (WHO, 2008). Coastal tourism is a key component of coastal and marine economies, and in many countries it is the fastest growing area of contemporary tourism, which has placed increased pressure on the coast.

Source: Annual Review of Developments in Globalization and Regional Integration in the Arab Countries, 2007, UN-ESCWA.

Eco-tourism is defined by the International Union for Conservation of Nature (IUCN) as, "Environmentally responsible travel to natural areas, in order to enjoy and appreciate nature (and accompanying cultural features, both past and present) that promote conservation, have a low visitor impact and provide for beneficially active socio-economic involvement of local peoples." Eco-tourism could be negatively impacted by climate change, since climate change will impact different ecosystems upon which eco-tourism is built, e.g. forests and wildlife. Adapting the sector to the impacts of climate change requires a multidimensional strategy that involves nature conservation, infrastructure development and technology development. Access to technology, such as early warning systems and infrastructure, is essential in reducing vulnerability and increasing the tourism sector's capacity to adapt. Developing and adapting eco-tourism can be a powerful ally for nature conservation, by generating much needed revenues for the maintenance of natural areas and reserves and through environmental education and awareness for both the local population and tourists. Through its multiplier effect, tourism has great potential to provide socio-economic benefits for local economies via improved standards of infrastructure.

Coastal tourism can be enhanced by Integrated Coastal Zone Management (ICZM). Such plans can help solve conflicts through more cooperation between coastal tourism and other marine and terrestrial sectors, while also resolving overlapping responsibilities of involved agencies and increasing the cooperation between countries that share coasts (see Box (1) on the Dead Sea and Box (5) on the Dead Sea canal). The importance of tourism in the ICZM process is much greater in tourism dependent regions, such as the Mediterranean, than in many other regions of the world. This is because of the high dependence of economic activities on coastal tourism in those countries, and because tourism development plans could influence the development and planning of traffic routes, infrastructure, communications, etc.

Box (5) The Dead Sea-Red Sea Canal

The Dead Sea is considered the lowest spot on earth – about 400 meters below sea level. Its water is ten times more saline than ocean water, making it one of the saltiest bodies of water in the world. The Dead Sea's distinctive chemical composition and fresh/salt water interface have created a unique ecology of international importance. The region around the Dead Sea is considered by some as the cradle of human culture and civilization. It features numerous archeological and historic sites. Until recently, tourism and recreation made a major contribution to the economy of the region. The Dead Sea's unique environment is changing, as the water level is dropping due to a sharp decrease in inflow. The water level has fallen from 394 meters below sea level in the 1960s to 418 meters below sea level as of 2006. As a result, the Dead Sea's water surface area has been reduced by one-third: from roughly 950 square kilometers to 637 square kilometers today. The water level continues to drop at an alarming pace of 0.8 to 1 meter per year, and the Dead Sea's surface area is shrinking accordingly.

The need to save the unique values of the Dead Sea and the desire to avoid an environmental calamity has led Jordan and Israel to promote the rehabilitation of the Dead Sea. As part of peace negotiations, they conceived the concept of water conveyance from the Red Sea to the Dead Sea as a means to arrest the declining water level and to allow gradual refilling overtime to a feasible level. A canal between the Red and Dead Seas (the Red Sea, Dead Sea Water Conveyance Project) in Jordan is currently the focus of a World Bank-funded feasibility study. The proposed canal would pump water from the Red Sea coast near Aqaba north to the Dead Sea. After hydropower generation and desalination, the remaining water would be allowed to flow into the Dead Sea, in theory slowly reversing the precipitous decline in its level over the last few decades (Qahman, K.A. & Zhou, Y., 2001). However, there are also potential critical environmental and social challenges. The mixing of Red Sea and Dead Sea waters will require careful study to determine the way they would interact. Other potential environmental impacts of a conveyance system could include changes in the Upper Gulf of Aqaba/Eilat, changes in the ecological connectivity in the Wadi Araba, and a potential impact on groundwater (See Annex (3)).

4. Adaptation needs for policy makers and the public

Although adaptation activity is beginning to take place, further efforts may be stimulated by increasing awareness and education about the potential impacts of climate change. Restrictions in the quality and quantity of available data, as well as limitations in our ability to model specific impacts of climate change, introduce uncertainties into all predictions (Hegerl, Gabriele C. et al, 2007). These uncertainties must be acknowledged and minimized in research and properly communicated to managers and the public.

