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Mapping of Climate Change Threats and Human Development Impacts in the Arab Region

Balgis Osman Elasha

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Contents

Acronyms and abbreviations

ESCWA	Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization
FoEME	Friends of the Earth-Middle East
GCC	States of the Gulf Cooperation Council
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
HDI	Human Development Index
MDGs	Millennium Development Goals
MENA	The Middle East and North Africa
NAPA	National Adaptation Programme of Action
NC	National Communications
PDSI	Palmer Drought Severity Index
PRSP	Poverty Reduction Strategy Paper
SLR	Seal Level Rise
SST	Sea Surface Temperature
UAE	United Arab Emirates
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

Introduction

The aim of this report is to present a comprehensive desk review and mapping exercise for an overview of the impact of climate change on the Arab region. The report is based on existing literature from the Intergovernmental Panel on Climate Change (IPCC), technical papers and expert reports about the impact of climate change on Arab countries. Information and analysis are presented by sub-region, and in order to facilitate analysis, countries were grouped into: The Middle East and North Africa (MENA), namely, Algeria, Egypt, Iraq, Jordan, Lebanon, Libyan Arab Jamahiriya, Mauritania, Morocco, the Occupied Palestinian Territory, Tunisia, Syria, and Yemen; the States of the Gulf Cooperation Council (GCC), namely, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates; and the Sub-Saharan countries, namely, Comoros, Djibouti, Somalia and Sudan.

1. Background

Climate change presents a new and real threat of severe environmental, economic, political and security impacts in the Arab region. For a region that is already vulnerable to many non-climate stresses, climate change and its potential physical and socioeconomic impacts are likely to exacerbate this vulnerability, leading to large scale instability. Climate change is likely to act as a risk multiplier, aggravating water scarcity. Water scarcity on the other hand threatens food security by reducing agricultural productivity, as well as hindering human health and economic development; water scarcity can also lead to additional environmental stress, as well as increase tensions within and between nations sharing water resources. North African countries are most in danger of experiencing desiccation due to their large projected reductions in rainfall and the significant increases in temperature foreseen for that region; suffering will be most acute for poor and vulnerable populations.

The Intergovernmental Panel on Climate Change (IPCC) projects an increase in the frequency and intensity of extreme climate events, such as floods and drought. This, in turn, could lead to mass migration in the Arab region. Scenarios conducted by the United Nations Environment Programme (UNEP) and other organizations indicate that a 0.5 meter (approximately 19 inches) rise in sea level, for example, could displace 2-4 million Egyptians by 2050 (see Annex 3: Sea Level Rise on Nile Delta). Climate change presents a great challenge for the region and calls for more regional cooperation to mitigate its impact and protect people's livelihoods.

About the Arab region

- The Arab region covers 10 million square kilometers (more than 2.5 times the size of Western Europe) and stretches from the Atlantic Ocean to the Zagros Mountains in southwest Asia. Almost all of the Arab countries lie in semi-arid and arid regions that are highly vulnerable to climate change (see Annex 1: Map of global vulnerable areas). The region has wide variations in relation to climatic conditions, with 90% of its land classified as arid and dry subhumid (Abahussain A, *et al*., 2002). It is generally characterized by great variability in both seasonal and annual precipitation, which is typical of dry land ecosystems. Average annual temperatures, as well as maximum and minimum temperatures, also vary from freezing to over 50 degrees Celsius (ºC), depending on the season and location. Among the most influential climatic factors is rainfall. The region receives an estimated 2,282 billion cubic meters (m^3) of rainwater each year compared to an estimated 205 billion m^3/year of surface water and 35 billion m^3/year of groundwater. It is worth mentioning that out of the 22 Arab countries, 15 are among the world's most-water stressed countries with water per capita of less than

1,000 m^3 (UNDP, 2002). The rainfall distribution varies between countries; around 52% of the region's area receives an average annual rainfall of less than 100 mm, while 15% receives 100 – 300 mm and 18% receives more than 300 mm. Meanwhile, parts of the region—e.g., the highlands of Lebanon, Syria, and North African countries, as well as along the coastal areas and southern Sudan—receive as much as 1,500 mm of rainfall on an annual basis. However, even in areas with more significant rainfall, a large portion of rain water is lost to evaporation and surface runoff. The highest losses occur in the desert and semi-desert zones.

- The population of the Arab countries has nearly tripled since 1970, climbing from 128 million to 359 million. The Arab Region is expected to have 598 million inhabitants by 2050, increasing by two-thirds or 239 million more people than in 2010 (UNDESA 2009).

- All of the above mentioned factors reflect the high variability of climatic features and the subsequent impact on land-use systems, particularly on rangelands, rain-fed agriculture, and coastal management. However, since environmental problems do not know national boundaries, they should be tackled through implementing approaches and measures adopted at regional and sometimes global levels.

- The Arab world is often viewed as a unit or a homogeneous entity. This is partially true if we consider that the vast majority of its people share the same language (Arabic) and the same religion (Islam). More reasons exist that support the heterogeneity of the region, particularly in relation to socio-economic and environmental aspects. However, while the economy and livelihoods of the majority of the Arab countries depend primarily on agriculture and are consequently very vulnerable to any climatic variations, the Gulf countries depend on oil income and are therefore more vulnerable to any mitigation policy aimed at reducing oil consumption. Based on a report issued by the World Economic Forum, the Gulf region falls in the "high" category on the global map of vulnerability to climate change (Annex 2: Emission per capita for year 2000).

- Due in part to their position at the crossroads of the Asian, African, and European continents, individual Arab counties tend to be included within differing country groupings by different international agencies and analysts. A variety of approaches also exists for sub-regional groupings, in which countries can be clustered by spatial position, income levels or other factors. The present report utilizes the country groupings and sub-groupings shown in Box 1, which is oriented along spatial lines as well as, not coincidentally, common patterns of vulnerability to climate change.

BOX 1. GROUPINGS OF ARAB COUNTRIES USED IN THIS REPORT

Middle East and North Africa (MENA)[1]	**Sub-Saharan countries**	**States of the Gulf Cooperation Council (GCC)**
Algeria	Comoros	Bahrain
Djibouti	Djibouti	Kuwait
Egypt	Somalia	Oman
Jordan	Sudan	Qatar
Iraq		Saudi
Lebanon		United Arab Emirates
Libya		
Mauritania		
Morocco		
Occupied Palestinian Territory		
Syria		
Tunisia		
Yemen		

[1] The IPCC addresses these countries within the groupings "North Africa" and "West Asia".

2. Observed climate variability and change

- The IPCC, 2007 defines climate variability as the variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forces (external variability). The IPCC further defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity. The concentration of CO_2, one of the major greenhouse gases, in the atmosphere has increased significantly since the industrial revolution. This has contributed to the enhanced greenhouse effect known as 'global warming'. The CO_2 concentration in the atmosphere is currently about 370 parts per million (ppm)—an increase of more than 30% since 1750. The increase is largely due to anthropogenic emissions of CO_2 from fossil fuel combustion and to a lesser extent land-use change, some industrial processes, and biomass combustion (IPCC 2001a). Evidence of climate change is mounting. According to the IPCC reports (2007), global warming is unequivocal (i.e. earth's climate is warming); global surface air temperature increased from 1850 to 2005 by 0.76ºC. The linear warming trend over the last 50 years is recorded by 0.13ºC per decade, with a full range of projected temperature increase of 1.1 ºC to 6.4 ºC by the end of the century, leading to widespread melting of snow and ice and a rising global mean sea level. The report also points to the projected increase in extreme weather events (storms, precipitation, drought), noting that tropical cyclones (hurricanes and typhoons) are likely to become more intense, with higher peak wind speeds and heavier precipitation associated with warmer tropical seas. These extreme events are projected to increase in magnitude and frequency over the years. Additionally, there has been an increase in the number of heat waves, a decrease in the frequency and duration of frosts, and an increase in the frequency and intensity of extreme events in many parts of the world (see Annex 4: Trends in extreme climate events and Annex 5: Long term catastrophic trends).

- All the above indicate that climate change has already become a major global challenge for the 21st century. Based on the information derived from the IPCC (2007), the Arab region experienced an uneven increase in surface air temperature ranging from 0.2ºC to 2.0ºC that occurred from 1970 to 2004. Moreover, the majority of Arab countries, particularly those situated in the Middle East, are likely to be confronted with water-related problems and impacts resulting from climate change.

Contribution of Arab countries to climate change

The region's emissions of Greenhouse Gases (GHG) are generally small in absolute terms (less than 5% of the world's total), and in per capita terms. However, the amounts of these emissions and consequent contribution of the region to climate change varies between countries, with the oil producing countries (Algeria, Egypt, Iraq, Saudi Arabia and the United Arab Emirates) shouldering the biggest share (74% of the region's total). Moreover, at +88%, the growth of CO_2 emissions in the Middle East and North Africa was the third-largest in the world in 1990-2004 and more than 3 times faster than the world's average; most of that growth came from fuel combustion (WB 2007).

3. Assessment of projected impacts, vulnerability and adaptation of the Arab region

- Vulnerability is defined by the IPCC 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." Improving adaptive capacity is important in order to reduce vulnerability to climate change. In this respect, vulnerability is seen as the character, magnitude and rate of climate variation to which a system is exposed, the system's sensitivity to climate variation and its adaptive capacity (IPCC 2001b).

- The Middle East and North Africa (MENA) is considered one of the most vulnerable regions to climate change impacts, on account of its water scarcity (the highest in the world). The IPCC report estimates an increase in temperature in MENA of up to 2°C in the next 15-20 years, and over 4°C for the end of the century. Giorgi (2006) identifies North Africa and the Mediterranean among the most physically sensitive regions to climate change. Climate models are projecting hotter, drier and less predictable climate, resulting in a drop in water run-off by 20% to 30% in most of MENA by 2050, mainly due to rising temperature and lower precipitation (Milly *et al*., 2005).

- The projected higher temperature and reduced precipitation is expected to have a combined effect that will increase the likelihood of droughts. Many parts of North Africa, and in particular Morocco, are already experiencing more droughts. Morocco has had an increase of drought frequency from one event every 10 years in the beginning of the 20th century, to five or six events every 10 years currently (Agoumi, 2003). The vulnerability of the region to climate change is aggravated by the significant dependence on climate-sensitive agriculture, the concentration of population and economic activity in flood-prone urban coastal zones, and the presence of conflict-ridden areas in which climate-induced resource scarcity could escalate violence and political instability even beyond the region's boundaries.

- Arab countries in Sub-Saharan Africa are particularly vulnerable to the risk of environmental changes due to global warming. This area is home to many of the world's poorest nations, countries which will not be able to afford adaptation strategies on their own. The IPCC, 2007 report highlights that between 1900 and 2005, the Sahel (the boundary zone in Africa between the Sahara to the north and the more fertile region to the south), the Mediterranean, southern Africa, and parts of southern Asia have become drier, adding stress to water resources in those regions.

- Climate change will most severely impact vulnerable regions and vulnerable groups because of its effect as a threat multiplier, and because of the inherent vulnerability of people whose

human security is not assured. The impact of climate change will be even more acute in vulnerable regions and on poor groups that face pre-existing problems such as conflict, poverty and unequal access to resources, weak institutions, food insecurity and incidence of disease. These conditions will leave communities unable to meet the challenges of adapting to climate change impacts and will exacerbate existing problems (Warren, R., N. *et al*. 2006).

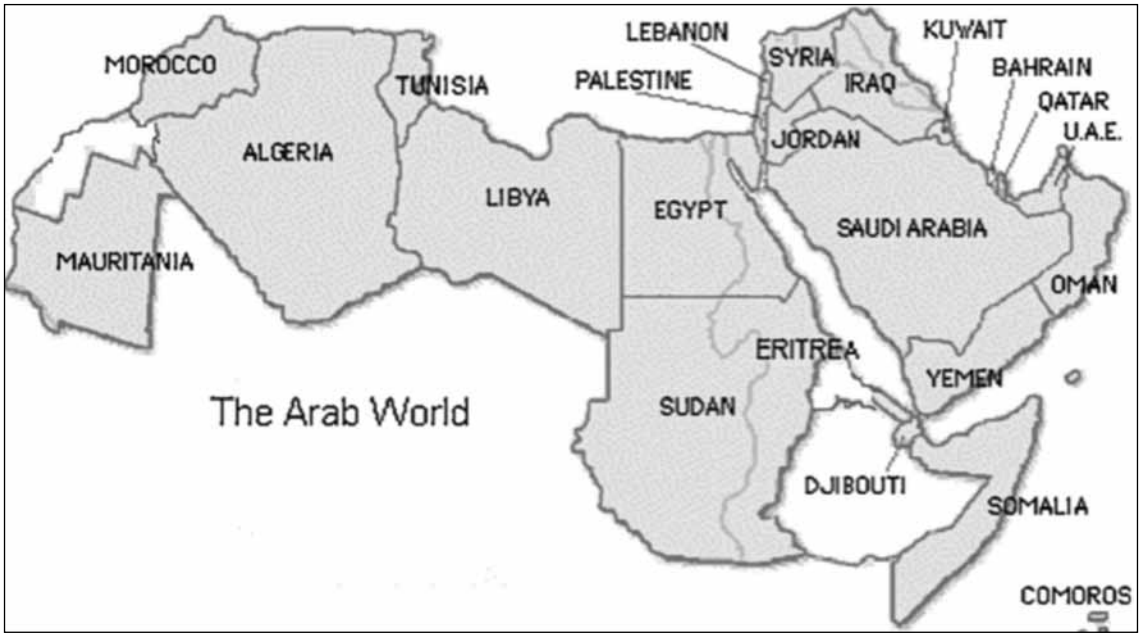
- Grasslands, livestock, and water resources are likely to be extremely vulnerable to climate change in the Arab region because they are located mostly in marginal areas.

