

Impact of Climate Change on Arab Countries

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I. INTRODUCTION

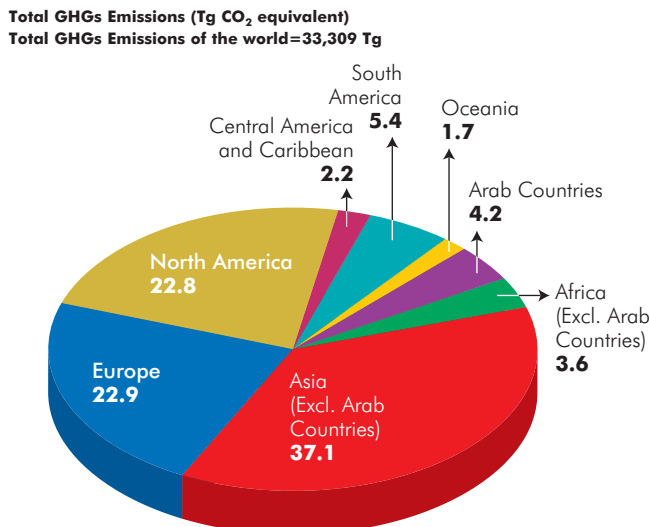
There is a widely-held scientific conviction that the global climate is changing as a result of the combined anthropogenic forcing due to greenhouse gases, aerosols, and land surface changes. Many pieces of evidence have concluded with a high degree of probability that human activities have exerted a substantial net warming influence on climate since 1750 (IPCC, 2007b). Recent climatological studies found that the global surface air temperature increased from 1850 to 2005 by 0.76°C. Moreover, the linear warming trend over the last 50 years is recorded by 0.13°C per decade (IPCC, 2007b). Furthermore, there has been an increase in the number of heat waves, a reduction in the frequency and duration of frosts, and an increase in extreme events frequency and intensity in many parts of the world. Regarding these global trends, the recent studies found that the Arab region experienced an uneven increase in surface air temperature ranging from 0.2 to 2.0°C that occurred from 1970 to 2004 (IPCC, 2007a).

For the next two decades, a warming of about 0.2°C per decade is projected for a range of IPCC SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected (IPCC, 2007b).



Physical and biological ecosystems on all continents and in most oceans have already been affected by recent climate changes (IPCC, 2007a). It is now generally accepted that this climate change is the result of increasing concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases (GHGs) in the atmosphere (IPCC, 2001a).

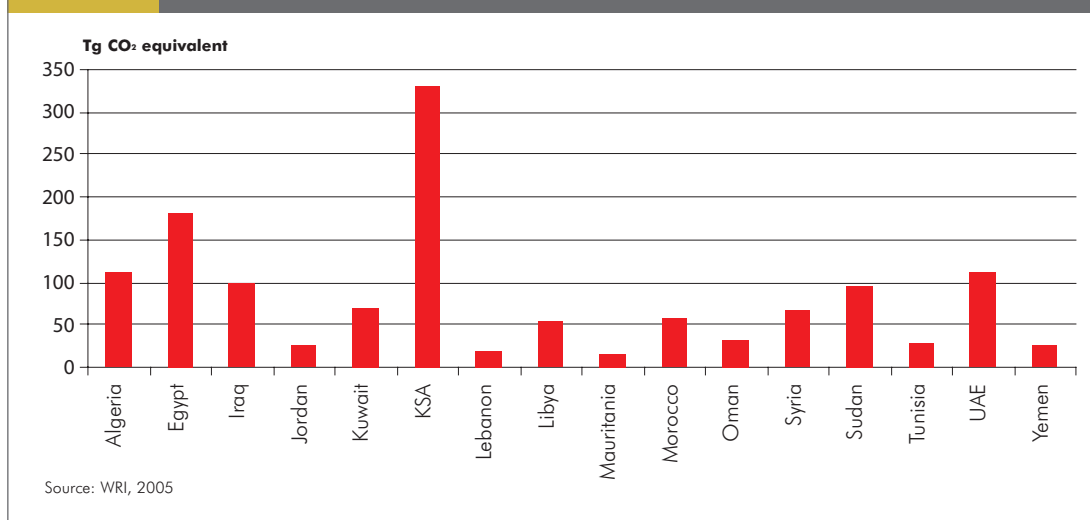
FIGURE 1 REGIONAL DISTRIBUTION OF GHGs EMISSIONS OF YEAR 2000



For the year 2000, the statistics showed that the world total GHGs emissions from all resources was about 33 thousand Tg (teragram) (Figure 1), with Arab countries contributing about 4.2% of these total world emissions (WRI, 2005). As presented in Figure 2, the Kingdom of Saudi Arabia (KSA) is contributing the highest percentage of the total GHGs emissions from the Arab countries, followed by Egypt and Algeria (WRI, 2005).