A number of cross-cutting adaptation issues need to be addressed before researchers and stakeholders can truly begin adapting to climate change. There is a need for models to be downscaled from a global to a watershed or regional level, which would enable more accurate decisions to be made with regards to managing resources in light of climate change (Pahl-Wostl, C. et al). As well, in order to allow decision makers to make the most accurate decisions, a greater access to climate change and natural resources

data is required. The dissemination of climate change research findings is paramount to furthering our understanding of impacts and adaptations related to climate change. Improving the interpretation and communication of all climate-related information into an appropriate mode to be used by various stakeholders will enable the research to be interpreted and used by the non-research community. Linking researchers and stakeholders with common interests to provide answers on climate change impacts with networks of data to complement their decisions is necessary. A greater awareness of the impacts of climate change on the natural resources sectors will allow for a greater facilitation of adaptation research and adaptation measures to be put in place across the country. Comprehensive education programs should be developed to educate the general public and demystify the impacts of climate change. Better communication strategies and a timelier and targeted diffusion of results from the researchers to the stakeholders and to the general public is necessary to adapt to climate change. Education and awareness of potential climate change impacts and adaptation strategies for stakeholders, researchers and decision makers are felt to be lacking in the region. A UNDP (2005) report emphasized the importance of increasing public awareness and putting the climate change issue higher up on the political agenda of the Arab countries[8]. Economic valuation is necessary so that the real cost of impacts and adaptations are accounted for. Finally, the need for integrated management conflict resolution will come more and more into play as natural resources become scarcer in certain parts of the Arab region.

5. Integration of adaptation into national development plans

Adaptation is successful if it reduces the vulnerability of poor countries and poor people to existing climate variability, while also building in the potential to anticipate and react to further changes in climate in the future. The evidence from past experience suggests that adaption is best achieved through mainstreaming and integrating climate responses into development and poverty eradication processes[9], rather than by identifying and treating them separately (Adger et al, 2003). The rationale for integrating adaptation into development strategies and practices is underlined by the fact that many of the interventions required to increase resilience to climatic changes generally benefit development objectives. Adaptation requires the development of human capital, strengthening of institutional systems, and sound management of public finances and natural resources (Adger et al, 2003). Such processes build the resilience of countries, communities, and households to all shocks and stresses, including climate variability and

[8] http://www.iq.undp.org/UploadedFiles/Sections/7f3aef29-e35e-4589-aab0-f21872fa0c8d.pdf

[9] http://ec.europa.eu/development/icenter/repository/env_cc_varg_poverty_and_climate_change_en.pdf

change, and are good development practice. Over recent years, several countries and regions have developed vulnerability and adaptation assessments, as well as practical policy proposals and strategic implementation plans to address climate change. This knowledge needs to be integrated into development support so as to manage climate vulnerability along with other non-climate risks in project design and implementation.

An examination by Osman et al (2007) of community development efforts in the Sudanese villages of Bara Province in North Kordafan, El Fashir in North Darfur and Arbaat in the Red Sea State demonstrate that development and adaptation to climate risks can be strongly complementary. Strategies for disaster risk reduction, water resource management and food security should all feature highly in local and national development planning in order to strengthen adaptation and resilience to climatic shocks. Access to the latest climate change information and knowledge must also be provided to enable communities to plan for adaptation strategies. Community development projects implemented in the villages integrated multiple strategies to improve livelihoods, quality of life, and sustainability of resource use within a context of recurrent drought. Using measures of changes in household livelihood assets (human, physical, natural, social and financial capital), the holistic approach to development taken in the study areas has succeeded in increasing the capacity of households to cope with the impacts of drought. Community participation in the projects and reliance on indigenous technologies for improving cultivation, rangeland rehabilitation and water management that are familiar to the communities are found to be important factors for success. The sustainable livelihood approach appears to be a viable model for integrating development and adaptation to climate hazards at the community scale.

National adaptation plans should benefit from experience in developing NAPAs (see Box (2)), but go beyond the NAPA-specific concept of urgent and immediate needs and the project approach toward a long-term programmatic approach to adaptation. Knowledge, experiences and lessons learnt from existing activities, including those carried out at the community level as well as activities from ongoing initiatives such as the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change, should be integrated into adaptation planning (Osma-Elasha & T. Downing, 2007).

Although adaptation must be a locally-driven process, it should be supported by national policies and frameworks. The primary objective of adaptation activities must be to build resilience and adaptive capacity in vulnerable local communities, which already need to adapt to climate change. Local approaches for adaptation could be further developed and built upon. Learning from these tested strategies can be used to inform

local and national planning. To address the impacts of climate change on poor and vulnerable communities within these countries, there is a need to move from support for projects to support for national adaptation plans and development interventions. Over time, support will need to move towards the strategic integration of climate change adaptation measures into the design and implementation of national development plans, poverty reduction strategies and sectoral policies and strategies, if these are to be sustainable in the face of climate change. Capacity building and sharing of best practices will be important in this process. Adaptation should not be viewed as a separate 'sector' with separate structures, frameworks, tools and approaches, but as an integral component of sustainable development (TearFund, 2007). Adaptation is needed in sectors that are crucial for wider development issues and for poverty reduction. Coordination between institutions and between different ministries will therefore be important. Traditional systems for adapting to climate variability include a range of livelihood strategies, from individual to collective savings mechanisms and migration. Social networks play a fundamental role for the poor by providing safety nets as an immediate response to adverse climate conditions (Osman-Elasha, 2006).