TABLE 1: SUMMARY OF PROJECTED CLIMATE CHANGE IMPACTS IN MENA, SUB-SAHARAN AND GULF COUNTRIES

Middle East and North Africa (MENA)	Sub-Saharan Countries (Djibouti, Somalia, and Sudan)	States of the Gulf Cooperation Council (GCC)
By the end of this century, this region is projected to experience an increase of 3°C to 5°C in mean temperatures and a 20% decline in precipitation (IPCC, 2007). Due to lower precipitation, water run-off is projected to drop by 20% to 30% in most of MENA by 2050 (Milly *et al.*, 2005). Reduced stream flow and groundwater recharge might lead to a reduction in water supply of 10% or greater by 2050. Greater seasonal temperature variability. More severe weather events, such as droughts and floods. Significant sea level rise: the Mediterranean is predicted to rise between 30 cm and 1 meter by the end of the century—causing flooding to coastal areas along the Nile Delta (IPCC, 2007b). Mediterranean biomes are expected to shift 300-500 km northward if a 1.5°C warming were to occur, which could mean that Mediterranean ecosystems (e.g. in Jordan) would become more desert-like. An increase in vector-borne diseases and pests, as well as mortality.	Climate models predict warmer temperatures and more variable rainfall for this region under global warming. Desertification and loss of productive land is expected to accelerate, while an increase in extreme events—such as droughts and floods—could lead to food shortages and famines. A warmer climate could expand the range of carriers of malaria, yellow fever, dengue fever, and other vector-borne diseases. The lack of adequate fresh water is a problem faced by several countries in these parts Africa. Environmental pressures such as dwindling food and water supplies may lead to conflict between struggling nations, unleashing migrations of environmental refugees on the African continent (Boko *et al.*, 2007). 70% of the Nile's water flows from the Ethiopian highlands. Climate change, compounded by rapid population growth, threatens an increase in competition for water in the region. A study by Strzepek *et al.* (2001) found a propensity for lower Nile flows in 8 out of 8 climate scenarios, with impacts ranging from no change to a roughly 40% reduction in flows by 2025 to over 60% by 2050 in 3 of the flow scenarios.	If temperature rise is not stopped, and particularly if it exceeds 2°C to 3°C, the IPCC warns that the world could face massive species extinctions, widespread starvation, declining production of crops, and a persistent rise in sea levels that could drown major parts of the world's coastal areas. Climate change is considered by many security experts to be a greater threat than global terrorism. Specifically, the impact of sea level rise is considered serious for many of the Arab countries (e.g. Agrawala *et al.*, 2004). Underground water salinity will increase, more land degradation will occur in the region, and biodiversity on land and in the Gulf will be affected. Rising sea levels will affect coastlines and marine life severely and could impact desalination plants that are the source of water for the GCC region (See Annex 6: Regional climate models for temperature and precipitation in Gulf region).

Source: compiled by author from the IPCC, 2007 assessment and related technical papers.

FIGURE 1: MAP OF THE ARAB COUNTRIES



Source: Arab Bay.com, http://www.arabbay.com/arabmap.htm

3.1 Temperature and precipitation

- ***Temperature:*** model projections for temperature change over 2030, 2070 and 2100 indicate a steady rise of temperature in most of the Arab region (MENA) under the best and worst case scenarios (see Figure 2: Projected changes in the precipitation pattern and Table 2: Projected temperature range over parts of the Arab region). According to Christy *et al*., 2001, the mean global temperatures are rising. This rise in global temperature is attributed to anthropogenic emission of GHGs, particularly CO_2.

TABLE 2: PROJECTED TEMPERATURE RANGE OVER PARTS OF THE ARAB REGION

	Increase in annual average temperature range in °C	
Years	**Best scenario**	**Worst scenario**
2030	0.5-1.0	1-1.5
2070	1.0 -1.5	2.0-2.5
2100	2.5-3.0	3.0-4.0

Adapted from the IPCC, 2007.

- ***Precipitation:*** The IPCC projections indicate that increases in the amount of high latitude precipitation are very likely, while decreases are likely in most subtropical land regions (See Figure 2: Projected changes in the precipitation pattern). Preliminary climate change and climate variability scenarios for the Arab region indicate that rainfall in the region will become intense and dry spells will become more pronounced. The zone of severely reduced rainfall in

the IPCC projections extends throughout the Mediterranean region and the northern Sahara, and inland from the Atlantic coast down to about 15° N. The anticipated increase in surface temperature and reduction in rainfall will result in a 30%-70% reduction in recharge in an aquifer located in the eastern and southern Mediterranean coast, hence impacting the quantity and quality of ground water (Döll and Flörke, 2005). Therefore, MENA countries are very likely to be subject to extreme desiccation in the coming decades, with projected temperature increases in excess of 4°C throughout the far Northern part of Africa (Maghreb) in the summer, and reductions in rainfall exceeding 30% in some parts for the A1B scenario (See Annex 8: Vulnerability to climatic desiccation in the MENA region).

- Djibouti, Somalia and Sudan, being part of the African Sahel, are subject to impacts projected for the region. For instance, a number of regional models suggest a continued "greening" of the Sahel and southern Sahara. However, these projections are associated with considerable uncertainties and disagreements between models (Brooks, 2004). Studies such as Strzepek *et al*. (2001) indicate that whilst there is general agreement that an increase in temperature due to climate change will lead to greater water losses to evaporation, there is more uncertainty regarding the direction and magnitude of future changes in rainfall. This is due to large differences in climate model rainfall predictions. The major climate change hazards facing Djibouti, Somalia and Sudan may therefore be defined as exaggerated climate variability coupled with greater uncertainty over a range of timescales. A similar situation is expected for countries in the southern Arabian Peninsula, such as Yemen, which has a projected increase in rainfall but notable uncertainty (Christensen *et al*., 2007). (See Figure 2: Projected changes in the precipitation pattern and Figure 3: Projected change in temperature and precipitation using different scenarios).

3.2 Climate variability and extremes

Climate change is also expected to increase the frequency and intensity of extreme climatic conditions and related disasters, exposing more people to risk situations and leading to more severe events such as droughts, floods, hurricanes and dust storms (IPCC, 2007). This situation could potentially aggravate the region's vulnerability to natural disasters, which include, in addition to drought and food shortage, floods, dust storms, and pest infestations. Increasing occurrence of El Niño, which is the warming of sea surface temperature (SST), presents a climate phenomenon that changes the regular wind pattern. This will potentially be accompanied by changes in the seasonal distribution and predictability of rainfall over the African Sahel, more intense rainfall events and associated flash flood risks, changes in the distribution and occurrence of pests and diseases such as locusts, malaria and dengue and possible changes in the occurrence of dust storms (See Annex 5: Extreme climate events).

FIGURE 2: PROJECTED CHANGES IN THE PRECIPITATION PATTERN

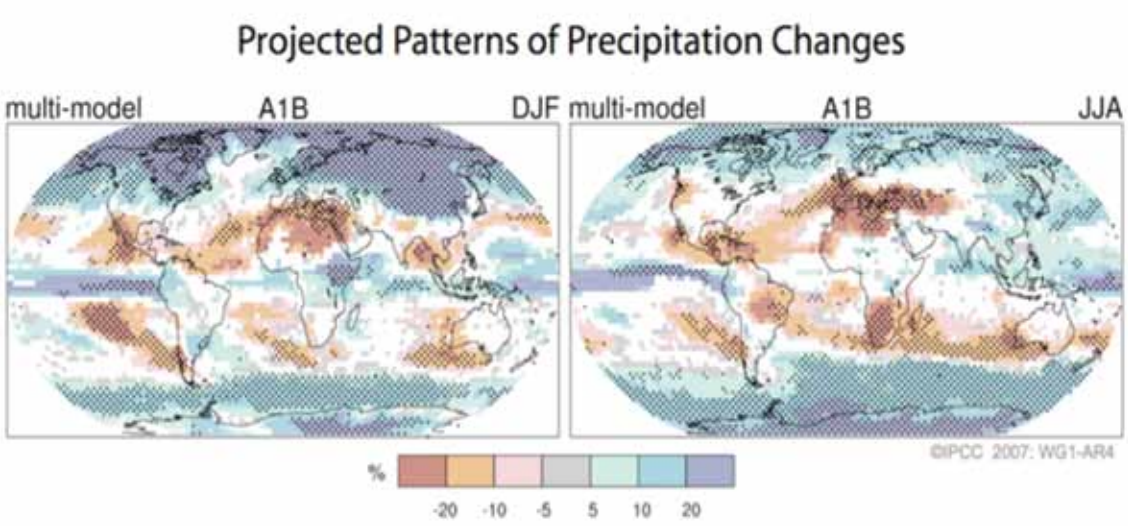
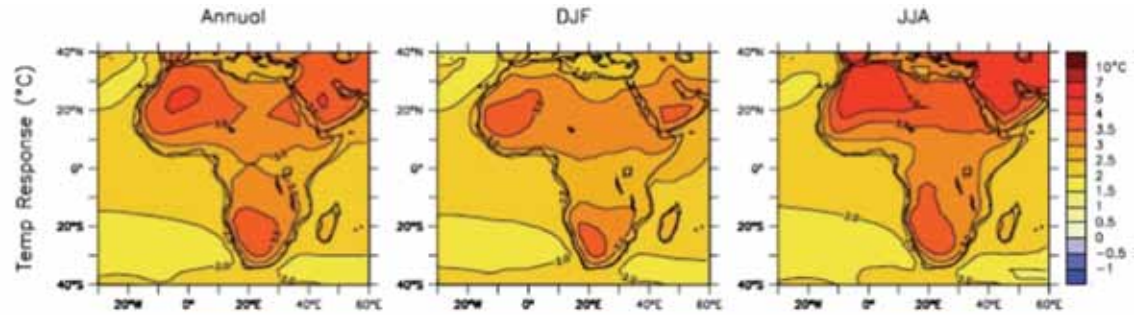


FIGURE 3: PROJECTED CHANGE IN TEMPERATURE USING DIFFERENT SCENARIOS. PROJECTED ANNUAL, DECEMBER-JANUARY AND JUNE-AUGUST TEMPERATURE CHANGES OVER AFRICA BETWEEN 1980-1999 AND 2080-2099, AVERAGED OVER 21 MODELS DRIVEN BY DATA FROM THE A1B SCENARIO.



Data derived from the IPCC AR4 (Christensen, 2007, p. 869).

- ***Dust storms:*** Most of the Arab region is desert with already high temperatures and prevailing dust storms and sand dune movements. Under a projected increase of temperatures, soil erosion is expected to increase. Loose soil is easily movable by wind storms, which are also expected to increase in terms of frequency and intensity. The fine particles of dirt kicked up during wind storms contribute to air pollution and negative health impacts. Increased movement of sand dunes is also expected to impact scarce water resources in the region. Dust storms are prevalent features of the Saharan and Sahelian environments. The Sahara Desert is considered the largest source of airborne dust minerals in the region. Some countries in the Arab region witness exceptionally huge dust storms that could sometimes turn day into night by completely concealing the sun light (e.g Khamasin in Egypt and Haboob in Sudan). In 2007 and 2009, the city of Khartoum in Sudan witnessed very severe wind storms that led to traffic accidents and delayed flights and aviation services (see photo of the dust storm in Khartoum, July 2009).

An estimated one billion tonnes of dust is exported from the Sahel-Sahara region annually (UNFCCC, 2006). A recent study by Dasgupta *et al*. (2009) on the potential impacts of increasing storm events indicated that intensified and more frequent storms would result in large Gross Domestic Product (GDP) losses equivalent to $12.7 billion in the MENA. Dust kicked up in the region can also be transported across large distances, traversing northern Africa and adjacent regions and landing as far away as Europe, Western Asia and the Americas (Moulin *et al*., 1997).