This relatively small contribution of GHGs of all Arab countries does not correspond to the projected impacts of climate change over the region. The Middle East and North Africa region is a vast zone of generally diverse climatic conditions, characterized by very low and highly variable annual rainfall and a high degree of aridity (FAO, 2002b). As shown in Figure 3, most of the Arab region lands are classified as hyper-arid, semi-arid and arid land zones (WRI, 2002). Most recent assessments have concluded that arid and semi-

FIGURE 2 GHGS EMISSIONS OF YEAR 2000 FROM ARAB COUNTRIES



arid regions are highly vulnerable to climate change (IPCC, 2007a; see also Chapter 7). Generally, the Arab countries are considered as developing countries and are highly vulnerable to climate change impacts due to their arid climates. If temperatures in the region get higher, or precipitation gets lower, pressure on natural and physical systems would be intensified.

According to modelling studies, the Arab region will face an increase of 2°C to 5.5°C in the surface temperature by the end of the 21st century. This increase will be coupled with a projected decrease in precipitation from 0 to 20%. These projected changes will lead to shorter winters, dryer and hotter summers, a higher rate of heat waves, a higher level of weather variability and a more frequent occurrence of extreme weather events.

The purpose of this chapter is to give a general overview of the studied impacts of the projected climatic changes in the Arab region, in order to address some key points in the way of adaptation and mitigation planning.

II. THE IMPACT OF SEA-LEVEL RISE

Sea level rise (SLR) is an important consequence of climate change and a serious global threat. It is very likely that 20th century global warming has contributed significantly to the observed sea level rise, through thermal expansion of sea water and widespread loss of land ice (IPCC, 2001b). The rate of the global sea level rise was observed to be

1.8 mm per year through the period of 1961-2003; it should be noted that the observed rate over 1993 to 2003 was markedly higher, at about 3.1 mm per year. The total 20th century rise is estimated to be 0.17 m (IPCC, 2007b).

The available scientific evidence has found that the continued growth of GHG emissions and associated global warming could lead to SLR of 1 to 3m in the 21st century, and an unexpectedly rapid break-up of the Greenland and West Antarctic ice sheets might produce a 5m SLR (IPCC, 2001b). However, there are uncertainties in the estimates of SLR in the longer run (IPCC, 2007b).

The nature of the impacts of sea level rise will vary from place-to-place and country-to-country. This is due to a variety of factors, depending on local conditions such as elevation of the land and currently occurring geological land subsidence, reflecting that certain settings are more vulnera-

FIGURE 3 ARIDITY ZONES OF THE WORLD

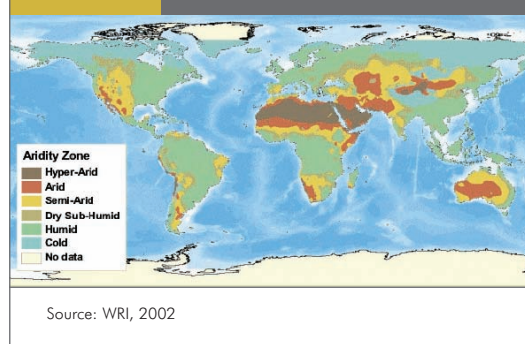
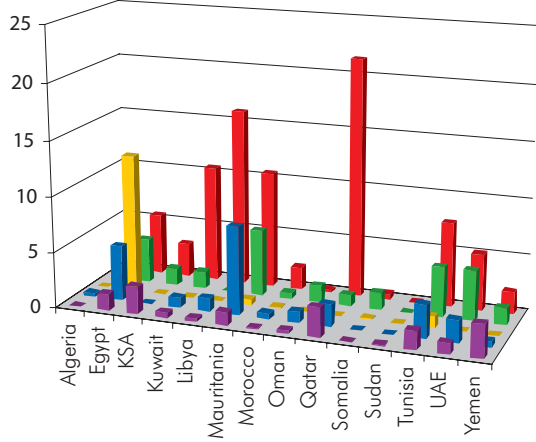
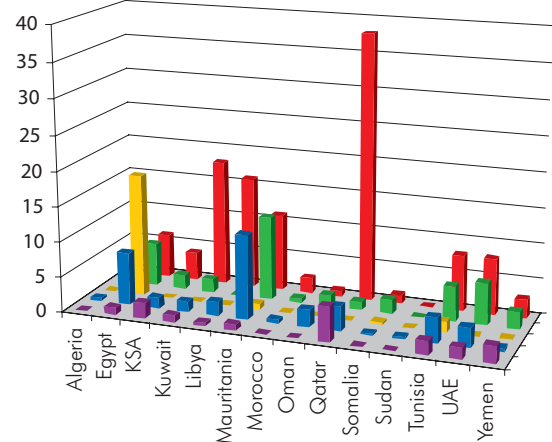