6. NAPA experience

Approaching climate change adaptation as a discrete planning process, segmented into a variety of activities, is likely to be less effective than building a broad understanding of the issue and taking action involving multiple stakeholders. Learning by doing, social learning, community-based adaptation and participatory assessment are relevant frameworks in which to take this forward. The UN Framework Convention on Climate Change's NAPA (national adaptation programme of action) process provides a platform for Least Developed Countries (LDCs) to prioritize activities for their urgent and immediate adaptation needs. Developing and least-developed countries often require external technical and financial assistance to research, design, and implement effective national climate policy. An evaluation study of NAPA experience across Africa's LDCs showed that Africa possesses a wealth of local knowledge relevant to adaptation that could significantly contribute to reducing vulnerability if properly utilized. Any planning for adaptation must be firmly rooted in this development knowledge in terms of what works, and where and when it works. Moreover, the study indicated that the consultation and continuous dialogue between scientists and other stakeholders proved to be an efficient way to raise awareness and build capacity amongst a wide range of stakeholders. Adaptation actions need to be taken at all levels (vertically and horizontally) and should provide room to involve all relevant stakeholders (Osman-Elasha & T. Downing, 2007[10]).

[10] http://www.eurocapacity.org/downloads/ecbi_NAPA_PA_Project_2007.pdf

One-third of LDC countries identify interventions targeting agriculture and food security as having the highest priority for NAPA. The main adaptation activities in the agriculture sector include the introduction of drought-tolerant crops. Research and development is equally important, particularly in the long-term, if NAPAs are to be seen as a transition step towards the sustainable implementation of adaptation activities. Countries are expecting support for the development and implementation of comprehensive longer term National Adaptation Plans. Where appropriate, adaptation must be integrated into national development planning and ultimately into sectoral plans and strategies (See Box (6) on Nepal NAPA).

Box (6) A case study - Nepal NAPA

More than 90% of Nepal's people live in rural areas, and forests are an integral part of rural livelihoods. Forests are especially important to the livelihoods of the poorest people, who depend on the forest for timber as housing material, fuel wood for heating and cooking, fodder for feeding animals, and medicinal herbs. Seventy-five percent of the country's households collect fodder for various purposes. The forestry sector is acknowledged for its contribution to reducing the risk of floods, gully erosions and landslides, and in providing food during droughts. Therefore, forest conservation and development presents an important component in the National Adaptation Programme of Action Plan for Nepal, aimed at reducing the level of vulnerability to climate change. The NAPA recognized the role of forests and the forestry sector in climate change adaptation, mainly in relation to rehabilitation of community land, in soil conservation and watershed management, and in the protection and management of the most adapted species, such as fodder and multipurpose trees and grasses. Some of the major coping strategies include crop diversification, shifting natural resource-based livelihoods to livestock, seasonal migration (to urban areas as well as internationally to India or the Gulf, among other places), adopting agro-forestry practices, following rotational grazing on pastureland, and applying local techniques to store grain seed fodder and grasses. Community Forest User Groups (CFUGs) directly contribute to achieving many of the objectives of the NAPA in a number of ways. They promote growing the most adapted and indigenous natural species, such as *Amliso*, different varieties of *Bamboo* and broad leaved species which are good soil binders, desirable fodder, sources of cash income during scarcity, and so on. Many species are promoted both in private and public land as shelter belts, wind breaks and fire barriers. CFUGs not only protect and manage forests on community land, but also they promote private tree and grass management practices on bonds in farm land. As a result, development of the most resilient agro-forestry systems is sustained and enhanced. There is evidence that most of the CFUGs play an absolutely crucial role in these coping strategies because community and private tenure rights ensure access of rural people to the forests and trees and the right to harvest timber and non-timber forest products. A sustainably managed forest is thus an important asset on which the community and private individuals can rely in times of need.

7. Funding adaptation

In general terms and to varying degrees, developing countries lack the social, technical and financial resources to cope with the impacts of climate change. A number of funds to support adaptation were set up in 2001 during the international Bonn-Marrakech agreements:

• UNFCCC funds include the Least Developed Countries Fund and Special Climate Change Fund. Kyoto Protocol Adaptation Fund: financed from a levy on Clean Development Mechanism (CDM) Projects. The UNFCCC report[11] concluded that total funding needed for adaptation by 2030 could amount to $49–171 billion per annum globally, of which $27–66 billion would accrue in developing countries (Table (4)). By far the largest cost item is infrastructure investment, which for the upper bound estimate accounts for three-quarters of total costs. Costs are over and above what would have to be invested in the baseline to renew the capital stock and accommodate income and population growth. Further on, the UNFCCC report indicated that information is scarce about the scale of future potential impacts, and is even more scant for the costs of avoiding them by adaptation, a point stressed in the UNFCCC report. Some sectors – such as mining, manufacturing, energy, retail, and tourism – were not included in the UNFCCC report.