- ***Droughts and floods:*** These events increase both in magnitude and frequency over the years. While there are numerous indices and metrics of drought, many studies use monthly precipitation totals and temperature averages combined into a measure called the Palmer Drought Severity Index (PDSI). The PDSI shows a large drying trend over many Northern Hemisphere land areas since the mid-1950s, with widespread drying over much of southern Eurasia, northern Africa, Canada and Alaska (IPC, 2007b). Recently, the Arab region started to witness some of these extreme events more frequently, particularly droughts, flash floods, and storm surges. However, the damage associated with these events has rarely been qualified. Generally, geographical variations define the degree of exposure in different parts of the region to these extreme weather events. Countries situated in the African Sahel—such as Djibouti, Somalia, and Sudan—are living under the constant threat of drought due to fluctuating rainfall coupled with high temperature. Increases in heavy precipitation events over the mid-latitudes in the last 50 years—even in places where mean precipitation amounts are not increasing—presents a prominent indication of a change in extremes. Some North African countries (particularly Algeria and Morocco, which are projected to face drier conditions under future climate change (Brooks, 2004)) have witnessed many flash floods during the last few years that damaged roads, buildings, bridges, railway lines and other properties, such as schools. Heavy rainfall equivalent to an entire month of rain in several hours was recorded in Algeria in 2001; this extreme event claimed 751 victims and caused damage estimated at US$300 million.

  Morocco has experienced devastating floods, with substantive infrastructure damage and human losses. Estimated losses included 89 dead and missing, dozens wounded, more than 400 houses collapsed or flooded, and hundreds of hectares of agricultural land damaged or lost (El-Raey, M., 2009). Moreover, the 1997-98 El Niño-related floods are reported to have caused epidemics in Djibouti and Somalia (UNEP, 2006). Climate change is expected to exacerbate the intensity and frequency of such extreme weather events (IPCC, 2007a).

  Similarly, the GCC countries are projected to have their share of extremes. Some models reviewed by the IPCC predict a trend of precipitation increase in some of the regions' desert areas (particularly in the Arabian Peninsula—including Saudi Arabia and Yemen). Moreover, the increase in rainfall could arrive in concentrated, short and intense precipitation events, which could lead to a higher risk of flash floods and might have negative consequences on aquifer recharge under certain geological conditions. The net result might be quite negative for countries of the Gulf region, particularly those already experiencing severe water crisis, like Yemen (WB, 2007).

Photo taken by author (Khartoum – July 2009).

3-A. Sectoral impacts of climate change

- Climate change—with its many dimensions (social, environmental, economic and political)—is expected to lead to multiple impacts at various scales and levels. The impacts on natural ecosystems will be reflected on all socio-economic levels, affecting livelihoods and human well-being. The prevailing climatic conditions in the Arab region have highly significant impacts on the different components of the ecosystems. Major impacts could be attributed to the inherent fragility of the dominating arid ecosystems of the region. These arid ecosystems are generally characterized by inferior physiochemical properties, weak resilience of soil resources and relatively-limited availability of surface/ground-water resources.

- The Middle East contains the world's hottest deserts, inhospitable to most forms of life. Scientists have depicted an increasingly clear image of changes that climate change can bring to ecosystems and societies. Most of the region is expected to remain very hot deserts under climate change scenarios. Climate change may put stresses on those areas which are more hospitable, such as the Mediterranean basin. Moreover, the grasslands of the Sahel, a band of semiarid land running across the continent south of the Sahara desert, are already shrinking. As climate models predict warmer temperatures and less rainfall for this region under global warming, land degradation, desertification, and biodiversity is expected to accelerate.

- Climate change is also expected to result in large-scale population movements across and within regions (environmental refugees), resulting in brain drain, lower economic growth and threats to national security.

3-A.1 Water resources

- Fresh water is one of the most valued and scarce resources in many countries of the Arab region. MENA is one of the regions most vulnerable to climate change impacts on water resources, and it is considered among the regions with the highest level of water scarcity in the world (IPCC, 2007). Currently, a lack of water is considered among the greatest problems in the MENA region. This situation is expected to be aggravated by the impacts of climate change, i.e. increased heat and evaporation. Such extreme climate conditions may cause conflict within and between nations. On the other hand, the lack of adequate clean water is a problem faced in many parts of the Arab countries of sub-Saharan Africa, particularly in areas where precipitation is projected to decline; this leads to more severe water shortages (IPCC, 2007).

- According to the UNDP Human Development Report 2007/2008, *Fighting Climate Change: Human Solidarity in a Divided World*, the Middle East is considered among the most water-stressed regions of the world. Recent estimates of water resources in the region indicate that total available natural water resources are 262.9Bcm, made of 226.5Bcm surface and 36.3Bcm groundwater in addition to 11,874Bcm of non-renewable (fossil) ground-water with great variations among different countries (Abahussain *et al*. 2002). Over three-quarters of the MENA's water resources are already being withdrawn for human use (see Figure 4: Withdrawal of total renewable water resources in 2000). Any given percentage reduction in precipitation in the MENA will therefore translate into a four times higher percentage decrease in water available for additional withdrawal (WB, 2007).

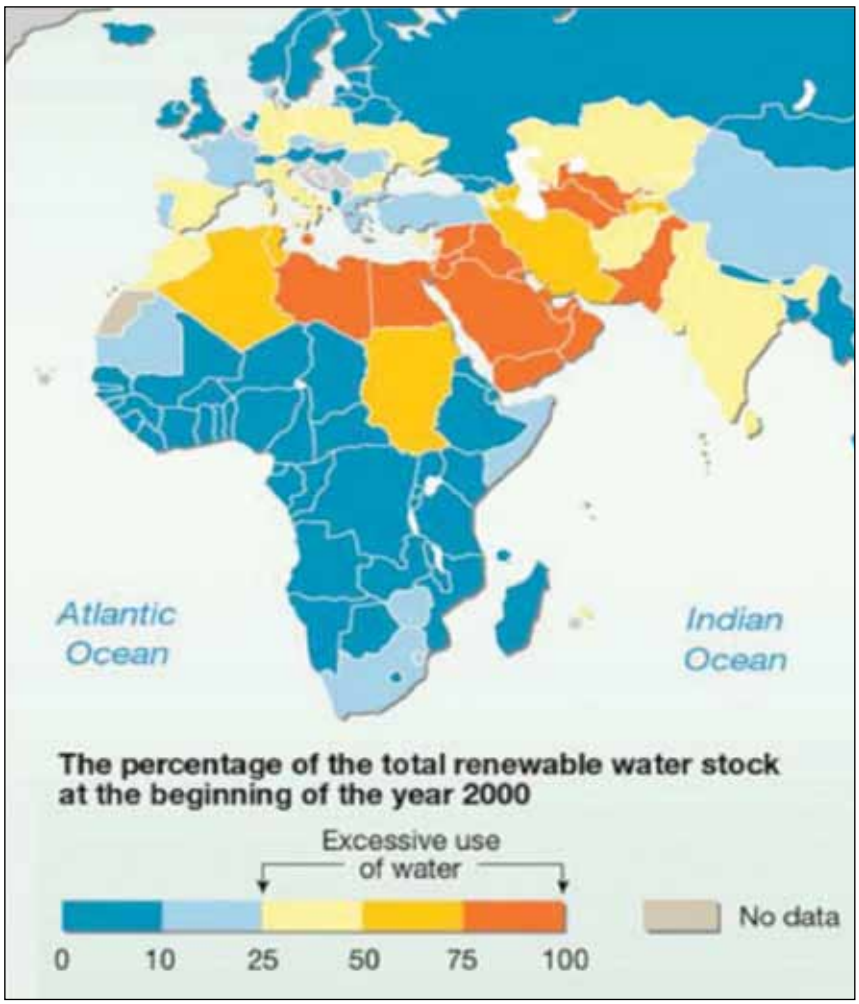
- Future scenarios project further decreases in rainfall and hence greater pressures on water resources. Based on some of these projections, the water deficit is likely to increase from about 28.3Bcm in the year 2000 to 75.4Bcm in 2030 due to climatic and non climatic factors. The change in the value of surface runoff will depend on the changes in temperatures and precipitation, among other variables. According to Smith *et al*. 2000, a temperature increase of 5°C will reduce the snow cover from 170,000 km^2 to 33,000 km^2 in the upland sections of the Euphrates and Tigris watersheds. This in turn would significantly reduce the discharge of the Euphrates and Tigris rivers. A study conducted by Abdulla and Al-Omari 2008 in showed that raising temperature by 2°C-4°C in Jordan would reduce the flow of the Azraq River by between 12% and 40%. *Smith et al*. 2000 showed that an increase in temperature of 5°C would result in the reduction of Euphrates discharge of 40%.

- Nine out of fourteen countries in the MENA region already have average per capita water availability below the water scarcity threshold. A warming climate is expected to place additional stresses on water resources in the MENA countries, whether or not future rainfall is

significantly altered (Hume *et al*., 2000). Per capita renewable water resources in the region, which in 1950 were 4,000 m^3 per year, are currently 1,100 m^3 per year. Trends of reduced surface water availability, reduced groundwater reserves, and increased occurrence of drought and flood events have been observed in several countries (e.g. in Morocco over the last 30 years). Projections indicate that per capita renewable water resources will drop by half, reaching 550 m^3 per person per year in 2050 (World Bank, 2006). (See Figure 5: Impact of climate change on water availability in the MENA in 2050.) Countries expected to experience decreased precipitation include: Egypt, Jordan, Lebanon and the Occupied Palestinian Territory (UNDP, 2007). Rising temperatures and changes in run-off patterns will influence the flow of rivers upon which countries in the region depend.

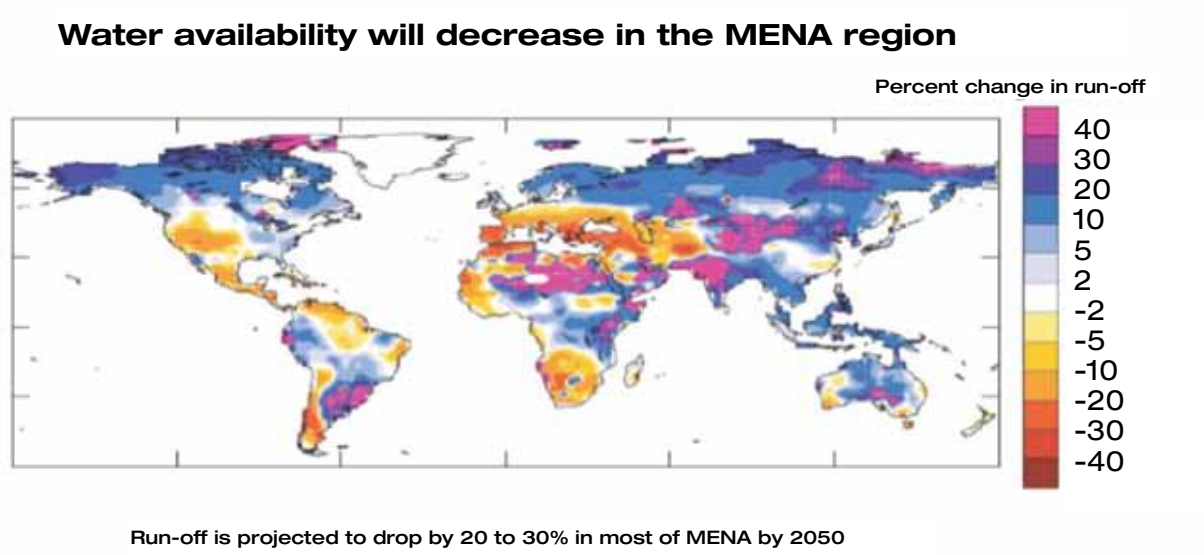
- It is evident that climate change scenarios for water in the Arab region cannot be viewed in isolation, as rapid population growth, industrial development, urbanization and increasing

FIGURE 4: WITHDRAWAL OF TOTAL RENEWABLE WATER RESOURCES IN 2000



Source: UNEP/GRID Arendal, 2007.

FIGURE 5: IMPACT OF CLIMATE CHANGE ON WATER AVAILABILITY IN MIDDLE EAST AND NORTH AFRICA IN 2050



Source: Milly et al., published in Nature.

demand for irrigation exert additional pressures on water resources (see Figure 4: Withdrawal of total renewable water resources in 2000).