FIGURE 4 THE IMPACT (%) OF SLR ON COUNTRY AREA, GDP, AGRICULTURE EXTENT, URBAN EXTENT, AND WETLANDS EXTENT IN ARAB COUNTRIES, UNDER FIVE SCENARIOS OF SLR OF 1, 2, 3, 4 AND 5M

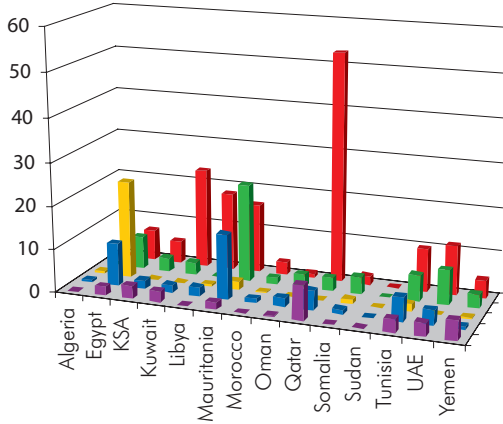
SLR 1m



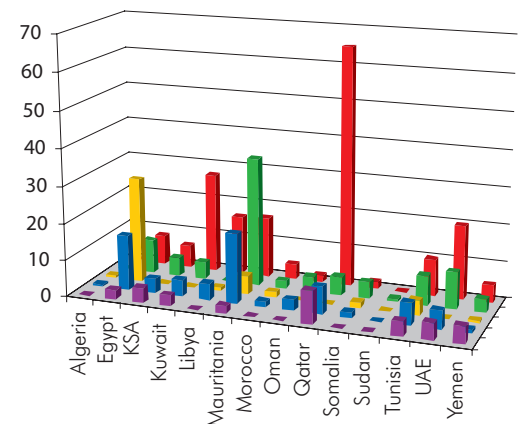
SLR 2m



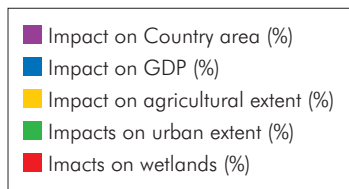
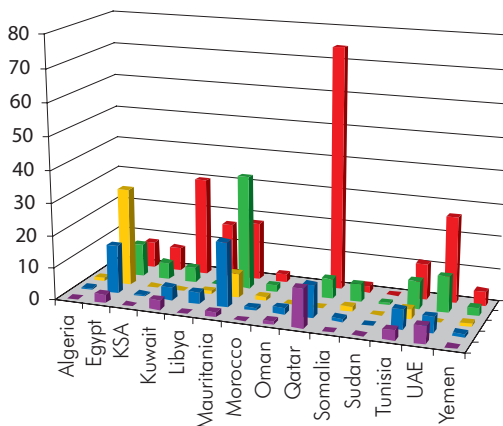
SLR 3m