Under the **GEF Strategic Priority for Adaptation** and the **Special Climate Change Fund**, the following concrete planned or ongoing adaptation projects are funded in the Arab region[12]:

- **Coping with Drought and Climate Change (regional project) --** This Strategic Priority on Adaptation-funded project aims to develop and pilot a range of coping mechanisms for reducing the vulnerability of farmers and pastoralists to future climate shocks. Components include piloting coping strategies, improving early warning systems, developing drought plans and integrating the topic of climate change/drought across sector policies.

- Community-based Adaptation (CBA) Programme (global project, including Morocco) - - This project is aimed at: (i) developing a framework, including new knowledge and capacity, that spans the local to the intergovernmental levels to respond to community-based adaptation needs; (ii) identifying and financing diverse community-based

[11] http://mlparry.com/docs/Adaptationcosts_Environment_final_12Nov09.pdf

[12] http://www.minenv.gr/medeuwi/download/Theme_2_Climate&Water_%20150708.pdf

adaptation projects in selected countries; and (iii) capturing and disseminating lessons learned at the community level to all stakeholders, including governments.

Other **projects, initiatives or institutional activities ongoing in the broader region** with regard to climate change include:

- The **Consultative Group on Agriculture Research's (CGIAR) "Climate Change Challenge Programme";**

- The **Assessments of Impacts and Adaptations to Climate Change (AIACC),** conducted in collaboration with the UNEP/World Meteorological Organization and IPCC and funded by the GEF, to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries;

- The **International Development Research Centre Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa (CCAA)**, in partnership with the UK Department for International Development (DFID), to support African countries in their efforts to address vulnerability, particularly of the poor, to climate change (five-year, $65 million program);

- The **Linking Climate Adaptation network (LCA),** funded by DFID, which is an effort to help communities, policymakers, practitioners and academics share knowledge on climate change adaptation;

- The **New Partnership for Africa's Development (NEPAD),** an African-led strategy for sustainable development and poverty reduction in Africa. NEPAD is a long-term agenda for Africa adopted as a program of the Africa Union;

- The **Sahara and Sahel Observatory (OSS)** work program in arid, semi arid and sub-humid areas in North, West and East Africa, including long-term observations and networks focusing on land degradation issues and the identification and collection of a number of biophysical indicators to help assess the needs and vulnerabilities of three sub-regions (North Africa, Sahelian Africa and Eastern Africa) to climate change, and thus identify potential action for adaptation;

- The **African Regional Centre for Space Science and Technology in the French Language (CRASTE-LF),** a training and research institute established under United Nations sponsorship to promote the utilization of space science and technology and develop related national and regional capacity.

Table (4) UNFCCC estimate of additional annual investment and financial flow needed by 2030 to cover costs of adaptation to climate change, in billions of dollars/year in present day values.

Sector	Global cost	Developing countries	Developed countries
Agriculture	14	7	7
Water	11	2	9
Human health	5	Not estimated	5
Coastal zone	11	7	4
Infrastructure	8-130	6-88	2-41
Total	49-171	22-105	27-66

Source: UNFCCC (2007)

The LDC Fund is the only fund that is currently operational in supporting the Least Developed Countries' preparation of National Adaptation Programmes of Action (NAPAs). This is accompanied by the formation of the Least Developed Countries Expert Group (LEG), which emphasizes poverty reduction during adaptation planning.

In addition, knowledge generation and dissemination related to climate impacts and vulnerability assessments are essential for making poverty reduction strategies more effective by mainstreaming and integrating climate issues. UNFCCC (2007) reported an additional expenditure on agriculture-related R&D of about 3 USD billion out of the 14 USD billion required to cope with climate change in agriculture in 2030.

8. Political and institutional support for adaptation

A significant increase has been witnessed in global awareness of climate change issues over the past three decades. The Arab countries have also got their share of this rapidly accumulating and widely spreading knowledge, which has been reflected in the stronger environmental commitments by many governments in the region and the establishment of new environmental institutions to considerably improve environmental governance in the Arab region. For example, all Arab countries have established climate change national focal points; some, such as Morocco and Sudan, have established a climate change unit (Morocco in 2001 and Sudan in 1998). In addition, several organizations are extensively involved at the national levels in climate change-related activities. These organizations include academic and research institutions, other relevant government agencies such as those in the energy, water, agriculture, and health sectors,

nongovernmental organizations and the private sector. Moreover, this new climate change institutional arrangement started to play a leading role in integrating climate change issues into national agendas. In Sudan, for instance, the recently established Higher Council for Environment and Natural Resources is mandated with coordinating and integrating environmental concerns into all national and sectoral development plans and strategies. However, significant gaps remain with respect to the ability of these newly established institutional frameworks to effectively manage climate change-related concerns. A number of policy-relevant initiatives and declarations have also been made in the Arab region, as illustrated below:

- The Council of Arab Ministers Responsible for Environment (CAMRE) during its 20th session on 20-21 December 2008 recognized the risks associated with climate change and the need to ensure integration of Disaster Risk Reduction (DRR) into climate change adaptation in the region when it adopted decision No. 29. That decision made the issue of "cooperation with the United Nations International Strategy for Disaster Reduction (UNISDR) and the follow-up on the implementation of the Hyogo Framework for Action" a permanent agenda item at meetings for CAMRE, its Executive Bureau, and its subsidiary mechanism, the Joint Committee for Environment and Development in the Arab region. To this end, the Arab Ministers for Environment have established a set of policies and frameworks that creates an enabling environment to advance risk reduction in the region. [13]

- The process started with the Arab Ministerial Declaration made at the 19th session of the Council meeting on 5-6 December 2007. The declaration calls for including appropriate mechanisms for risk insurance, improvement in the management efficiency of natural resources through the use of appropriate techniques and advanced monitoring, control and early warning systems, as well as adequate preparedness to confront disasters caused by climate change. In addition, the Arab Draft Framework Plan to deal with climate change issues for the period (2010–2020) takes DRR concerns into consideration. Moreover, the declaration calls for achieving the following adaptation-related objectives:
    - The inclusion of policies to deal with climate change issues in all sectors within national and regional policies for sustainable development in a manner that harmonizes with sustained economic growth and efforts to eradicate poverty.
    - Adaptation to measures that address climate change shall be fully consistent with economic and social development and in such a way so as to achieve sustainable economic growth and eradication of poverty.

[13] http://www.unisdr.org/arabstates/eng/hfa/docs/Implementation_of_the_Hyogo_Framework-En.pdf

- Adaptation programs which focus particularly on the provision of necessary infrastructure. This will include appropriate mechanisms for risk insurance, improvement in the management efficiency of natural resources through the use of appropriate techniques and advanced monitoring, control and early warning systems, as well as adequate preparedness to confront disasters caused by climate change, along with capacity building, information exchange, including weather information, in addition to raising the level of public awareness and promoting partnerships.
- Adoption of national and regional action plans dealing with climate change issues in order to assess possible impacts and develop mitigation and adaptation programs, with governments having the major role in implementation in coordination and cooperation with all parties concerned, including scientific research centers, universities and institutions of civil society, as well as the private sector.

Establishing a Strategy for Disaster Reduction Regional Office for Arab States (UNISDR)[14]: The Regional Office for Arab States (ROAS) has been operational in the region since September 2007, helping Arab states and communities build their resilience to disasters and implement the Hyogo Framework for Action 2005-2015 (HFA). Throughout the last two years, ROAS has focused on fostering partnerships for disaster risk reduction with the main regional intergovernmental organization, the League of Arab States, and its technical regional organizations. In addition, ROAS strengthened linkages and coordination at the regional level with civil society networks, expert technical groups, the media, the UN and international organizations operational in the region.

The World Bank is currently preparing a regional program for technical assistance on climate change adaptation and mitigation for the Arab region. The knowledge initiative builds on the experience of the Mediterranean Environmental Technical Assistance Program (METAP) and will serve as a vehicle to strengthen institutional capacity across the region. Moreover, the World Bank will continue to work with its Arab region clients to identify, analyze and implement policy reform options by mobilizing global knowledge and by providing targeted financial support (World Bank, 2007).

9. Equity issues related to adaptation

The capacity to adapt to climate change is not evenly distributed within nations. Adaptive capacity is highly differentiated within countries because multiple processes of change interact to influence vulnerability and shape outcomes from climate change (Leichenko and O'Brien, 2002). A combination of biophysical, socio-economic and technological conditions influences the capacity to adapt to changing environmental and