3-A.2 Agriculture and food security

- Agricultural production and food security are closely linked to the availability of water. Climate change is expected to affect food security through its impact on agriculture and food production systems. At the global level, aggregate agricultural output potential will be little affected by climate change, with significant variations between regions. According to the IPCC 2007, by the 2080s, agricultural potential could increase by 8% in developed countries, primarily as a result of longer growing seasons, while in the developing world it could fall by 9%, with sub-Saharan Africa and Latin America projected to experience the greatest losses (UNDP, 2007). (See Figure 7: Changes in agricultural output potential 2080).

- The majority of Arab countries are considered among the world's most water scarce, and in many places demand for water already exceeds supply. Higher temperatures and less rainfall will reduce the flow of rivers and streams, slow the rate at which aquifers recharge, and make the entire region more arid. These changes will have a series of effects, particularly on agriculture, energy and food security.

- The main climate change risks in the North African and Middle East region will largely be linked to long-term desiccation and drought associated with climatic variability. Water stress

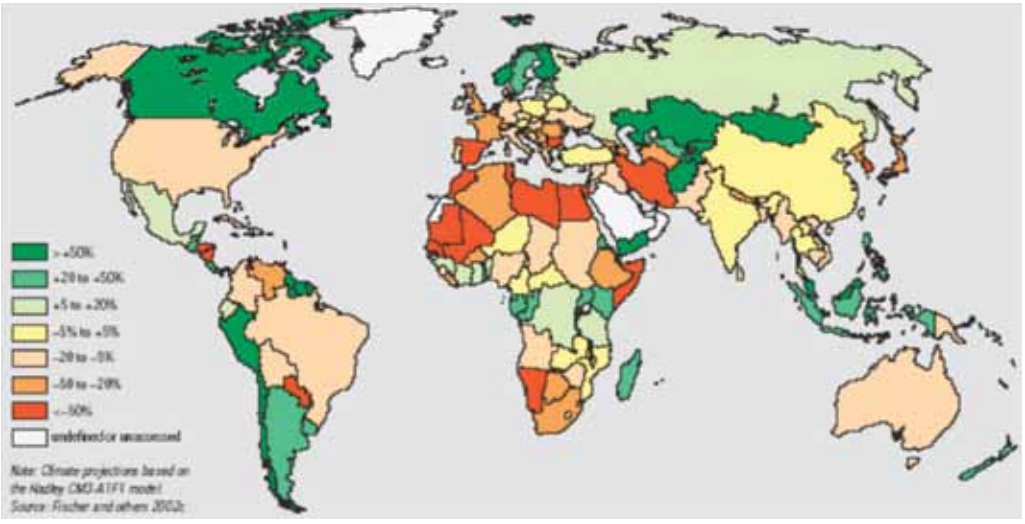
is of huge importance, and decreases in water availability may have severe impacts on food security. Some projections indicate that under moderate increases in temperature, water flow will be largely impacted. This is true for the Euphrates and Jordan Rivers, which could shrink by 30% and 80% respectively, by the end of the century.

- Agricultural yields, especially in rain-fed areas, are expected to fluctuate more widely over time and to converge to a significantly lower longer-term average. A recent study estimates that for the region as a whole, agricultural output will decrease 21% in value terms by 2080, with peaks of an almost 40% decrease in countries like Algeria and Morocco (WB, 2007). (See Figure 6: Projected percentage gain and losses in rain-fed cereal production potential by 2080).

- Since the economies of countries such as Comoros, Mauritania, Somalia and Yemen are still based on subsistence agriculture, a higher incidence of droughts and floods could lead to crop failures and food insecurity—and thus contribute to malnutrition, famine and starvation. Droughts and floods would further hamper the ability of countries to import sufficient quantities of food demanded by the population. In northeast Africa, more intense dry periods and shorter wet seasons are expected to affect even huge river systems such as the Blue Nile in Sudan, leading to serious water shortages and adverse consequences for agriculture and forestry sectors throughout the region (UNFCCC, 2006).

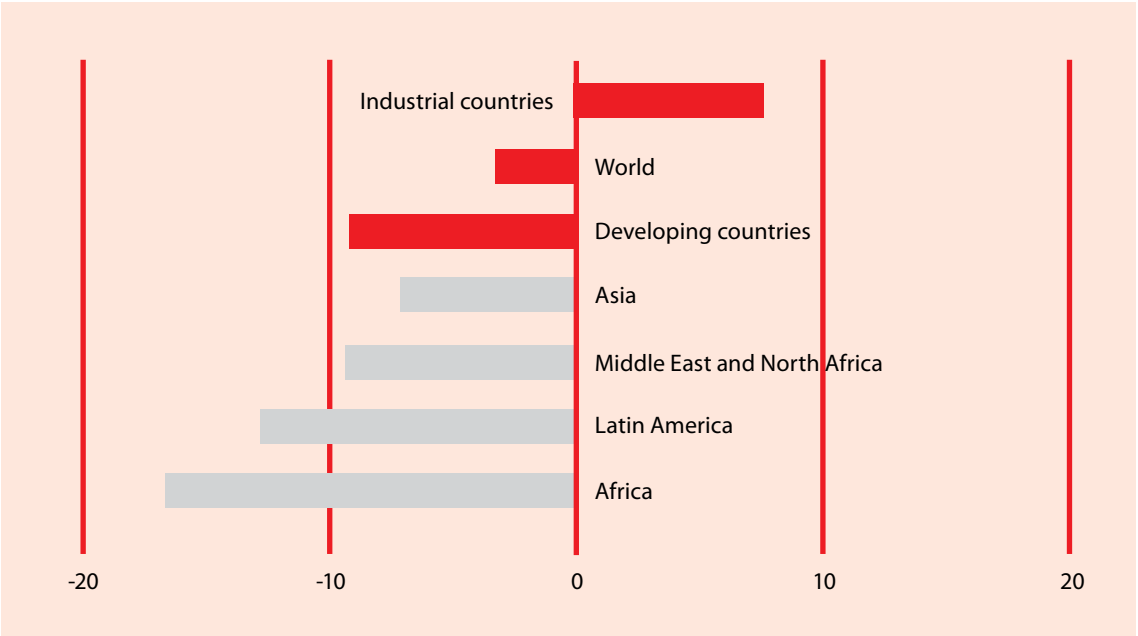
- In places with high dependence on fuel wood for energy, such as Sudan and Yemen, climate change may threaten the availability of fuel due to the expansion of agricultural lands into forests (deforestation) and cutting of trees to sell as a source of income (Osman-Elasha, 2007). According to FAO (1999), climate change in the already arid northern sub-region of Africa is expected to enhance desertification and bring a gradual decrease in forest cover.

FIGURE 6: PROJECTED PERCENTAGE GAINS AND LOSSES IN RAIN-FED CEREAL PRODUCTION POTENTIAL BY 2080



Source: UNEP (2006).

FIGURE 7: CHANGE IN AGRICULTURAL OUTPUT POTENTIAL (2080s as % of 2000 potential)



Source: Cline, 2007.

- Climate change could further decrease local agricultural productivity and make global food prices increasingly volatile, further politicizing the issue of food security. Growing demand for food associated with increasing population could further increase domestic pressures (UNFCCC, 2006).

3-A.3 Sea level rise (SLR), coastal inundation and erosion

- The Intergovernmental Panel on Climate Change (IPCC) indicated that the global sea level has already been rising at an average rate of 1.7 mm per year during the 20th century. With continued growth in global greenhouse gas emissions and associated warming, the sea level could rise by another 1 to 3 meters this century. Most of this anticipated increase is attributable to glacier melting and thermal expansion of oceans. While impacts on MENA's land areas are lower than the average of developing countries (0.25% vs. 0.31% with a 1 m Sea Level Rise), when measured in social, economic and ecological terms, impacts on MENA are estimated to be relatively higher. A 1 m SLR would affect 3.2% of MENA's population vs. 1.28% worldwide, 1.49% of its GDP vs. 1.30% worldwide, 1.94% of its urban population vs. 1.02% worldwide, and 3.32% of its wetlands vs. 1.86% worldwide (Dasgupta *et al*., 2007).

- Ocean- and sea-level rise could lead to inundation of the lengthy coastal areas of the Arab region. In particular, Bahrain and Comoros are island states that are highly vulnerable to inundation. SLR could result in loss of productivity, salt-water intrusion, loss of valuable biodiversity of wetlands, salinization of groundwater aquifers and migration of the population. In

Gulf countries, natural and especially man-made islands may disappear with rising sea levels. Bahrain will potentially lose up to 15 kilometers of its coastline, almost 11% of its land area, due to a sea level rise of 50 cm if no action is taken for protection (Al-Jeneid *et al*.).

- In addition, underground water salinity will increase, more land degradation will occur in the region, and biodiversity on land and in the Gulf will be affected. Assessment carried out under different climate change scenarios revealed that even the low SLR scenario of 0.5 m is expected to result in an inundation of about 11% of Bahrain's total land area by 2100 (Al-Jeneid *et al*., 2007).

- In urban areas in North Africa, between 6 and 25 million people are estimated to be exposed to coastal flooding under a temperature increase of 1°C-3°C. Sea level rise poses a risk to low-lying coastal areas in Kuwait, Qatar, Libya, Tunisia, United Arab Emirates, and particularly to Alexandria which is the second major city in Egypt after Cairo. An estimated 45% of the population of Alexandria currently lives on land that water will submerge once expected SLR occurs. Water will submerge an estimated 1.3% of its beaches, 26% of its residential areas, and about half of the city's industrial complexes. An estimated 17% of those employed in the tourism sector will lose their jobs because of SLR (Al-Jeneid *et al*., 2007).

- The extremely low elevation of arable cropland in the Nile Delta in Egypt makes sea level rise a clear threat for the country, as most of the 50 km wide land strip along the river is less than 2 m above sea-level and is protected from flooding by only a 1 to 10 km wide coastal sand belt. Erosion of this protective sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands, could be a serious problem. The impacts would be very serious, as one-third of Egypt's fish catch is made in lagoons. Erosion could also affect the water quality and productivity of agricultural lands.[2]

- Infrastructure, roads, and recreational tourism beach facilities would be endangered and essential groundwater would be contaminated with salt (UNEP, 2004). Based on the UN-Habitat's State of the World's Cities 2008/09, by 2070 coastal cities that could be severely affected by rising sea levels include Alexandria (Egypt), Algiers (Algeria), Casablanca (Morocco), Djibouti (Djibouti) and Tunis (Tunisia).

3-A.4 Conflicts and human insecurity

- The recent IPCC report highlighted the impacts of internal and across-boarder migration as a response measure to climate-induced stresses, and the severe impacts of such migration, i.e. escalating conflicts, pressure on natural resources and loss of biodiversity (IPCC, 2007).

- There is a growing concern about future access to water, particularly where two or more countries share water resources, which is the case for 65% of the river basin in the Arab

[2] http://www.grida.no/climate/vitalafrica/english/16.htm.

region. A study by Strzepek *et al*. (2001) presented much drier scenarios of Nile flows, with nine recent climate scenarios ranging from no change to a roughly 40% reduction in flows by 2025. The results of studies by Conway (2005) highlight the significance of natural variability for the Nile's water supply, primarily due to rainfall fluctuations over the Ethiopian highlands. This indicates that, whilst the modeled flow results for the 2020s with climate change lie within inter-decadal variability, the current observations reveal a real change, not just in the periodic fluctuations as has occurred in the past. Similarly, the Euphrates and Tigris Rivers will experience a reduction in flow of as much as 30% to 50% (ESCWA, 2008). Kunstmann *et al*. (2007) projected a 25% decrease in the mean annual precipitation in the Upper Jordan catchment, a decrease of 23% in total run-off at the outlet, coupled with a significant decrease in groundwater recharge.

- In regions suffering from political instability and tensions, climate change is likely to act as a "threat multiplier"—aggravating water scarcity and tensions within and between the nations sharing hydrological resources, geography, and political boundaries. For instance, climate change impacts could increase tensions and deepen the conflicts between the Occupied Palestinian Territory and Israel (Tropp, H., Jagerskog A., 2006). With anticipated climate change, water-sharing arrangements between countries and sharing water resources will only become politically more difficult to respect (FoEME, 2007).

- Both the MENA and Sub-Saharan regions are hotspots for many of the world's conflicts. Scarce water and food have always triggered conflicts and civil wars. Such strife is among the main reasons for mass migration and displacement. Environmental stresses, especially contracting water supplies, could only exacerbate animosities in the region. According to Warren *et al*. (2006), between 1995 and 2025, some additional 80-100 million people will be exposed to water stress defined as access to less than 1,000 m^3/capita/year (see Figure 6: Impacts of climate change on water availability in MENA in 2080). Water stress will exacerbate competition for water across sectors and geographic locations and will put further pressure on groundwater, which is currently being extracted in most areas beyond the aquifers' recharge potential. Such water pressures have been associated in many areas with conflicts and political disputes at the national and regional levels (Osman-Elasha, 2008).