SLR 4m

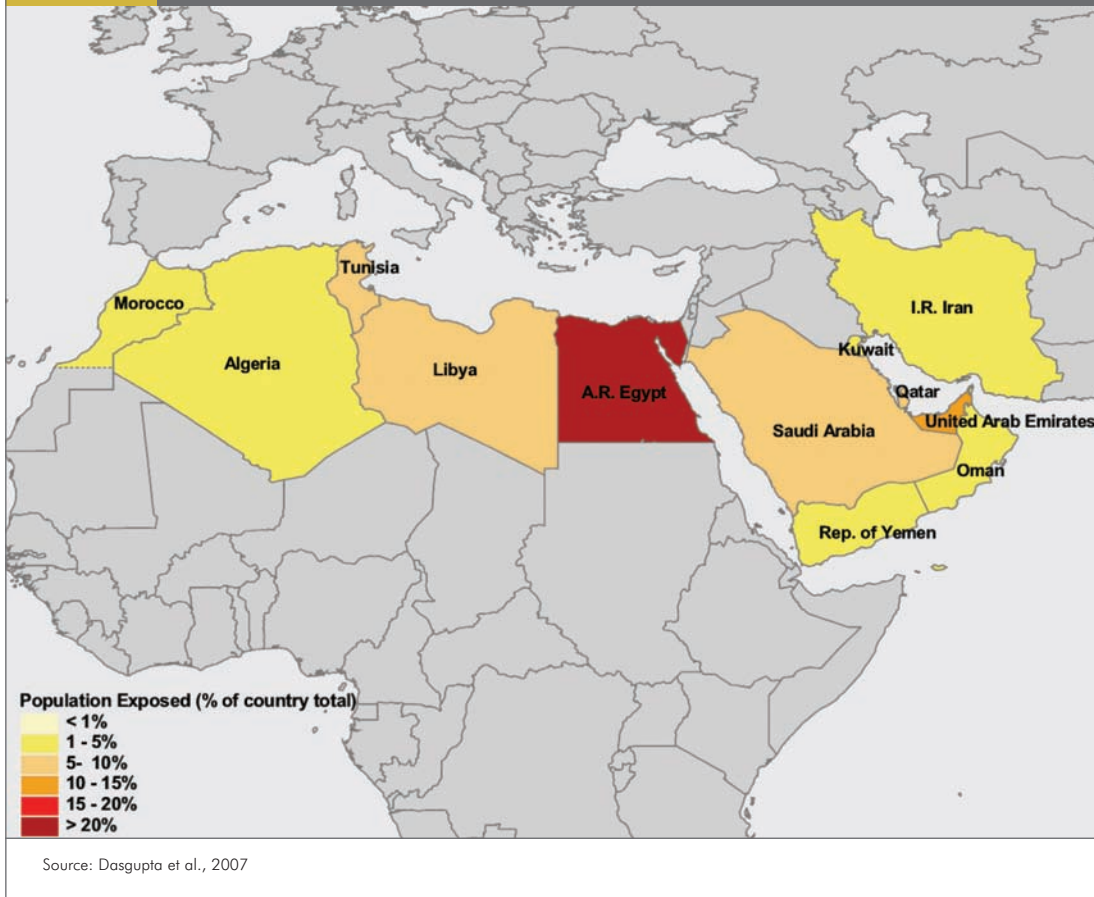


SLR 5m



Source: Dasgupta et al., 2007

FIGURE 5

**MIDDLE EAST AND NORTH AFRICA REGION,
EXPOSED POPULATION TO THE NEGATIVE IMPACTS OF 5M SLR**


ble than others. Socioeconomic factors, including human response to climate change, are also considered (Neumann et al., 2000). River deltas, low-lying coastal urban areas, and small islands have the highest exposure of key human vulnerabilities to climate change and sea-level rise (Nicholls, 2004).

Egypt is one of the highly vulnerable countries to the impacts of SLR. A 1m SLR would affect 6 million people in Egypt, where under this scenario 12 to 15% of agricultural land in the Nile Delta region would be lost. The high-risk areas in Egypt include parts of Alexandria, Behaira, Port Said, Damietta and the Suez governorate. If no protective measures were to be taken, or a business-as-usual scenario to prevail, the agriculture sector would be severely negatively affected (a loss of over 90% of the total area of the governorates under risk), followed by the industrial sector (loss of 65%), and the tourism sector (loss of 55%) due to SLR of 0.5m.

The impact of SLR on the Arab countries is studied in a recent assessment by the World Bank (Dasgupta *et al.*, 2007). This study examined the impact of SLR, of 1, 2, 3, 4 and 5m, on country area, population, GDP, agricultural extent, urban extent, and wetlands (Figures 4 and 5). The results of the study indicated that Qatar's land area would experience a significant reduction of about 2.6 to 13% due to 1m and 5m rises, respectively. Dasgupta et al. found that with an SLR of 1m, approximately 10% of Egypt's population would be directly impacted, with the strongest impact being in the Nile Delta; it reaches a loss of 20% with a 5m SLR. In the United Arab Emirates and Tunisia, a SLR of 1m would impact about 5% of the population.