[14] http://www.unisdr.org/arabstates/eng/about-roas/mission.html

economic conditions. Much new research emphasizes that adaptive capacity is also highly heterogeneous within a society or locality, and for human populations it is differentiated by age, class, gender, health and social status. Ziervogel et al (2006) undertook a comparative study between households and communities in South Africa, Sudan, Nigeria and Mexico and showed how vulnerability to food insecurity is common across the world in semi-arid areas where marginal groups rely on rain-fed agriculture. Across the case studies, food insecurity was not determined solely or primarily by climate, but rather by a range of social, economic, and political factors linked to physical risks. Gender differences in vulnerability and adaptive capacity reflect wider patterns of structural gender inequality. One lesson that can be drawn from the gender and development literature is that climate interventions that ignore gender concerns reinforce the different gender dimensions of vulnerability (Denton, 2004). The role of gender in influencing adaptive capacity and adaptation is thus an important consideration for the development of interventions to enhance adaptive capacity and to facilitate adaptation. It has also become clear that a shift in policy focus away from reactive disaster management to more proactive capacity building can reduce gender inequality (Mirza, 2003). Women in the Arab countries are more vulnerable to impacts of climate change and have less capacity to adapt (Osman-Elasha, 2008). Lower levels of education reduce the ability of women and girls to access resources and information, including early warnings, or to make their voices heard. Cultural values could also contribute to women's vulnerability in some countries. In Sudan, the increase in migration of men from drought-hit areas of western Sudan raises the number of female-headed households and consequently their responsibilities and vulnerabilities during natural disasters. Adaptation initiatives should identify and address gender-specific impacts of climate change, particularly in areas related to water, food security, agriculture, energy, health, disaster management, and conflict (AOAD, 2007). Important gender issues associated with climate change adaptation, such as inequalities in access to resources, including credit, extension and training services, information and technology should also be taken into consideration. Women's priorities and needs must be reflected in development planning and funding. Moreover, mainstreaming gender equality into climate change initiatives can enhance efforts for reducing vulnerabilities, increase effectiveness of the identified solutions and contribute to peace and security and natural resource management.

10. Barriers to adaptation

A growing amount of literature has emerged in recent years to highlight potential limits and barriers to adaptation (e.g. Adger et al, 2009; and Burton, 2009). This literature reflects the reality of our current understanding of adaptation and adaptive capacity.

Generally, barriers such as a lack of technical capacity, financial resources, awareness, communication, etc. are cited in association with adaption in developing countries. However, a number of recent climatic events and disasters in developed countries have exposed what could be named adaptation deficiency in their capacity to respond to disasters. The examples of the European heat wave of 2003 and the devastating hurricanes in the US in 2004 and 2005, and the droughts and fires in Australia in recent years, have served as important wake-up calls for developed countries (Moser, 2009).

The Arab countries face barriers to adaptation characteristic of developing countries, in addition to a number of constraints and challenges unique to the region as summarized in the Arab Human Development Report (AHDR) series produced by the United Nations Development Programme (UNDP, 2002, 2003, 2005, 2006). The UNDP's key diagnosis was that the Arab world suffered from three fundamental deficits: in political rights, in women's rights, and in knowledge. According to the UNDP reports, these deficits together are obstacles to human development across the region. These deficits consequently hamper adaptation efforts. In order to overcome these deficits, a great transformation would be needed from traditional management approaches to a more collaborative and integrative management strategy that relies not just on institutional capabilities and technical know-how, but also on awareness at different levels, women empowerment, accountability, performance evaluation and transparency.

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12. Annexes

Annex (1) Summary of causes of risk, consequences and potential adaptation

Source: author

Consequences for livelihood	**Main climatic causes of risk**	**Potential adaptation**
Crop area changes due to decrease in optimal farming conditions • **Farming optimal conditions altered resulting in increased risk to rural income**	Changes in monthly precipitation distribution Increased temperatures in critical periods Increased erosion Loss of soil water retention capacity	Livelihood diversification Strengthen local capacity to reduce sensitivity Conversion of ambient storage to refrigerated stores Irrigation Changing cultivation practices Additional fertilizer application Increased need for pest control Change of crop mix Switching to alternative crops
	Loss of indigenous species	Climate change resilient crops Insurance
	Soil deterioration due to land use changes	
	Land abandonment due to very large changes in optimal conditions	
Decreased crop productivity **Main climatic causes of risk** ○ **Changes in monthly precipitation distribution** ○ **Increased temperatures in critical periods (heat stress)** ○ **Loss of soil's water retention capacity**		
	Crop productivity decrease	Change in crops and cropping patterns Industry research Increased input of agro-chemicals to maintain

		yields (as fertilizers rates) Irrigation Advisory services for farmers on adapted farming practices, new crops
	Crop productivity variability risk increased	Agricultural insurance Crop planting diversification
	Land abandonment	Design of regional adaptation plans Livelihood diversification
	Agricultural trade intensification	Strengthen local capacity to reduce sensitivity
Increased risk of agricultural pests, diseases, weeds **Main climatic causes of risk** o **Increased water logging** o **Increased average temperatures**		
	Pest populations and distribution increase with higher temperatures	Use new pest resistant varieties Use of thermostats and rapid cooling to reduce pest and disease infestation Develop sustainable integrated pesticides strategy Use of natural predators Vaccinate livestock Monitoring of pest/disease patterns to prevent damages
	Pollution by increased use of pesticides	Develop sustainable integrated pesticides strategy Advisory support for farmers
Main causes of risk: o **Crop quality decrease** o **Main climatic causes of risk** o **Heat stress** o **Changes in annual and seasonal precipitation distribution**		
	Crop quality reduction in fruits and vegetables	Thermal screens Temperature control Use of thermostats and rapid cooling
	Damage to grain formation due	Thermal screens