- Migration is expected to intensify in the different regions of sub-Saharan Africa with projected increases in the number of environmental refugees—those who are exposed to climatic shocks, in addition to war refugees. Shifting rainfall patterns, spreading desertification and falling agricultural productivity are likely to undermine rural livelihoods, worsen job prospects in rural areas and accelerate migration to urban areas. This could strain services in cities and lead to increased resentment of existing refugee populations. Environmental pressures such as dwindling food and water supplies may lead to conflict not only within countries, but also beyond national boundaries, unleashing migrations of environmental refugees in large numbers (Osman Elasha, 2008).

- Drought and other climate-related shocks may spark conflict and violence, as they have already done in parts of Africa such as Sudan. In addition, climate-induced resource scarcity could

further spark tensions in the region's conflict-ridden areas, potentially escalating violence and political turmoil even beyond the region's boundaries. This is very critical since almost 80% of surface water resources and 66% of total water resources in the Arab region are shared water resources (Al-Jenied *et al.*, 2007).

3-A.5 Human health

- Human health in the region varies, reflecting the environmental and socio-economic situation of the different countries. Some countries, where poverty is high, have high infant mortality rates and low life expectancies. The impacts of climate change—such as heat stress and a possible increases in vector-borne (e.g., malaria) and waterborne diseases—are likely to be harmful to the health of the population. Climate models project that temperatures in the region may increase by 1°C-2°C by 2030-2050, with the greatest increases in the summer. As extreme temperatures are already occurring in the Middle East, even a small rise in temperature could have severe impacts on human livelihood and health. Heat-related mortality is also expected to increase. Precipitation projections vary from model to model and from one part of the region to another. Decreases in water availability and food production would lead to nutritional and hygiene issues (IPCC, 2007).

- A warmer climate could expand the range of carriers of malaria, yellow fever, dengue fever, and other vector-borne diseases. The lack of strong public health infrastructure in some countries, particularly in sub-Saharan Africa and the MENA, will render them more vulnerable to projected increase in the lengths of epidemic seasons and geographic range of the aforementioned vector-borne diseases. Rift valley fever, which afflicts people and livestock, is closely related to heavy rainfall. An outbreak in 1997 associated with an El Niño event killed up to 80% of livestock in Somalia and northern Kenya. In addition, heat waves, increased "heat island effect," water scarcity, poor water quality, worsening air quality, and ground ozone formation are likely to lead to an overall worsening of public health, and more generally, to a deterioration of living conditions.

3-A.6 Implications on human development

- Climate change with its multiple impacts is expected to adversely affect the three main pillars of sustainable development: environmental, economic and social. Moreover, climate change threatens the region's ability to achieve the Millennium Development Goals (MDGs) and other developmental goals, particularly poverty reduction, gender equality and environmental sustainability. Achievement of environmental sustainability will require more concerted efforts to address climate change concerns, protect and conserve natural resources, particularly energy, water and soil resources, and to diversify economies.

- Regional and intra-country discrepancies exist regarding the progress towards achieving the MDGs. The high-income, oil-dependent GCC countries are relatively well placed to achieve the MDGs, while the majority of the low and middle income/ agriculture-based economies in

the Sub-Saharan and MENA regions have varying potential for reaching each goal, depending on country-specific situations. According to UN, 2005, the Arab LDCs (Comoros, Djibouti, Somalia, Sudan and Yemen), in addition to Iraq and the Occupied Palestinian Territory, will likely only make limited progress toward achieving the MDGs. This is because climate change impacts on agriculture and natural resources may result in damages to strategic economic sectors and may even constrain opportunities for rural communities to generate income or improve their livelihoods. Moreover, changes in temperature and precipitation patterns, extreme events such as droughts, floods and sand storms could damage infrastructure necessary for development.

- As mentioned in previous sections of this report, the climate-induced water scarcity projected for the region could negatively impact the development of different sectors particularly agriculture, energy and health, all of which are determining factors in sustainable development in the region. A 2006 study commissioned by the United Kingdom and carried out by Sir Nicholas Stern, the former chief economist of the World Bank, estimated that the economic cost of climate change at a global level could rise to between 5% and 20% of global GDP if no action is taken. Reduced agricultural productivity, rising sea levels, more frequent natural disasters, and accelerated desertification might have the net effect of constraining economic growth and increasing poverty across the region.

- One of the development indicators for the Arab countries includes the percentage of population below poverty lines of $1/day and $2/day. In five countries the GDP/capita is about $1/day, while almost 85 million or 30% of the region's population are below the poverty line of $2/day (UNDP, 2003). This indicates clearly the different levels of development and poverty situations in the Arab countries. The Human Development Index (HDI) in countries of the region ranges from 0.482 (Yemen) to 0.843 (Bahrain) compared to an average of 0.651 for the Arab States.[3] A climate-driven reduction in GDP would further increase the number of people below the $2/day poverty line by 2100. Climate change could constrain the development of the tourism industry in a number of ways: bleaching corals in the Red Sea; and the water level of the Dead Sea, an important touristic area, is dropping at a rate of one meter per year as a result of evaporation and reduced rainfall.

3-A.7 Gender considerations

- Empowerment of women is an essential component of all eight MDGs with gender equality taken as an integral part of sustainable development. Climate change is expected to constrain all the efforts aimed at achieving the MDGs through its impact on different economic and social sectors. Climate variability is already causing unpredictable damage, making vulnerable people, including women, more vulnerable. Current socio-economic and cultural constraints affect women in a disproportionate manner. Based on FAO, 2005, women in sub-Saharan Africa and the Near East play a major role in household animal-production enterprises, where

[3] http://www.un.org/esa/sustdev/csd/csd14/escwaRIM_bp2.pdf.

they tend to have the primary responsibility for the husbandry of small animals and ruminants, beside taking care of large-animal systems, herding, providing water and feed, cleaning stalls and milking animals. Women in Arab countries, especially the least developed countries, are already suffering unacceptable high rates of morbidity and mortality connected with pregnancy and reproductive functions. The average maternal mortality rate in the Arab countries is around 270 deaths per 100,000 live births. This rises to over 1,000 deaths in the poorest Arab countries (Mauritania and Somalia) and falls to a level of 7 for every 100,000 births in Qatar (UNDP, 2006). Climate change related impacts could exert additional pressures on vulnerable Arab women, causing serious health problems and diseases. Heat waves associated with high humidity in the gulf region could increase, leading to higher exposure to heat-related diseases.

- A study in western Sudan indicated that women are usually the last to migrate when drought strikes their lands. Men usually leave their lands first in search of work and income, leaving women and children behind. Women shoulder the responsibility of households and manage the dwindling resources (Osman Elasha *et al*., 2007).

- Gender bias during disasters is also under-reported. When disasters strike, they hurt whole communities—but women often bear the brunt. Floods frequently claim far more female victims because their mobility is restricted and they have not been taught to swim. When Bangladesh was hit by a devastating cyclone and flood in 1991, the death rate was reportedly five times higher among women. Also women and children refugees of natural disasters or conflicts caused by scarcity of resources are exposed to increased risks compared to male refugees, be it in refugee camps, resettlement areas, or even in countries where they seek asylum. Women and girls, in particular, are vulnerable to exploitation, trafficking and other forms of gender-based violence. In the aftermath of a disaster, restrictions on the legal rights and entitlements of women to land and property can limit access to credit needed for recovery. For example, the tropical storm that hit Hadramaut governorate in Yemen in October 2008 resulted in devastating flash floods. Flash floods and surging waters killed 80 persons and forced an additional 20,000 to 25,000 people into displacement.[4] It was found that the majority of the displaced people were generally women and children. In one school alone, 900 women and 550 children were sheltered (with 100 people staying in one room).[5]

- It is also evident that women play a major role in buffering the family against unexpected climatic shocks. Their knowledge of local people and ecosystems, their skills and abilities, social networks and community organizations help communities mitigate hazardous conditions and events and respond effectively to disasters when they occur. However, women are not considered during the planning and implementation of adaptation projects. For example, none of the National Adaptation Programme of Action (NAPA) projects specifically target women development and capacity building in order to improve their contribution to the community's adaptation. However, some of the projects aimed at supporting the agriculture sector

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4 http://www.internal-displacement.org/8025708F004BE3B1/(httpInfoFiles)/6D020F4AD5C0A59DC12575FB0052665B/$file/Yemen+-+July+2009.pdf.

5 http://www.reliefweb.int/rw/RWFiles2008.nsf/FilesByRWDocUnidFilename/YSAR-7L9NYA-full_report.pdf.

may involve the integration of women in sector development, e.g. Mauritania has a project on integration of women in the development of small-scale farming (Osman-Elasha and Downing T, 2007).

- A recent paper on gender and climate change in the Arab region (Osman-Elasha, 2008) concluded that the prevailing socio-economic inequalities in the Arab region could render women more prone to a range of climatic and socio-economic impacts. The paper further highlighted the importance of giving women equal participation in the decision making process in all national and regional efforts aimed at reducing the spread of poverty, supporting economic growth and achieving greater justice and wealth distribution.

3-B. Adaptation to climate change

- Adaptation is defined by the IPCC as the "adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." According to the IPCC Report, climate change is already happening and will continue to happen even if global greenhouse gas emissions are reduced significantly in the short to medium term. The people of the Arab regions, MENA and Africa Sahel are accustomed to coping with a warm and arid climate. However, the projected changes in temperature and precipitation may be beyond their coping. Therefore, selection of appropriate adaptation strategies will be critical.

- In view of the projected impacts of climate change on the Arab region, adaptation is a priority for ensuring the long-term effectiveness of national and regional efforts to eradicate poverty and achieve sustainable development. Through the decisions of the United Nations Framework Convention on Climate Change (UNFCCC), work has been initiated to develop the adaptive capacity of poor people and poorer countries (Least Developed Countries) to cope with the impacts of climate change. Yet, a stronger focus must be placed on poverty reduction and sustainable development. It is believed that the development and environment community must ensure that adaptation is not treated as a stand-alone issue, but in the context of poverty reduction and the Millennium Development Goals (MDGs). Moreover, the IPCC Report, 2007 concluded that adaptation measures, if pursued in the sustainable development framework, can diminish the damage from future climate change and climate variability.

- Climate change requires that immediate action be taken to strengthen coping capacity and to reduce the vulnerability of sensitive sectors and systems, and to promote the diversification of productive livelihoods in rural areas. A more drastic adjustment is needed in the management of the region's water resources than in any other region, since most water resources are already being exploited for human use and further stresses are projected under climate change.

- A number of adaptation options have been identified under national development and research programs, including in the National Communications and NAPAs. Many of these adaptation

measures/ plans could be piloted to generate lessons. Priority interventions should cover areas related to good governance, human resources, institutional structures, public finance, and natural resource management. Moreover, development agendas should consider climate change concerns in order to ensure that all interventions will lead to improving economic and social welfare. It is equally important to address synergies between climate change adaptation and related development agendas and strategies, such as the Poverty Reduction Strategy Paper (PRSP), agricultural development, and energy conservation at different levels and scales.

- Empowerment of communities—particularly women and other vulnerable groups—so that they can actively participate in the planning and implementation of adaptation programs is a priority, both for their own well-being as well as to ensure that adaptation programs are based on local knowledge, a key for their success.

- Regional cooperation among the Arab countries in adaptation efforts should be fostered through the adoption of action plans that address climate change issues, and through the development of a regional early warning system for weather forecasts, risk assessment and monitoring of extreme events such as droughts, floods and a rise in sea level.

- The mainstreaming of climate change adaptation strategies within national development plans and efforts needs to be fostered, as does the incorporation of climate-sensitive policy components into sectoral, national and regional policy frameworks. An enhanced cooperation, development and implementation of integrated regional water management between countries sharing the same fresh water sources—both surface and groundwater—could ensure conservation, sustainable utilization and avoid conflicts.

4. Mapping Initiatives for addressing climate change (National communications and NAPAs)

National Communications: The entire Arab region under the UNFCCC pact is under the Non-Annex I Parties category. Almost all countries submitted their first National Communication Report—Mauritania submitted the second National Communication Report in 2008. The few countries that have not yet submitted their reports are from the Gulf region in addition to Libya (see Table 3: National communication submitted by Arab countries). The Gulf countries joined the UNFCCC in the mid-1990s; some of them submitted their report only in the last two years. The National Communication Reports contain a chapter on vulnerability and adaptation assessment—common across the Arab countries is the focus on water resources and agriculture as most vulnerable sectors to the impacts of climate change (see Annex 7: Vulnerability and Adaptation assessment based on National Communications).