The study by Dasgupta et al. also covered the projected impact of SLR on the GDP and agricultural sector, finding that Egypt's GDP would also be significantly impacted by SLR. The study partially attributes this negative impact on



GDP by pointing to the direct impact of SLR on agricultural production in Egypt; in fact, in the Arab region, Egypt's agricultural sector is most vulnerable to SLR. A 1m SLR would impact approximately 12.5% of Egypt's agricultural output, with the percentage rising to 35% with a 5m SLR.

Abd-El Wahab (2005) emphasized that the projected impact of SLR on agricultural lands in Egypt could be intensified by 80 to 120% due to land subsidence and ground water rise. Urban areas of the Arab region would also be significantly impacted; in Egypt, Libya, the United Arab Emirates, and Tunisia, the impact reaches approximately 5% with a 1m SLR, 6 to 7% with a 2m SLR, and approximately 10% with a 5m SLR. The wetlands of Qatar, and to lesser extent Kuwait, Libya, and United Emirates would be significantly impacted by SLR.

The results of the previous studies are presented with high degrees of uncertainties, and there is no continuous monitoring for the sea level in the threatened spots. Therefore, there is no way of assessing the real magnitude of the impact and the suggestion of adaptation measures required.

III. THE IMPACT ON FRESHWATER SOURCES

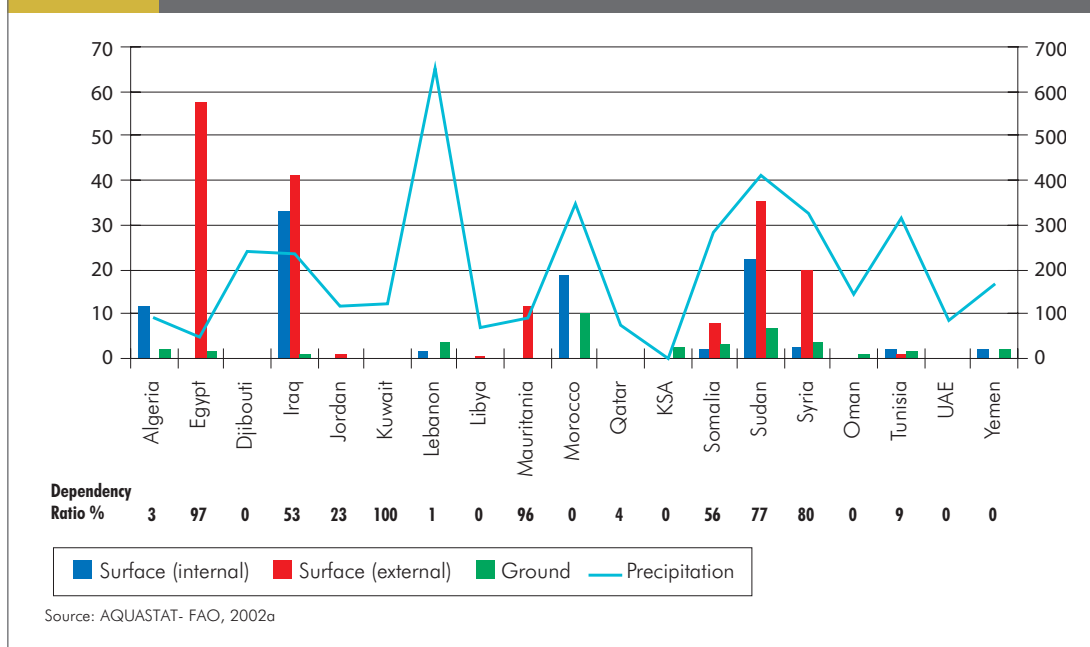
As stated earlier, most of the Arab countries are located in arid and semi-arid regions that are characterized by low and limited water resources and high evaporation. Total water resources are defined as an aggregation of total renewable ground water, internal surface water resources, and external surface water resources. The higher the "external surface water resources" percentage of "total renewable water resources," the higher the "dependency ratio" (%) and the lower the water-security. The "dependency ratio" (%) is the part of the total renewable water resources originating outside the country (FAO, 2003); a high dependency ratio thus implies a degree of external vulnerability (see also Chapter 5).