	to heat stress	Temperature control Use of thermostats and rapid cooling
Increased risk of floods **Main climatic causes of risk** ○ **Increase of extreme events frequency** ○ **Loss of soil's water retention capacity**		
	Increased expenditure in emergency and remediation actions	Develop contingency plans Create/restore wetlands Enhance flood plain management Hard defenses
	Flash flood frequency and intensity increase	Increase rainfall interception capacity Move towards farmers as 'custodians' of floodplain lands with appropriate compensation Reduce grazing pressures to protect against soil erosion from flash flooding
	Flooding and storm damage increase	Increase rainfall interception capacity/soil management Contour plowing Increase drainage Addition of organic material into clay soils (difficult to work in wetter conditions) Insurance for farm infrastructure
Increased risk of drought and water scarcity **Main climatic causes of risk** ○ **Decreased annual and/or seasonal precipitation** ○ **Increase in the frequency of extreme conditions (droughts and heat waves)**		
	Conflicts among water users due to drought and water scarcity	Shift crops from areas that are vulnerable to drought Set clear water use priorities Increase water use efficiency
	Water supply reduced	Increase rainfall interception capacity (techniques for conserving soil moisture) Improve field drainage and soil absorption capacity Reduced run-off via contoured hedgerows and buffers

		Introduce forage crops into arable rotations Altering crop rotations to introduce crops more tolerant to heat/drought Woodland planting Use of precision farming: tillage and timing of operations Small-scale reservoirs and methods to collect water Water management Re-negotiation of water abstraction agreements Water charging/tradable permit schemes to promote efficient use of prescribed (reduced) sources Insurance (or other risk protection tools)
	Groundwater abstraction, depletion and pollution	Re-negotiation of water abstraction agreements
	Damage to wetlands	Installation of small-scale water reservoirs on farmland Recreate wetlands
Increased irrigation requirements **Main climatic causes of risk** ○ **Increased average and extreme temperature** ○ **Increase of drought and heat stress conditions frequency** ○ **Decreased precipitation**		
	Water availability decrease Water shortage in irrigated areas	Invest in irrigation equipment that helps reduce the severity of dry soil and collects rain water Technical improvements in advanced irrigation equipment Trickle irrigation Irrigation during the night Separation of clean and dirty water Installation of small-scale water reservoirs on farmland
Water quality deterioration **Main climatic causes of risk** ○ **Increased precipitation extremes, flood and drought frequency**		
	Water quality loss due to higher leaching and run-off	Aerating plowing equipment Industry research Develop less polluting inputs Timed input of N inputs

		Reduce N outputs from soil through enhanced efficiency of fertilier use
Soil erosion, salinization, desertification **Main climatic causes of risk** ○ **Increased temperature** ○ **Sea level rise** ○ **Decreased precipitation** ○ **Extreme conditions (heavy precipitation, drought)** ○ **Melting of permafrost soils**		
	Desertification due to water resources deficit, loss of soil structure, land abandonment	Livelihood diversification Strengthen local capacity to reduce sensitivity Intensify research efforts and enhance training
	Soil salinization increases	Change in cropping Allocate fields prone to flooding from sea level rise as set-aside
	Erosion and accretion increase	Change fallow and mulching practices to retain moisture and organic matter Use intercropping to maximize use of moisture
	Soil drainage changes leading to increased salinity	Change fallow and mulching practices to retain moisture and organic matter
	Water logging increases	Invest in machinery or development and disseminate good practices that minimize the adverse effects of water logging
	Loss of rural income	Change fallow and mulching practices to retain moisture and organic matter Livelihood diversification Strengthen local capacity to reduce sensitivity
Deterioration of conditions for livestock production **Main climatic causes of risk** ○ **Increased temperature and variability (heat stress)** ○ **Appearance of new pests and diseases** ○ **Change of optimal crop areas**		
	Livestock changes: health, nutrition, productivity and heat stress	Decline in number of native breed livestock and introduction of more heat tolerant species/breeds Increase shelter for animals Windbreak planting to provide shelter for animals from extreme weather Change breeding and shearing patterns for sheep production

		Supplemental feeding
	Loss in forage quantity and quality and grazing behavior	Balance of grazing and cutting Use extended grazing or changes in the grazing regime Increase use of legumes Change of seed mixture Change the time of operations Match stocking densities to forage production
Sea level rise **Main climatic causes of risk** ○ **Increased sea temperature and accompanying thermal expansion of sea water**		
	Sea level intrusion in coastal agricultural areas and salinization of water supply	Hard defenses Alternative drainage systems Set aside land for buffer zones Alternative crops Livelihood diversification Research into other options for management of salt water intrusion
OPPORTUNITIES **Main climatic causes of opportunity** ○ **Increased water availability**		
	Potential increase in water availability for crops in wetter seasons	Extend arable farming to new areas Extend livestock farming to new areas Substitute higher-yielding cereal crops, e.g. sorghum for millet or wheat for barley

Annex (2) Dead Sea-Red Sea Canal

Annex (3)

Adaptation measures identified by Arab countries under National Communication and NAPA reports

Source: National Communications www.UNFCCC.int

Country	Key vulnerable sectors	Potential adaptation measures			
		Water	**Agriculture and Food Security**	**Coastal Zone and Marine Ecosystem**	**Health**
Egypt	Coastal Zones and Marine Ecosystems • Water Resources • Public Health • Industry	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizing watershed management, desalination • Decrease water demands, e.g. by increasing efficiency, reducing water losses, water recycling, changing irrigation practices • Improve or develop water management	Improve and conserve soils • Enhance irrigation efficiency and/or expand irrigation • Develop new crops	Protect coastal areas • Build sea walls • Beach nourishment • Retreat	
Sudan	Reduced agricultural production • Water shortage and/or groundwater depletion • Increased disease and/or other health problems • Food security • Income generation	Improved water harvesting practices Strategies to adapt to drought-induced water shortages in highly vulnerable areas in Central Equatorial State	Rangeland rehabilitation and water harvesting in the Butana area of Gedarif State Improving sustainable agricultural practices under increasing heat-stress in the River Nile State Environmental conservation and biodiversity restoration in northern Kordofan State as a coping mechanism for rangeland protection		
Saudia Arabia	Agriculture/Food Security • Coastal Zones and Marine Ecosystems • Water Resources • Biodiversity	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizing watershed management, desalination • Reduce water pollution		Develop Integrated Coastal Zone Management • Develop planning/new investment	

		• Improve or develop water management			
Algeria	Agriculture/Food Security	Improve and conserve soils • Enhance irrigation efficiency and/or expand irrigation • Develop new crops	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizing watershed management, desalination • Develop and introduce flood and drought monitoring and control system • Improve or develop water management	Develop planning/new investment requirements • Research/monitor the coastal ecosystem	
Djibouti	Reduced agricultural production • Reduced fishery productivity • Water shortage and/or groundwater depletion • Flooding • Increased disease and/or other health problems • Infrastructure damage • Food security • Loss of biodiversity	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizing watershed management, desalination Promote appropriate measures for protection of f water supply in the city of Djibouti	Promote appropriate management of rangeland and endogenous regeneration of pasture areas Promotion of agro-livestock farms Promoting agricultural and irrigation techniques appropriate against salinity in agricultural areas	Shoreline protection and restoration of degraded agricultural lands Restoration of marine protected areas around coral, protection and restoration of coastal mangrove	
Jordan	Water resources	Decrease water demands, e.g. by increasing efficiency, reducing water losses, water recycling, changing irrigation practices • Develop and introduce flood and drought monitoring and control system • Reduce water pollution			
Lebanon	Coastal Zones and Marine Ecosystems • Water Resources • Public Health • Fisheries • Terrestrial Ecosystems	Educational & outreach activities to change management practices to those suited to climate change • Improve and conserve soils • Establish seed banks • Develop and introduce policy measures, including taxes, subsidies, facilitation of free market • Improve pest and disease forecast and control			
Morocco	Agriculture/Food Security • Coastal Zones and Marine				

	Ecosystems • Terrestrial Ecosystems				
Mauritania	Agriculture/Food Security • Coastal Zones and Marine Ecosystems	Flooding (flash) • Salt water intrusion • Changes in river morphology/loss of water bodies • Coastal zone inundation • Drought and low flows • Human resettlement	etter knowledge of the surface water cycle of 20 ponds Construction of flooding breakdown dikes in pluvial & oasis zones Promotion of water-saving techniques in oasis zones Introduction of 50 electric Moto-Pumps in the valley Dissemination of the drip technique in the valley and oasis zones Promotion of livestock mobility Reorganization of the communities adversely affected by climate change Promotion and development of domestic poultry-farming Improvement of agricultural techniques in pluvial zones Substitution of ligneous fuel Participatory reforestation for energy and agro-forestry in agricultural zones		
Tunisia	Agriculture/Food Security • Coastal Zones and Marine Ecosystems • Water Resources				
Yemen	Agriculture/Food Security • Coastal Zones and Marine Ecosystems • Water Resources				
United Arab Emirates	Agriculture/Food Security • Coastal Zones and Marine Ecosystems • Water Resources • Public Health • Land Resources • Soils • Tourism	Increase water supply, e.g. by using groundwater, building reservoirs, improving or stabilizing watershed management, desalination • Decrease water demands, e.g. by increasing efficiency, reducing water losses, water recycling, changing irrigation practices • Develop and introduce flood and drought	Switch to different cultivars • Enhance irrigation efficiency and/or expand irrigation • Agricultural research and transfer of technology • Develop new crops	Protect coastal areas, including through building sea walls and beach nourishment	

	• Wildlife • Biodiversity • Energy	monitoring and control system • Improve or develop water management • Alter system operating rules, e.g. pricing policies, legislation			