TABLE 3: NATIONAL COMMUNICATION SUBMITTED BY ARAB COUNTRIES (UNFCCC WEBSITE)

Country	Ratified UNFCCC	Ratified Kyoto Protocol	Submitted 1st NC	Submitted 2nd, NC
Algeria			April, 2001	
Bahrain			April, 2005	
Comoros			April, 2003	
Djibouti			June, 2002	
Egypt			July, 1999	
Jordan			March, 1997	
Kuwait				
Lebanon			Nov., 1999	
Libya				
Morocco			Nov., 2001	
Mauritania			July, 2002	Dec, 2008
Oman				
Qatar				
Saudi Arabia			Nov., 2005	
Sudan			June, 2003	
Syria				
Tunisia			Oct., 2001	
United Arab Emirates			Jan., 2007	
Yemen			Oct., 2001	

Source: UNFCC website accessed on 31 Nov, 2009,
http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php.

National Adaptation Programme of Action (NAPA)

NAPA is an adaptation initiative that aims at building the adaptive capacity of the most vulnerable communities in the most vulnerable countries (identified as the Least Developed Countries or LDCs), through the identification and development of specific measures aimed at reducing vulnerabilities to climate change of the different groups and sectors. Based on this, the main objective of the NAPA is to serve as a simplified and direct channel of communication for information related to the urgent and immediate adaptation needs of the LDCs. Six Arab countries are included in the world's 50 LDC list. They are Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen (UNCTAD, 2004). All of them prepared and submitted their NAPAs. NAPAs provide a process for LDCs to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change. The rationale for NAPAs lies in the fact that LDCs have very limited capacity to adapt, and in the need for specific support that will allow them to deal with the adverse effects of climate variability and change. A summary of the NAPAs in the Arab region is given in the table below:

TABLE 4: NATIONAL ADAPTATION PROGRAMME OF ACTION (NAPA)

Country	NAPA submission	Sample of priorities
Comoros http://unfccc.int/resource/docs/napa/com01e.pdf	Nov., 2006	• Varieties that are most adapted to drought • Defense and restoration of degraded soils • Reconstitution of basin slopes • Improve water supply and quality • Fodder production for goats
Djibouti http://unfccc.int/resource/docs/napa/dji01f.pdf	Oct., 2006	• Reduce vulnerability of productive coastal systems • Reduce vulnerability to climate change along coastal zone • Strengthen Djibouti's capacity to promote sustainable development and climate-proof its integrated coastal zone management
Mauritania http://unfccc.int/resource/docs/napa/mau01e.pdf	Nov., 2004	• Improve management of underground water resources • Institutional reinforcement of the structure responsible for nature conservation • Reforestation for energy and Agro-forestry in the agricultural zones • Halt shifting of dunes that threatens the national socioeconomic infrastructure
Sudan http://unfccc.int/resource/docs/napa/sdn01.pdf	June, 2007	• Enhance resilience to increasing rainfall variability in the rangelands • Rehabilitation and water harvesting in the Butana area of Gedarif State • Reduce the vulnerability of communities in drought-prone areas of southern Darfur State through improved water harvesting practices • Improve sustainable agricultural practices amid increasing heat-stress in the River Nile State • Environmental conservation and biodiversity restoration in northern Kordofan State as a coping mechanism for rangeland protection under conditions of increasing climate variability • Adopt strategies to adapt to drought-induced water shortages in highly vulnerable areas in the Central Equatorial State

Yemen http://unfccc.int/resource/docs/napa/yem01.pdf	April, 2009	• Develop and implement Integrated Coastal Zone Management programmes • Conserve water through reuse of treated waste water and grey water from mosques, and irrigation saving techniques • Develop and implement an awareness programme on adaptation to the potential impacts of climate change • Establish and maintain a database for climate change and adaptation • Plant and re-plant mangroves and palms for adaptation to projected sea level rise • Develop and implement programmes to improve Yemen's preparedness to cope with extreme weather events • Rainwater harvesting through various techniques including traditional methods • Rehabilitation and maintenance of mountainous terraces • Promotion of research on drought resistant and heat- and salinity-tolerant crops • Design and implement sustainable land management strategies to combat desertification and land degradation • Sustainable management of fisheries resources • Incorporation of climate change and adaptation to school education

Main conclusions

- Although the contribution of the Arab region to climate change is still very limited (less than 5% of the global emissions), with variations between countries, the region is highly vulnerable to a range of impacts on water, agriculture and health that affect all socio-economic levels. Preliminary climate change and climate variability scenarios for the Arab region indicate that rainfall in the region will become intense and dry spells will become more pronounced. The zone of severely reduced rainfall in the IPCC projections extends throughout the Mediterranean region and the northern Sahara Desert. North Africa and the Middle East region is very likely to be subject to extreme desiccation in the coming decades, with projected temperature increases in excess of 4°C throughout the far Northern part in summer, and reductions in rainfall exceeding 30% in some parts for the A1B scenario.

- Climate change will act as a threat multiplier that is likely to exacerbate existing vulnerability of the region to current climatic and non-climate stresses, leading to a large scale of instability with severe environmental, economic, political and security implications. The impact of climate change will be even more acute in vulnerable regions and among poor groups that face pre-existing problems such as conflict, poverty and unequal access to resources, weak institutions, food insecurity and high incidence of diseases. These conditions will leave communities unable to meet the challenges of adapting to climate change and will exacerbate existing problems.

- The majority of the Arab countries are considered among the world's most water scarce, and in many places demand for water already exceeds supply. Trends of reduced surface water availability, reduced groundwater reserves, and increased occurrence of drought and flood events have been observed in several countries (e.g. in Morocco over the last 30 years). Countries expected to experience decreased precipitation include Egypt, Jordan, Lebanon and the Occupied Palestinian Territory. Increased temperatures coupled with changes in run-off patterns will influence the water flow of rivers upon which countries in the region depend. Moreover, it is becoming evident that climate change scenarios for water in the region cannot be viewed in isolation, as many factors interact to aggravate the situation, including rapid population growth, industrial development, urbanization, and increasing demand for irrigation—all of which exert pressure on water resources.

- Climate change is also expected to increase the frequency and intensity of extreme climatic conditions and related disasters, leading to more severe events such as droughts, floods, hurricanes and dust storms, and exposing more people to risk situations. Climate change could potentially aggravate the region's vulnerability to natural disasters, which include, in addition

to drought and food shortage, floods, dust storms, and pest infestations. Increasing frequencies of El Niño events will potentially be accompanied by complex changes in climate variability and extremes, such as changes in the seasonal distribution and predictability of rainfall, more intense rainfall events and associated flash flood risks, and changes in the distribution and occurrence of pests and diseases. Recently, the Arab region started to increasingly witness a number of extreme events like droughts, flash floods, and storm surges. Although the damage associated with these events has rarely been qualified, primary estimates indicate huge economic, social and environmental losses and costs that could constrain development in many countries.

- Higher temperatures and less rainfall will reduce the flow of rivers and streams, slow the rate at which aquifers recharge, and make the entire region more arid. These changes will have a series of effects, particularly on agriculture, energy and food security, and contribute to malnutrition, famine and starvation. Agriculture yields, especially in rain-fed areas, are expected to fluctuate more over time, and to stabilize at largely lower averages over the long-term.

- Ocean- and sea-level rise could lead to inundation of the lengthy coastal areas of the Arab region, particularly small islands. Two Arab countries, Bahrain and Comoros, are island states that are highly vulnerable to inundation. SLR could result in loss of productivity, salt-water intrusion, the loss of valuable biodiversity of wetlands, salinization of groundwater aquifers, and migration of the population. In Gulf countries, natural and especially man-made islands will be threatened by sea level rises. In addition, salt water could contaminate ground water, leading to severe land degradation and biodiversity loss.

- Increasing urbanization and abandonment of rural areas are among the observed impacts of climate change in some Arab countries. Shifting rainfall patterns, spreading desertification and falling agricultural productivity are likely to undermine rural livelihoods, worsen job prospects in rural areas and accelerate migration to urban areas. This could strain services in cities and lead to increased resentment of existing refugee populations.

- More competition over resources, mass movement, outmigration and conflicts are some of the expected outcomes of climate change in the Arab region. Scarce water and food triggers conflicts and civil wars, which are among the main reasons for mass migration and displacement. Environmental stresses, especially the difficulty of contracting water supplies, could only exacerbate animosities in the region. In countries suffering from political instability and tensions, climate change is likely to act as a "threat multiplier"—aggravating water scarcity and tensions within and between nations that share hydrological resources, geography, and political boundaries. With anticipated climate change, water-sharing arrangements between countries will only become politically more difficult to achieve.

- Climate change is projected to bring many direct and indirect health implications. For example, a warmer climate could expand the range of carriers of malaria, yellow fever, dengue fever, and other vector-borne diseases. The lack of a strong public health infrastructure in some of the region's countries—particularly in sub-Saharan Africa—will render them more vulnerable

to an increase in the length of epidemic seasons and geographic range of the aforementioned vector-borne diseases. Also, rift valley fever, which afflicts people and livestock, is closely related to heavy rainfall that could occur under climate change scenarios.

- Climate change—through its impacts on agriculture and water resources—may contribute to damaging strategic economic sectors and may even prevent the achievement of the Millennium Development Goals (MDGs), particularly Goal 1 on Poverty Alleviation. However, progress towards achieving the MDGs varies within the region, with the high-income/oil-dependent GCC countries better placed to achieve the MDGs and the majority of the low and middle income agricultural-based economies (MENA and sub-Saharan countries) possessing less potential for reaching each Goal.

- Women in the Arab region already face a number of stresses and socio-economic inequalities, which could increase their vulnerabilities and render them more prone to a range of climatic and socio-economic implications. Women play a key role in adapting households and buffering the family against unexpected climatic shocks. Their knowledge of local people and ecosystems, their skills and abilities, social networks and community organizations help communities mitigate hazardous conditions and events, and respond effectively to disasters when they occur. These factors support giving women more opportunities to participate in the planning of adaptation projects and to take part in national and regional efforts to reduce the spread of poverty, support economic growth and achieve greater justice and wealth distribution.

- In view of the projected impacts of climate change on the Arab region, adaptation is a priority for ensuring the long-term effectiveness of national and regional efforts to achieve poverty eradication and sustainable development. Immediate actions should be taken in order to strengthen the adaptive capacity and reduce the vulnerability of sensitive sectors and systems to climate change, and to promote diversification of productive livelihoods in rural areas. Some of the adaptation measures identified by the report include: taking a more drastic adjustment in the management of the region's water resources, since most are already being exploited for human use and further stresses are projected under climate change; mainstreaming adaptation into national and regional development plans and efforts; and promoting research and education. Priority interventions should cover areas related to good governance, human resources, institutional structures, public finance, and natural resource management.

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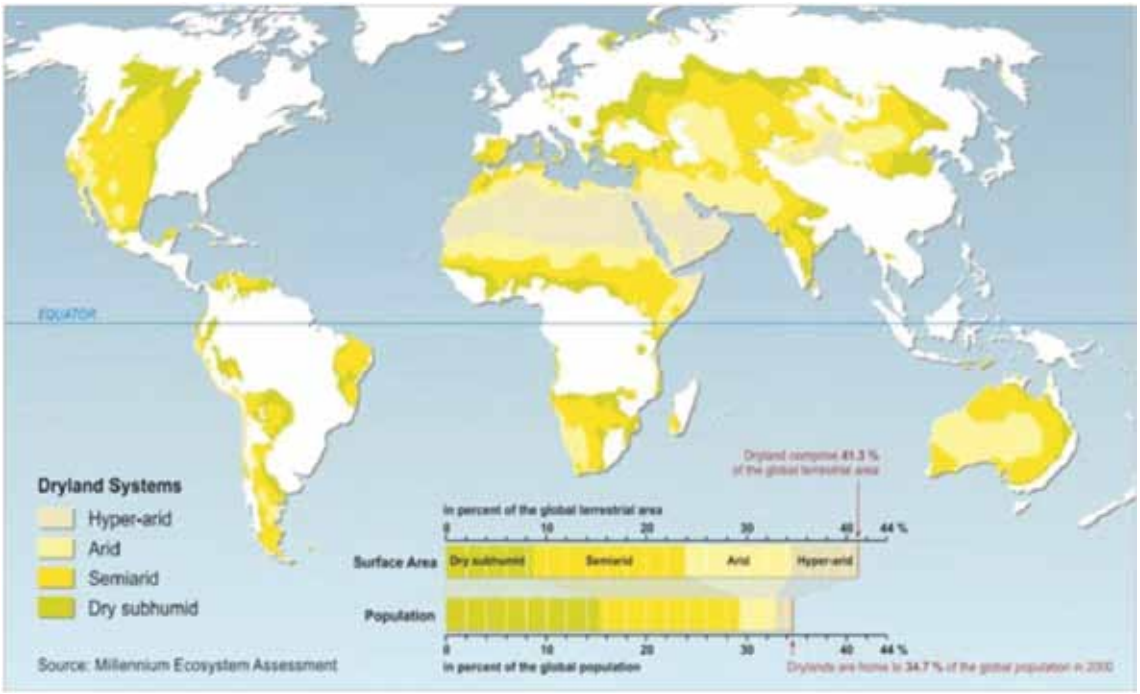
Annexes

Annex 1: Global vulnerable areas



Source: MEA, 2000.