Iraq, Sudan and Egypt have the highest annual water resources between the Arab countries of 75, 65 and 58 billion m³/year, respectively. Nonetheless, since more than 50% of their surface resources are external, more pressures are generated on their water situation. Figure 6 shows that Algeria, Lebanon, Mauritania, Morocco, Somalia, Syria, Tunisia and Yemen fall in the second category of total water resources between 5 to 30 billion m³/year. The rest of Arab countries are the worst endowed with water resources of less than 5 billion m³/year.

Total annual groundwater resources in the Arab region are about 35 billion m³, and more than 50% of the water in the Arab Peninsula is ground water. Annual average precipitation is varied along the Arab region. In Lebanon and Syria the average annual amounts of precipitation are 600 and 300 mm/year, respectively. This rate decreases gradually to be 300 mm/year by moving to northern and eastern parts of Mediterranean coast of Morocco and Tunisia. The average annual precipitation reaches 130 mm/year over North African countries and the Arab Peninsula, while the average annual precipitation over the rest of the Arab countries is about 290 mm/year.

Kuwait has the poorest water resources in the Arab region with average precipitation of 121 mm/year, total annual water of 0.02 billion m³/year and a 100% dependency ratio. Egypt has the second lowest annual precipitation in the region. The overall situations of Egyptian, Mauritanian,

FIGURE 6 RENEWABLE WATER RESOURCES OF THE ARAB COUNTRIES



Syrian and Sudanese water resources are very vulnerable, because they have high dependency ratios in the region of 97, 96, 80 and 77%, respectively, in addition to their limited total renewable water resources.

“Annual water resources per capita” is an important measure of national water situations. All Arab countries can be classified as vulnerable in this regard, except Iraq that has water resources of more than 2,900 m³/capita/year. Syria is currently facing water stress (1,000 to 1,500 m³/capita/year), while the rest of the Arab countries are facing water scarcity (less than 1,000 m³/capita/year).

The water situation in the Arab region is threatened by both environmental and socio-economic pressures. Many negative impacts of climate change on freshwater systems have been observed in recent studies. These impacts are mainly due to the observed and projected increases in temperature, evaporation, sea level and precipitation variability (IPCC, 2007a). Many arid and semi-arid areas will experience a decrease in water resources due to climate change.

Generally, by the end of the 21st century, the flow of high latitude rivers is projected to increase, while those from major rivers in the Middle East, Europe and Central America tend to decrease.

However, the magnitude of change is highly uncertain (Arnell, 2004). Moreover, sea-level rise will extend the area of saline groundwater, resulting in a decrease in freshwater availability for humans and ecosystems in coastal areas (Bobba, *et al.*, 2000). In addition, groundwater recharge will decrease considerably in some already water-stressed regions (Doll and Florke, 2005).

As a direct consequence of climate change, and given the current rapid trends of population increases, FAO projections show that Algeria, Egypt, Morocco, Syria and Tunisia are expected to experience severe water shortages by 2050, and only Iraq is expected to be in a relatively better situation (FAO, 2002b). Typically, heavy reliance on surface and groundwater prevails in all countries of the region, with 60–90 percent of water being used for agriculture. All over the region, water demand is steadily increasing while water supply is steadily decreasing.

The shortage of water resources is aggravated by water accessibility factors. Water quality, watershed conditions, infrastructure, and policy and conflicts are nearing the top of the priority list of water accessibility strategies in the Arab region. Currently, the quality of water resources in the Arab region is affected by pollution, urbanization, floods and over use of water resources. Climate change is projected to increase salinity

levels of lakes and ground water as a result of increased temperature (Haas, 2002). Moreover, higher pollutant concentrations in rivers, increased ground water contamination, and increased leaching of agricultural chemicals into groundwater are projected as a result of changes of runoff in catchments (IUCN, 2003). Watersheds are now facing frequent drought coupled with sudden intense rainfall events that cause serious soil erosion and desertification. Under climate change conditions, watershed degradation and desertification processes would intensify (Haas, 2002).

Haas (2002) projected first order impacts of climate change on Mediterranean hydrological systems as wetter winters and dryer summers, hotter summers and heat waves, and more variability and extreme weather events take their toll. These impacts may induce an increase in evaporation (E) from natural and artificial water bodies and soils that reduce the available water supply. Additionally, it will increase evapotranspiration (ET_o) from crops and natural vegetation. Attaher *et al.* (2006) carried out a case study of Egypt to investigate the impact of climatic changes on ET_o based on air temperature changes according to different scenarios. The study indicated that projected future climatic changes will increase the potential irrigation demand of Egypt by 6-16% due to the increase in ET_o by the 2100s.

IV. THE IMPACT OF INCREASING DROUGHT

Drought is one of the serious water related disasters threatening the Arab region for both current and future time scales. From a climatic point of view, drought can be defined as a “temporary reduction in water or moisture availability significantly below the normal or expected amount for specified period.” From the hydrological point of view, drought is “a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance, carrying connotation for moisture deficiency with respect to man’s usage of water” (Rossi, 2001).

Droughts affect rain-fed agricultural production as well as water supply for domestic, industrial, and agricultural purposes. Some semi-arid and sub-humid regions of the globe have suffered from more

intense and multi-annual droughts, highlighting the vulnerability of these regions to the increased drought occurrence that is expected in the future due to climate change (Nicholson, 2005).

Drought frequency increased during the last 20-40 years in Morocco, Tunisia, Algeria and Syria, and changed in Morocco from an average of 1 year of drought in every 5 year period, before 1990, to 1 year drought for each 2 year period (Karrou, 2002. Abbas, 2002. Mougou and Mansour, 2005). In Lebanon, varying conditions of water shortage (regarding the availability of the hydraulic resources) have been experienced in the last decade (Karam, 2002).

In Morocco, of the twenty-two drought years in the twentieth century, ten occurred during the last two decades and included the three successive dry years of 1999, 2000 and 2001. Drought is also a recurring event in the Near East. Jordan, for example, is predominantly arid and has experienced chronic water shortages and has suffered from severe shortages since the 1960s. The recent droughts in Jordan and Syria were the worst ever recorded in recent decades (FAO, 2002b).

A warmer climate, with its increased climate variability, will increase the risk of both floods and droughts (Wetherald and Manabe, 2002). Drought-affected areas will probably increase, and extreme precipitation events, which are likely to increase in frequency and intensity, will augment flood risk. Increased frequency and severity of floods and droughts will also have implications for sustainable development (IPCC, 2007a). Water shortage is already the main constraint in most countries of the region, and IPCC model simulations indicate that water scarcity may worsen substantially as a result of future changes in climatic patterns.

V. SCIENTIFIC RESEARCH, MITIGATION AND ADAPTATION MEASURES

Although climate change is projected to have serious impacts on natural and human systems in the Arab region, only modest efforts and steps are taken in scientific research related to mitigation and adaptation.

The scientific community in most Arab countries still harbours many suspicions regarding climate



change phenomena, and remains hesitant to acknowledge the risks. Climate change studies are based in most cases on using modelling, remote sensing and projection techniques, but, due to the lack of facilities and low allocated funds for the Arab research institutions, the empirical and experimental techniques are still applied in Arab countries.

As a result of this, a small and scattered number of research studies were published in the field of climate change, and there are many gaps that still need to be filled in the future, especially pertaining to the vulnerability of water resources, agriculture, and health sectors.

Few and limited studies on mitigation and adaptation are developed in the Arab countries. In Morocco, a drought insurance program based on rainfall contracts is an important example of adaptation strategies, and it had a potentially significant benefit over the current scheme, minimizing drought hazard and protected the cereals production (IUCN, 2003). Shoreline protection along the northern coast of Egypt is another obvious example of an adaptation strategy (El-Raey, 1999).

VI. CONCLUSION AND RECOMMENDATIONS

Integrating climate change mitigation and adaptation in development strategies and poli-

cies strengthens these strategies and increases their efficiency. The following considerations could be included to encourage and enhance the planning of adaptation and mitigation strategies under Arab countries' conditions:

- Improving the scientific capacity in the various fields related to climate change should be a top priority.
- Ensuring political and financial support for the implementation of adaptation strategies.
- Applying the bottom up approach of planning and implementing adaptation and mitigation strategies.
- Developing community-based measures by stakeholders' involvement in adaptation planning, and improving the adaptive capacity of the different sectors of the society.
- Increasing public awareness of the impacts of climate change on the environment and human health. Public awareness activities should cover the following:
 - Clarify and explain the scientific facts and terms to improve the vision of stakeholders and to reduce the communication gaps between researchers and stakeholders.
 - Simplify the scientific message to match background level, education level, knowledge level, experiences, and role of stakeholders.
 - Indicate the best sources of information available.

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