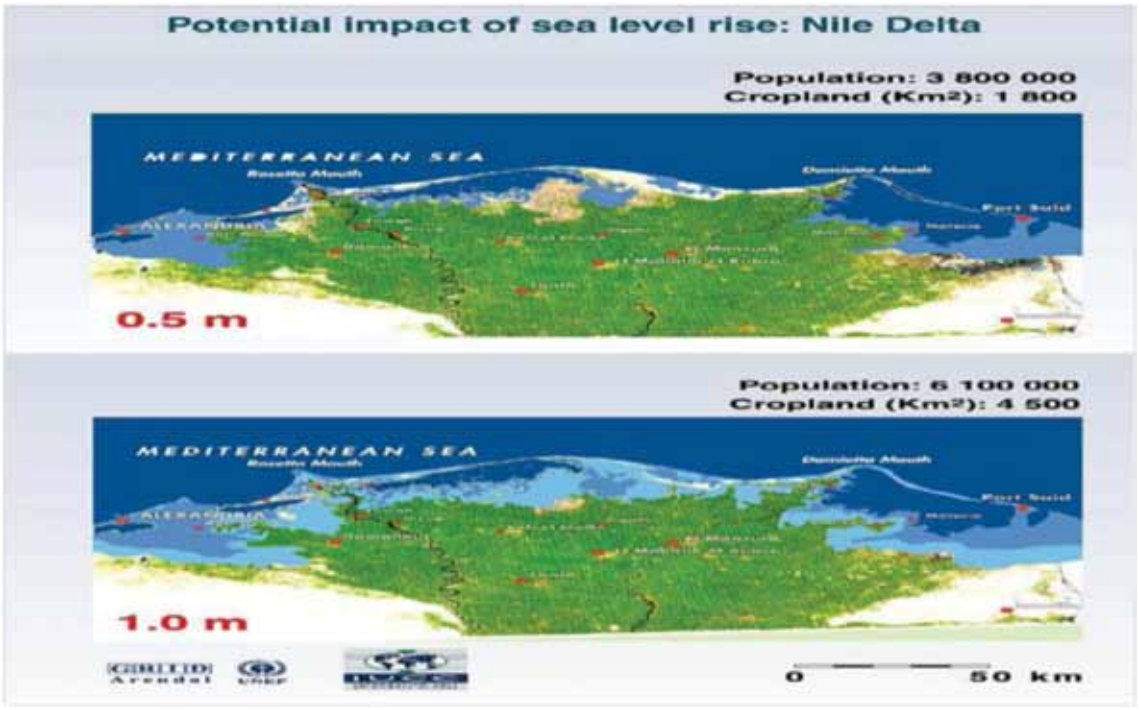
Annex 2: Emission per capita for year 2000

GHGs = Greenhouses gases *tCO2e = tons of Carbon dioxide equivalent*

Country	GHG (tCO2c)	Rank	CO2 only	Rank
Qatar	67.9	1	60.0	1
United Arab Emirates	36.1	2	25.2	3
Kuwait	31.6	3	26.8	2
Australia	25.6	4	17.3	7
Bahrain	24.8	5	20.6	4
United States	24.5	6	20.4	5
Canada	22.1	7	17.1	8
Brunei	21.7	8	13.7	10
Luxembourg	21.0	9	19.2	6
Trinidad & Tobago	19.3	10	16.7	9
New Zealand	18.9	11	8.6	32
Antigua & Barbuda	18.5	12	4.9	62
Ireland	17.3	13	10.9	18
Estonia	16.6	14	11.3	17
Saudi Arabia	16.4	15	13.4	11
Belgium	14.5	16	12.2	14
Czech Republic	13.9	17	12.1	15
Singapore	13.9	18	13.1	12
Turkmenistan	13.8	19	7.8	40
Netherlands	13.5	20	10.9	19
Finland	13.3	21	10.9	20
Russia	13.2	22	10.6	21
Palau	12.9	23	12.7	13
Nauru	12.8	24	11.4	16
Denmark	12.5	25	9.7	27
Germany	12.3	27	10.4	22
United Kingdom	11.1	32	9.4	30
South Korea	11.1	33	9.9	26
EU-25	10.5	37	8.5	34
Japan	10.4	39	9.5	29
Poland	9.8	43	7.8	41
Ukraine	9.7	44	6.3	47
South Africa	9.5	46	7.9	39
Spain	9.4	47	7.5	44
Italy	9.2	48	7.7	42
France	8.7	50	6.2	48
Argentina	8.1	52	3.9	70
Iran	7.5	60	5.3	56
Turkey	5.3	75	3.3	78
Mexico	5.2	76	3.9	71
Brazil	5.0	83	2.0	100
China	3.9	99	2.7	88
Indonesia	2.4	122	1.4	111
Pakistan	2.1	131	0.8	132
India	1.9	140	1.0	120
Developed world	**14.1**		**11.4**	
Developing world	**3.3**		**2.1**	
TOTAL WORLD	**5.6**		**4.0**	

Source: Navigating the Numbers: Greenhouse Gas Data and International Climate Policy. World Resources Institute, 2005; http://pdf.wri.org/navigating_numbers.pdf.

Annex 3: Potential impacts of sea level rise



Potential impacts of 0.5 and 1 m sea level rise in the Nile Delta

Source: Cartographer/Designer, Otto Simonett, UNEP/GRID – Arendal.

Annex 4: Trends in extreme weather and climate events

Extreme Weather Events and Trend	Likelihood	Major Projected Impacts
Frequency of heat waves and hot extremes increases over most land areas	Very likely	Wildfires. Increased water demand. Water quality problems.
Heavy precipitation events increase over most areas	Very likely	Damage to crops. Soil erosion. Flash floods. Landslides. Subsidence. Mudslides.
Area affected by droughts increases	Likely	Land degradation. Wildfires. Losses in agriculture (crops and livestock).
Intense tropical cyclone activity increases	Likely	Disruption by floods and extreme winds. Damage to coast and coral riffs.
Extreme high sea level	Likely	Increase of losses due to severe floods and sea surge. Increased costs of coastal protection and land-use relocation.
Changes in wind, precipitation and temperature patterns	Likely	Increase of losses due to extreme weather events.

Source: IPCC Report 2007.

Annex 5: Long term trend catastrophes

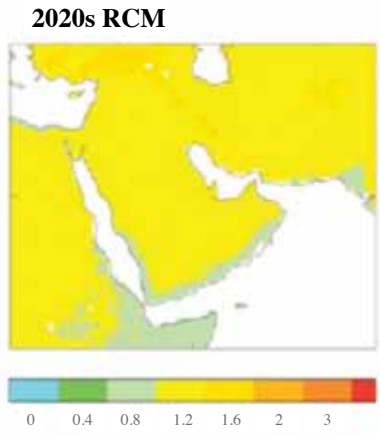
Great natural catastrophes 2007

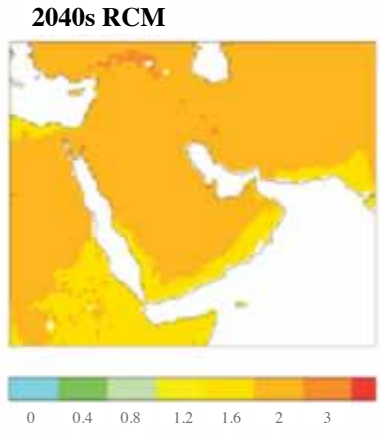
No.	Date	Region	Loss event	Fatalities	Overall losses (US$ m)	Insured losses (US$ m)
5	18.1.	Europe	Winter storm Kyrill	49	10,000	5,800
16	4-8.6.	Oman	Cyclone Gonu	70	3,960	650
20	June	United Kingdom	Floods	4	4,000	3,000
27	July	United Kingdom	Floods	1	4,000	3,000
45	November	Mexico	Floods	22	2,500	350
47	15-17.11.	Bangladesh	Cyclone Sidr	3,360	3,700	

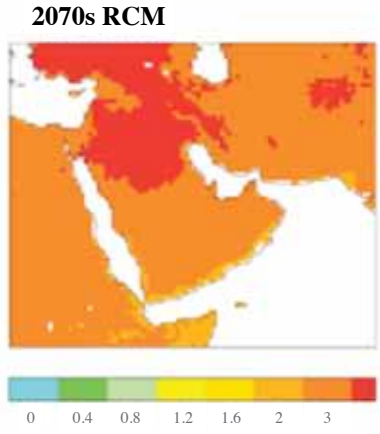
Source: Munich Re.

Annex 6: Regional climate models for temperature and precipitation in the Gulf region

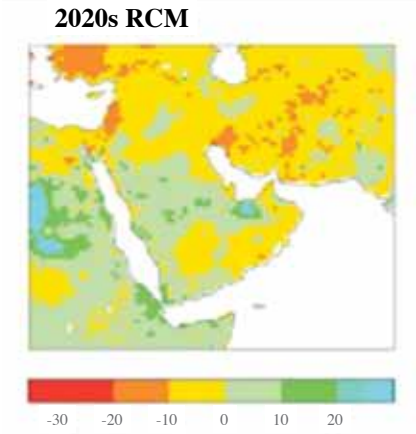
Regional Climate Model projections of average temperature changes (ºC) across the Gulf region for the 2020s, 2040s and 2070s, relative to the 1990s

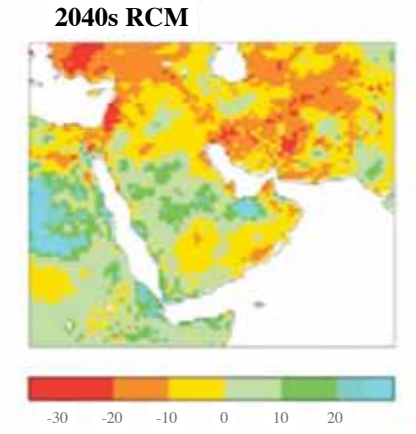


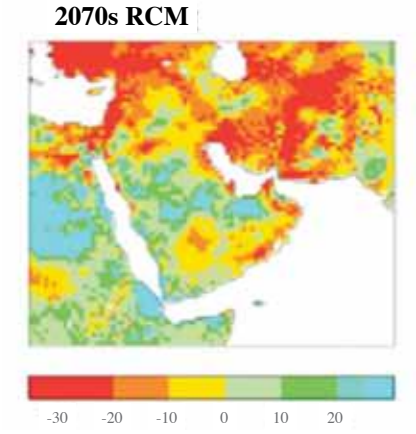




Regional Climate Model projections of precipitation changes (%) across the Gulf region for 2020s, 2040s, and 2070s, relative to the 1990s







Source: Hemming D., Betts R, & Ryall D. 2007.

Annex 7: Vulnerability and adaptation assessment-priority sectors

Country	Sectors assessed	Projected climatic changes	Potential impacts
1. Algeria http://unfccc.int/resource/docs/natc/algnc1.pdf	- Agriculture - Forestry - Land degradation - Oases	- Rising temperature - Reduced precipitation	- Changing weather patterns and the encroachment of the Sahara Desert - Reduced agricultural productivity - Soil erosion
2. Bahrain http://unfccc.int/resource/docs/natc/bahrnc1.pdf	- Sea level rise - Agriculture - Human settlement	- SLR up to one meter by 2100	- The low sea level rise scenario results in inundation of 5% (36 km^2) of the total land area of Bahrain - A one meter increase in SLR will result in 10% (69 km^2) inundation of the total land area - 11% of arable land would be lost due to SLR - Damage to drainage systems - Increase in water logging problems - Higher groundwater tables
3. Comoros	- Sea level rise - Agriculture - Water resources	- 20 cm SLR in 2050	- Accelerated reduction of the agricultural and fishing production - Increased saline intrusion in the coastal aquifers - Destruction of 29% of the roads and works - Spreading of malaria and other vector-borne diseases - Significant losses at the level of coastal infrastructures estimated at about $400 million, e.g. 2.2 times the GDP of 2001
4. Djibouti http://unfccc.int/resource/docs/natc/djinc1eres.pdf	- Sea level rise - Water resources	- **SLR:** +20 cm as compared to the 1990 - **Temp:** increases of between +0.6°C and +2.4°C - **Rainfall:** variations lie between –10.9% and +17%	- Inundation of coastal zone - Shortages in water
5. Egypt http://unfccc.int/resource/docs/natc/egync1.pdf	- Agriculture - Water - Aquaculture and fisheries - Coastal zone and tourism	- **Temp:** 2°C- 4°C increase in temperature by 2020 - **Rainfall:** 10-20% decrease	- Cotton productivity may increase relative to other crops - Economic losses due to loss of fertile delta soil and the impact on tourism infrastructure - Negative impact on fisheries
6. Jordan	Not submitted		
7. Kuwait	Not submitted		
8. Lebanon http://unfccc.int/resource/docs/natc/lbnnc01.pdf	- Water - Agriculture - Ecosystems - Coastal zone	- **Temp:** Increase in temperature - **Rainfall:** reduced between 61 mm and 99 mm	- Reduced quantity and quality of water - Reduced productivity of important agricultural crops (citrus, olive, apple and sugar beet) - Disappearance of certain types of vegetation and coastal inundation
9. Libya	Not submitted		
10. Morocco http://unfccc.int/resource/docs/natc/mornc1f.pdf http://unfccc.int/resource/docs/natc/mornc1e.pdf	- Water resources - Agriculture	- **Temp:** Increase in annual average (between 0.6°C and 1.1°C in the horizon of 2020). - **Rainfall:** Decrease in annual average volume of about 4% in 2020.	- Decrease in water resources (10% to 15%) - Decrease in cereal yields by 50% in dry years and 10% in normal years - Extinction of some crops (such as the Alpist) and some tree species (such as the Argan)
11. Mauritania http://unfccc.int/resource/docs/natc/maunc1.pdf	- Agriculture - Rangeland - Water resources	- **Temp:** Increase of 1°C- 2.08°C by 2050-2100 - **Rainfall:** A decrease of 15%-30%	- Water shortages - Reduced agricultural productivity - Reduced rangeland and fodder
12. Oman	Not submitted		

13. Qatar	Not submitted		
14. Saudi Arabia http://unfccc.int/resource/docs/natc/saunc1.pdf	- Water - Rangeland - Flora distribution	- **Temp:** Relative increase of up to 4°C for the period 2070 to 2100 in northern and southern parts of the Kingdom during summer - **Relative humidity:** A decrease in the relative humidity in the range of 1% to 2% in Tabuk and increase 2%-2.5% near Jeddah - **Rainfall:** During summer, a 15-20 mm decrease in western coast and northern regions near Tabuk—an increase is expected in the south. Northern and eastern regions will experience drought.	- Water shortages, increase soil salinity - Reduce the productivity of rangelands and change the areas amenable to livestock production - Change the species composition in favor of woody, less palatable, plants-Increase dust and fires.
15. Sudan http://unfccc.int/resource/docs/natc/sudnc1.pdf	- Water - Agriculture &forestry - Health	- **Temp:** Increase of 1.5°C to 3.1°C in August and 1.2°C to 1.1°C in January for the years 2060 - **Rainfall:** Decrease in rainfall at an average of 0.6 mm during the rainy season	- Reduced soil moisture, reduced crop productivity (up to 80% for sorghum and 50% for millet), shifting of the Gum Arabic belt southward and reduced productivity by 30% - Expansion of malaria geographically and temporally (during winter time)
16. Syria	Not submitted		
17. Tunisia	Not submitted		
18. United Arab Emirates http://unfccc.int/resource/docs/natc/arenc1.pdf	- Coastal zones - Water resources - Dryland ecosystems - Agricultural production - Human settlements - Public health - Energy infrastructure	- **Temp:** Annual average temperatures in 2050 are projected to be between about 1.6°C and 2.9°C warmer than they were over the period 1961-90, and between 2.3°C and 5.9°C warmer by 2100 - **Rainfall:** Is projected to be between 20% less or up to 10% more in 2050 than levels over the period 1961-90, and between 45% less or 22% more by 2100. - **SLR:** Global mean sea level is projected to rise by 9 cm to 88 cm between 1990 and 2100, with a central value of 48 cm, for the full range of SRES scenarios	- Severe shortage of water resources - Increasing soil and water salinity in some coastal aquifers through direct salt water intrusion - Salinization of soil and water used for irrigation would threaten agricultural and food production in the UAE and, in turn, the stability of these sectors of the economy
19. Yemen		- **Temp:** Increased temperatures - **Rainfall:** Changes in precipitation patterns and increased climatic variability - **SLR:** Increased sea levels	- Increased water scarcity and reduced water quality - Increased drought frequency, leading to degradation of agricultural lands, soils and terraces - Deterioration of habitats and biodiversity - Expansion of desertification - Reduced agricultural productivity leading to deterioration of wetlands, coastal mangrove migration, erosion, infrastructure damage, and seawater groundwater intrusion - Spread and growth of vector-borne and water borne diseases

Source: National Communications[6].

[6] http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php.

Annex 8: Vulnerability to climatic desiccation in the MENA region

Relative vulnerability according to various relevant indicators (scale of 1-3, 1 = highest): access to improved water source (IWS), population undernourished (FI), renewable water resources per capita (WR), water stress (WS), percentage of population in agriculture, Climate Vulnerability Index score (CVI), average score (Ave.), number of indicators with score of 1 indicating highest vulnerability (N)

Country	IWS	FI	WR	WS	% in ag	CVI	Ave	N
Yemen	1	1	1	1	1	1	1	6
Djibouti	1	1	1	n/a	3	2	1.6	3
Mauritania	1	2	3	n/a	1	2	1.8	2
Palestinian Territories	2	1	1	n/a	3	2	1.8	2
Tunisia	2	3	1	2	2	2	1.8	1
Jordan	3	2	1	1	3	2	2	2
Egypt	3	3	2	1	2	2	2.2	1
Morocco	2	2	2	3	2	2	2.2	0
Syria	2	3	1	2	2	3	2.2	1
Algeria	2	3	2	3	2	2	2.3	0
Iran	2	3	3	2	2	3	2.5	0
Lebanon	3	3	3	3	3	2	2.8	0
Iraq	n/a	n/a	3	n/a	3	n/a	3	0

Source: Brooks, N., 2009.

Annex 9: Climate change glossary[7]

Adaptation
The adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptive capacity
The ability of a system (e.g. ecosystem) to adapt to climate change, or other environmental disturbances. This may mean moderating potential damages, taking advantage of opportunities or coping with consequences. In discussions on global warming, adaptive capacity often refers to a country. In this case it is currently much lower in developing countries, due to poverty.

Anthropogenic climate change
Anthropogenic means "human made." So in the context of climate change, it refers to greenhouse gases or emissions that are produced as the result of human activities.

Biodiversity
Life in all its forms, essential to maintain functioning ecosystems that provide services essential for human survival and quality of life.

Climate
Climate refers to the average weather experienced in a region over a long period, typically at least 30 years. This includes temperature, wind and rainfall patterns.

Climate change risk
Additional risk to investments (such as buildings and infrastructure) and actions from potential climate change impacts.

Climate change impact
A specific change in a system caused by its exposure to climate change. Impacts may be harmful (impact) or beneficial (opportunity).

Climatic variability
The Earth's climate is not static, but varies on time scales of decades to millennia in response to interactions between the ocean and the atmosphere, changes in the Earth's orbit, fluctuations in energy from the sun and volcanic eruptions. Fluctuations in the Earth's climate are known as climatic variability.

Deforestation
Practices or processes that result in the conversion of forested lands for non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect, for two reasons: 1) the burning or decomposition of wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

Desertification
Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. The United Nations Convention to Combat Desertification (UNCCD) defines land degradation as a reduction or loss - in arid, semi-arid, and dry sub-humid areas - of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation. Conversion of forest to non-forest.

Drought
A period of abnormally dry weather long enough to cause serious shortages of water for agriculture and other needs in the affected area.

Ecosystem
Any natural unit or entity including living and non-living parts that interact to produce a stable system through cyclic exchange of materials.

El Niño
Translates from Spanish as 'the boy-child'. Peruvian fishermen originally used the term referring to the Christ child. This was used to describe the appearance, around Christmas, of a warm ocean current off the South American coast. Today, the term El Niño refers to the extensive warming of the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. In Australia, especially in the east, El Niño events are associated with an increased probability of dry conditions.

Emission scenario
A plausible representation of the future development of emissions of substances (e.g. greenhouse gases, aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development,

[7] http://climatechangeglossary.com/

technological change) and their key relationships. Concentration scenarios, derived from emission scenarios, are used as input into a climate model to compute climate projections.

Emissions
The release of a substance (usually a gas when referring to climate change) into the atmosphere.

Environment
The combination of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism (a living thing) or an ecological community (a collection of living things) and ultimately determine its form and survival. The circumstances, objects, and conditions that surround each of us.

Extreme weather events
An extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An extreme climate event is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. rainfall over a season).

Forest
Vegetation dominated by trees. Many definitions of the term forest are in use throughout the world, reflecting wide differences in bio-geophysical conditions, social structure, and economics.

Global Surface temperature
The global surface temperature is the area-weighted global average of (i) the sea-surface temperature over the oceans (i.e. the subsurface bulk temperature in the first few meters of the ocean), and (ii) the surface-air temperature over land at 1.5 m above the ground.

Global Warming
Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities.

Greenhouse Gas (GHG)
Any gas that absorbs infrared radiation into the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Gross Domestic Product
The value of all goods and services produced or consumed within a nation's borders.

Habitat
The place or environment where a plant or animal naturally or normally lives and grows.

Heat Stress
A variety of problems associated with very warm temperatures and high humidity. Heat exhaustion is a condition marked by weakness, nausea, dizziness, and profuse sweating that results from physical exertion in a hot environment. Heat stroke results from prolonged exposure to high temperature and is marked by cessation of sweating, extremely high body temperature, and collapse.

Inter-annual variability (IAV)
Climatic variations with periods of longer than 1 year and normally less than 10 years.

Intergovernmental Panel on Climate Change (IPCC)
The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

Kyoto Protocol
The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Third Session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change, in 1997 in Kyoto, Japan. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most OECD countries and countries with economies in transition) agreed to reduce their

anthropogenic greenhouse gas emissions (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) by at least 5% below 1990 levels in the commitment period 2008 to 2012.

Maladaptation
Action or investment that enhances vulnerability to climate change impacts rather than reducing them.

Mitigation
A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Mitigation of global warming
Actions to reduce or avoid greenhouse gas emissions (in order to avoid global warming).

Precipitation
Rain, hail, mist, sleet, snow or any other moisture that falls to the Earth.

Reforestation
Planting of forests on lands that have previously contained forests but that have been converted to some other use.

Renewable energy
Energy derived from the wind, the sun, the tides and other sources that, for all practical purposes, cannot be depleted (unlike fossil fuels, for example).

Resilience
The ability of a social or natural system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization and the capacity to adapt to stress and change.

Scenario (generic)
A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a "narrative storyline."

Sea level rise
Increasing temperatures result in sea level rise by the thermal expansion of water and through the addition of water to the oceans from the melting of continental ice sheets.

Soil moisture
Water stored in or at the land surface and available for evaporation.

System vulnerability
The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. This is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Thermal
Thermal properties are dependent on temperature; they are related to, or caused by, heat.

Thermal expansion
In connection with sea level, this refers to the increase in volume (and decrease in density) that result from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level.

Uncertainty
Is an expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement over what is known or even knowable. Uncertainty may arise from many sources, such as quantifiable errors in data, or uncertain projections of human behavior. Uncertainty can be represented by quantitative measures or by qualitative statements.

United Nations Framework Convention on Climate Change (UNFCCC)
The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention enjoys near universal membership, with 189 countries having ratified.

Under the Convention, governments:
* gather and share information on greenhouse gas emissions, national policies and best practices
* launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
* cooperate in preparing for adaptation to the impacts of climate change

The Convention entered into force on 21 March 1994.

Vulnerability
Is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Water Vapor
The most abundant greenhouse gas, it is the water present in the atmosphere in gaseous form. Water vapor is an important part of the natural greenhouse effect. While humans are not significantly increasing its concentration, it contributes to the enhanced greenhouse effect because the warming influence of greenhouse gases leads to a positive water vapor feedback. In addition to its role as a natural greenhouse gas, water vapor plays an important role in regulating the temperature of the planet because clouds form when excess water vapor in the atmosphere condenses to form ice and water droplets and precipitation.

Weather
Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The typical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that 'climate' is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard).