AGIR

THE ARAB GEOGRAPHICAL INFORMATION ROOM

League of Arab States - Arab Water Council

Geographical Information towards Building Risk Resilience in the Arab Region

(Water, Food and Social Vulnerability Nexus)

August 2019 - TR No.1

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المجلس العربي للمياه

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List of Abbreviations	
ADC	Agriculture Drought Consecutive
ADF	Agriculture Drought Frequency
ADH	Agricultural Drought Hazard
ADI	Agriculture Drought Intensity
ADV	Agriculture Drought Variability
AGIR	Arab Geographical Information Room
AI	Aridity Index
AWC	Arab Water Council
BCM	Billion Cubic Meters
CC	Climate Change
CCA	Climate Change Adaptation
CLD	Cloud Cover
CRN	Climate Risk Nexus
CRNI	Climate Risk Nexus Initiative
CRU	Climate Research Unit
DRR	Disaster Risk Reduction
DTR	Diurnal Temperature Range
ESA	European Space Agency
FAO	Food and Agricultural Organization
FRS	Frost Day Frequency
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GLC	Global Land Cover
HICs	High Income Countries
IPCC	Intergovernmental Panel on Climate Change
JJA	June-July-August
Km	Kilometres
LAS	League of Arab States

LD	Land Degradation
LICs	Low Income Countries
MICs	Medium Income Countries
MIS	Management Information Systems
mm	millimetres
P	Annual Precipitation
PET	Potential Evapotranspiration
Pre	Monthly total precipitation
RCP	Representative Concentration Pathway
S&T	Science and Technology
SDG	Sustainable Development Goals
SPEI	Standardized Precipitation-Evapotranspiration Index
TMN	Monthly average daily minimum temperature
TMP	Daily mean temperature
TMX	Monthly average daily maximum temperature
TS	Time Series
UAE	United Arab Emirates
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
US$	United States Dollars
USD	United States Dollars
VAP	Vapour Pressure
WET	Wet day frequency

ACKNOWLEDGEMENT

This report was prepared under the framework of the League of the Arab States/ Climate Risk Nexus Initiative (LAS/CRNI) addressing water scarcity, social vulnerability, climate change and food security in the Arab Region. The preparation of this report was led by the team of the Arab Geographical Information Room (AGIR), established in 2015 and hosted by the Arab Water Council (AWC).

This report was developed based on the Climate Impact Assessment work prepared by the AGIR-Team headed by Prof. Wadid Erian, Professor of Soil Science at Cairo University; with the intention to provide more understanding on how emerging climate-related risks interact with structural challenges in the Arab Region.

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EXECUTIVE SUMMARY

Climate Change is Real and is Hitting the Arab Region

The Arab region is the most water-scarce and food-import dependent region in the world. Due to recent conflict and political instability, it is also home to the largest population of refugees and displaced people. Climate change (CC) is expected to exacerbate conditions and factors in the region which will make these challenges harder to resolve.

The situation is particularly severe for vulnerable communities that are already struggling due to food and water insecurity. Unless assisted, these communities likely will not be able to cope with a scenario where growing and accessing food, and ensuring sufficient water for production and consumption, is ever more difficult.

This projected negative impact of CC on agriculture is occurring rapidly. In Syria, prior to the current armed conflict, the crop production decline already exceeded the projected CC impacts on food production that was estimated by Intergovernmental Panel on Climate Change (IPCC) for the period 2030–2049 by more than 25%. In Egypt in 2009, and due to water deficit, many people migrated in large numbers into the metropolis of Cairo from the Nile Delta, one of the world's most populated, fertile areas, responsible for 63% of Egypt's agriculture. They were driven by unemployment and poverty, as a result of shortage in water which affected their land production and consequently their income from farming. Even before the current conflict in Yemen, the two million residents of Sana'a, Yemen's capital, couldn't rely on supplies of piped city water for more than once a week at best. Otherwise, those who could afford it had to buy it. Caused by problems of urbanization combined with the increased intensity in precipitation, Jeddah City (Saudi Arabia) witnessed several flash flood disasters in 2009 and 2011. The floods caused several fatalities and considerable losses at the social, psychological, economic, health, and environmental levels.

In light of the above, achieving the vision of both the League of Arab States (LAS) and member states to succeed in making development sustainable, requires a deep appreciation of climate, and disaster trends, Land degradation, dryland expansion, food and water insecurity, as well as increased levels of social vulnerability. An important gap likewise exists in the use of generated data, information and knowledge for decision-making processes, and development policies and practices.

Building regional and local geo-information include databases on:

Agriculture (Crop type mapping, precision farming, soil types and conditions); Water resources (Watershed delineation and management, water quantity, quality and productivity); Environmental status (environmental assessments, climate change analysis, surface and groundwater contamination); Forestry (Timber management, deforestation analysis, forest resource inventory); Socio-economic Vulnerability indicators; Migration patterns and trends and Human development

The Arab Geographical Information Room (AGIR) supported by the Climate-Risk Nexus initiative was established in 2015, hosted by the Arab Water Council (AWC) to address the information and analytical gaps to better inform decision-makers in the region. AGIR activities focus on better characterization of hazards, vulnerabilities and exposure for policy, programme and monitoring purposes. Increased synergies between data sets are sought, as well as enhanced quality and uptake of climate impact and disaster loss databases for proactive preventive measures and as a foundation for decision-making.

This report on “Geographical Information towards Building Resilience in the Arab Region (Water, Food and Social Vulnerability Nexus)” seeks to provide more understanding on how emerging climate-related risks interact with structural challenges. It utilizes satellite imagery and Geographic Information Systems (GIS) maps for land cover, Potential Evapotranspiration (PET), precipitation and weather conditions to provide regional analysis for climate change patterns and hydro-meteorological risks in the Arab Region. The report also highlights the need for promoting inter-disciplinary actions that can help improve the role of science and technology in decision-making.

It utilizes satellite imagery and Geographic Information Systems (GIS) maps for land cover, Potential Evapotranspiration (PET), precipitation, weather conditions to provide regional analysis for climate change patterns and hydro-meteorological risks in the Arab Region.

Climate Change Patterns & Hydro-Metrological Risks in the Arab Region (1961-2015)

Temperatures warming of about 0.2°C per decade have been observed in the region for the period 1961–1990. The highest warming rates are expected to take place close to the Mediterranean coast. According to the latest results performed by AGIR, temperature is also increasing in Sahara “The Great Desert”, steppe areas and Sudan by 1.6 to 2.6°C. While in general “summer months June-July-August (JJA)” reflected higher level of increase by at least 0.5°C from the mean. The analyzed data provide evidence for significant warming trends throughout the entire Arab region, reflected generally in more and stronger warm extremes and fewer and weaker cold extremes.

Similarly, AGIR Evapotranspiration results, showed an increase by 50 to 120 mm in Sudan, Upper Egypt, Tunisia and parts of Palestine and Morocco, and an increase by 20 to 60 mm in Arab Mashreq and some areas in Algeria and eastern parts of Arabian Peninsula. Meanwhile, a slight increase of 10-30 mm was observed in the rest of the region. Only a small part of Atlas Mountains is showing a decline of 10 to 45 mm.

Moreover, rainfall is declining annually in the Arab Mashreq countries by around 25-75 mm, while increasing in all other areas in Arab Maghreb, relatively by around 25–50 mm, mainly in Atlas Mountain areas. At the mean time rainfall is increasing in Sudan (25–75 mm) and in southern west corner of Arabian Peninsula and south Egypt by around 25 mm annually.

Rainfall variability in the Mediterranean reflected in high vegetation green cover observed during the months of January and February in most rainfed areas except for some parts where it extends till March. Yet in Somalia a shorter season is shown. In Monsoon areas the highest vegetation green cover is observed during July and August.

The obtained results provide evidence of significant changes in the occurrence of climate extremes during the past five decades. There are consistent warming trends across the region. Significant warming trends are also found in the absolute temperature values. The changes in the precipitation-based indices are generally less significant and spatially inconsistent. Consequently, this large increase in the heat-waves combined with warmer average temperatures will put intense pressure on already scarce water resources with major consequences on regional water and food security. Crop yields could decrease by up to 30% at 1.5–2°C and by almost 60% at 3–4°C. At the same time, migration and climate-related pressure on resources might increase the risk of conflict, putting food, water and energy security at risk.

Land Degradation Impacts on Agriculture and Vegetation Cover

Land degradation in the Arab Region is widespread and is proceeding at accelerating rates. Failures of resource management policies are aggravated by overgrazing, overexploitation of water and land resources, over-cultivation of marginal lands, deforestation, and the use of inappropriate technologies. Natural resource degradation, especially where agriculture is practised, is a real threat in all countries of the region and remains a major limitation to achievement of food security.

With seventy percent of agricultural production in the Arab region being rainfed, the sector is highly vulnerable to temperature and precipitation changes and the associated potential consequences for food, social security and rural livelihoods. The strongest crop reductions are expected for legumes and maize as they are grown during the summer period. 43% of the Arab region population lives in rural areas and poor rural farmers are particularly vulnerable to hunger and malnutrition as a direct consequence of yield loss and high food prices. The present risk is approaching medium, but in the near term (2030–2040) will come to above medium, and due to the increased demand in the future will be growing to become very high.

In total for all Arab countries, about 67.28 million hectares of Vegetation Cover (rainfed, rangeland, and forest), that value 11.51 billion US$, are lost in ≈ 10 to 12 years. This will leave 22.79 million workers jobless and are in need of about 59 billion US$ for the creation of alternative job opportunities. Countries of relatively larger losses in the Arab Region are provided in (Case Study 1 - Table 3) .

Climate Change, Poverty and Human Security

Climate change threatens human security as it undermines livelihoods, compromises culture and individual dignity. Situations of acute insecurity, such as famine, conflict, and socio-political instability, almost always emerge from the interaction of multiple factors. For many populations that are already socially marginalized, resource-dependent, and have limited capital assets, human security will be progressively undermined with climate change.

Climate variability or climate change is popularly reported to be significant causes for the conflict in Darfur region that began in 2003

Conflicts directly related to Climate Change impacts include drought, vegetation losses, ecosystem deterioration, limited economic development and inadequate provision of public services and social protection. Other factors contributed to the conflict were poor governance and policy failures, political instability, corruption and misuse of official development funds.

Mazo, J., 2009: Climate change and security. The Adelphi Papers, 49(409), 73-86.

Poverty, discrimination of many kinds, and extreme natural and technological disasters undermine human security. Over the next century, climate variability will increase and the Arab countries will experience unprecedented climate extremes resulting in higher rates of poverty and unemployment percentage that will reduce the quality of life, cause socio-economic disturbance and increase food insecurity.

In Syria and during the year 2008, about 1.3 million people (6% of the total population), were severely affected by drought, of which 800,000 have lost almost all their livelihoods and faced extreme hardship as a result of a severe reduction in rainfall and increase in potential-evapotranspiration. The situation exacerbated with the armed conflict in the country which resulted in further displacement and migration undermining the national and regional stability.

Pathways for Building Climate-Resilience in the Arab Region

Facing these multiple challenges within the domain of the climate-poverty-development nexus, decision-makers in the Arab region should increasingly focus on the root causes of poverty, inequality, and climate change. Development pathways should be shifted towards greater social and environmental sustainability, equity, resilience, and justice. Based on trends of climatic hazards in the Arab region, the existing institutional capacity, the on-going engagements in Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR), and the gaps identified, the following are recommended:

The focus should be on policies and actions that prioritize prevention of future risk accumulation and the exacerbating factors to underlying social tensions and challenges in the Arab region.

Tunisia has set an example by including the protection of the environment in its new constitution.

Morocco has made adapting to climate change and setting the country on a path to green growth a national priority. The Maroc Plan Vert is focused on sustainable water and land management, along with agricultural adaptation.

- Policy-makers should address the severe implications of climate variability, especially for the most vulnerable groups in society, such as resource-poor, small-scale farmers and poorer households. Their needs must be considered and addressed explicitly while designing the national development policies and strategies.
- There is a need for political commitment, including appropriate governmental entities and strong scientific institutions, for integrating drought risk issues into sustainable development and disaster risk reduction processes.
- The sustainability of development and resilience of people, nations and the environment depend on sound risk management, which needs planning and investments that go beyond the reduction of existing risk and includes the prevention of new risk accumulation.
- Adaption along with mitigation measures will be essential to build up the resilience needed to cope with the changes ahead and to lessen the effects for those whose lives will be radically altered.
- Insurance programs, social protection measures, and disaster risk management may enhance long-term livelihood resilience among poor and marginalized people, if policies address poverty and multi-dimensional inequalities.
- A fundamental shift towards near- and long-term climate-resilient development pathways would require vibrant policies to assess social vulnerabilities and provide development responses that can reduce disaster risks.
- The availability of open-source and open-access science-based risk information and knowledge platforms is instrumental for conducting cost-benefit analysis, transparent transactions, developing proper vulnerability indicators, and the development of partnerships with stakeholders towards building sustainable development policies and actions.
- More investment in research is needed to develop smart, climate-resistant agriculture and water management practices and to further explore CC interrelation with migration, displacement and human mobility. At the same time, economic diversification is essential to help vulnerable populations develop new revenues.
- Finally, the increasingly trans-boundary and global characteristic of risk drivers requires further cooperative efforts in their assessment, joint management and benefit-sharing.

Introduction

This report on “Geographical Information towards Building Resilience in the Arab Region (Water, Food and Social Vulnerability Nexus)” covers a large range of topics focusing on climate change as a challenge in managing and reducing risks. It emphasizes the inter-connectedness of climate change with risk, thus highlighting the importance of understanding the multi-stressors of the risks of climate change which can open doors to new insights and approaches for solutions. The report also contributes to increasing knowledge towards a deeper assessment in several climate change areas including risk, resilience and nexus.

1. Climate Change is Real and is Hitting the Arab Region

1.1 Background

Climate change is arguably the greatest challenge facing mankind in the twenty-first century. Its importance has been recognized in recent reports from the IPCC and the United Nations Framework Convention on Climate Change (UNFCCC), and the overwhelming economic consequences are set out in the Stern Report.

Impacts of climate change are experienced in the day-to-day realities in the Arab Region, spreading desertification, devastating flash floods and prolonged droughts. The Arab region is the most water-scarce and food-import dependent region in the world. The Arab region has the lowest freshwater resource endowment in the world. All but four Arab countries (Egypt, Iraq, Saudi Arabia, and Sudan) suffer from “chronic water scarcity,” and over half of the countries fall below the “absolute water scarcity” threshold (Verner, Dorte, ed. 2012). Thus, in 2015, the Arab countries imported 128.4 Million Metric Tons of agricultural food and livestock products with a value of 70.7 Billion USD and with an equivalent of 288 BCM of virtual water embedded in these food products.

In light of the above, climate change is expected to disrupt reconstruction and development pathways and act as a risk multiplier to social instability, fragility and conflict in many parts of the region. Both growing risks to food security in the natural sphere (i.e. drought, ground water scarcity, crop disease) and the social sphere (i.e. social instability, inflation, food price spikes) are being exacerbated by rising temperatures, increased climate variability and extreme events. Moreover, model results used in IPCC’s Assessment Report 5 indicate that food production may decline by up to 20% as the signal from climate change amplifies by 2050 and beyond. For the Arab Region, projections suggest that the rate of increase in agricultural production will slow over the next few decades, and it may start to decline after 2050 (Verner, Dorte, ed. 2012).

Even before the current conflict in Yemen, the two million residents of Sana’a, Yemen’s capital, could rely on supplies of piped city water only once a week at best. Otherwise, those that could afford it had to buy it.

In Egypt, by 2009, many people had migrated into the metropolis of Cairo from the Nile Delta, one of the world’s most populated, fertile areas, responsible for 63% of Egypt’s agriculture. They were driven by unemployment and poverty, the result of too little water for everyone to rely on income from farming.

Additionally, political unrest has affected water infrastructure and the ability for meeting the Arab region’s developmental goals particularly in water and agriculture sectors in several countries in the region such as Syria, Libya and others, including the repercussion of the war in Iraq. Due to recent conflict and political instability, it is also home to the largest population of refugees and displaced people. Climate change is expected to exacerbate conditions and factors in the region which will make these challenges harder to resolve.

1.2 Climate multi Dimensional Risks & Potential Responses

Climate Change increases the risk of social instability and poverty. The situation is particularly severe for vulnerable communities in the region that are already struggling with food and water insecurity. Unless assisted, these communities will likely not be able to cope in a scenario where growing and accessing food, and ensuring sufficient water for production and consumption, is ever more difficult. Some countries in the region may face the threat of decades of development progress being rolled-back and situations of vulnerability and poverty becoming entrenched.

Climate-related risks are now evolving over time due to both climate change and development, which increased the needs for shifting to risk management aiming at creating a foundation for assessing future climate-related risks and potential responses. Responding to climate-related risks involves decision-making with continuing uncertainty about the severity and timing of climate-change impacts and which limits the effectiveness of the adaptation actions. Iterative risk management is a useful framework for decision-making in complex situations characterized by large potential consequences, persistent uncertainties, long timeframes, potential for learning, and multiple climatic and non-climatic influences changing over time.

It is increasingly clear that if development is not risk-informed, it is not sustainable, taking into consideration that national development policy needs to be re-thought. Investments in risk and resilience should represent an important part of development cooperation in our ever-more complex and inter-connected region.

Achieving the vision of both LAS and member states to succeed in making development sustainable requires a deep appreciation of climate and disaster trends, dryland and land degradation expansion, food and water insecurity, as well as increased levels of social vulnerability. Development challenges in the region also include a lack of a strong 'Arab region profile' that helps understand the nature of converging multi-dimensional risks and the implications for development and crisis recovery efforts. An important gap likewise exists in the use of science for decision-making processes, with development policies and practices often not aligned to the actual contextual analysis and needs that arise from accurate science and data generation.

In Algeria, **20 drought events** during the period (2013-2015) have been reported, while 2 drought events have occurred in Sudan. 96 flood events have occurred during the period (2013-2015) in the Arab region. 10 floods are reported for each of Somalia and Sudan resulting in an estimated economic loss of 0.43% and 0.08% of the national GPD in both countries and casualties of 169 and 135 human life losses, respectively.

Jeddah City Disaster in 2009 & 2011: Recently it has become clear that Saudi Arabia is located in new climatic trends, represented mainly by torrential rains. Jeddah disasters recorded in 2009 and 2011 were caused by problems of urbanization combined with the frequency of precipitation that was recorded in less than 2 hours. The city experienced floods causing death and serious damage at the social, psychological, economic, health, and environmental levels.

Damage includes the destruction of thousands of cars, the displacement of hundreds of families, the evacuation of homes in the affected areas and the nearby neighborhoods during the crisis, the destruction of farms, and the emergence of mental disorders of people who lived the disaster. Losses were estimated at US$ 3 billion, resulting in damages of US$ 5.1 billion

2. Addressing the Information and Analytical Gaps for Better Informed Decision-Making Processes in the Region

At the base of a risk-informed approach to decision-making is the need for better evidence and information. Science and practical experiences can provide an improved foundation for decision-making and policy setting in a region defined by increasing complexity and greater need for systems-based thinking and decision-making. Efforts have been made to provide scientific data to describe these complexities. However critical gaps still exist to reliably predict temporal and spatial distribution of risk, particularly in fragile environments and in areas affected by conflict and unrest. Remote sensing, Geographical Information Systems (GIS), Management Information Systems (MIS) could be utilized to forecast severity and frequency of extreme temperatures, evapotranspiration, drought, etc.

A successful Geographical Information Systems would include the following set of skills: Cartographers create maps; Database managers store and extract information from structured sets of geographic data; Remote sensing analysts use satellite to map the Earth; Spatial analysts use techniques to manipulate, extract, locate and analyze geographic data; Land Surveyors measure the physical and geometric characteristics of Earth.

As an attempt to bridge trends in natural resource systems and socio-economic data in the Arab Region, the Arab Geographical Information Room (AGIR) has been instituted. Hosted by the Arab Water Council (AWC), and supported by a Unit of Technical Excellence, AGIR was established by **LAS Arab Water Ministerial Council** on May 27, 2015. AGIR's main objective is to collect and analyze studies and information to support decision-making on environmental, socio-economic and development-related issues and to make this information available to all Arab countries.

The AGIR Unit will implement this overall objective through collecting and analyzing the available environmental studies, socio-economic data and information and digital maps related to natural resources, particularly those related to risks and disasters; and through systematic identification of the knowledge gaps within the Arab World. AGIR's activities will also enhance the role of science and technology in climate change adaptation (CCA) and disaster risk reduction (DRR). AGIR will support building indicators and benchmarks related to the biophysical climate, environmental and social stresses. It will also produce regional profile reports related to water, food and social vulnerability nexus to meet its role in CCA and DRR toward sustainable development and human security in the Arab region.

Operationalization of AGIR is also considered part of output 1-C of the Sustainable Development Goal (SDG)-Climate Nexus Facility which was established as a joint program. Output 1-C aims to undertake policy-facing efforts including high-level reports with related communication materials and training. The high-level reports will cover the state of multi-dimensional risk trends in the region, capturing findings of social vulnerability that are unique to the profile of the Arab region.

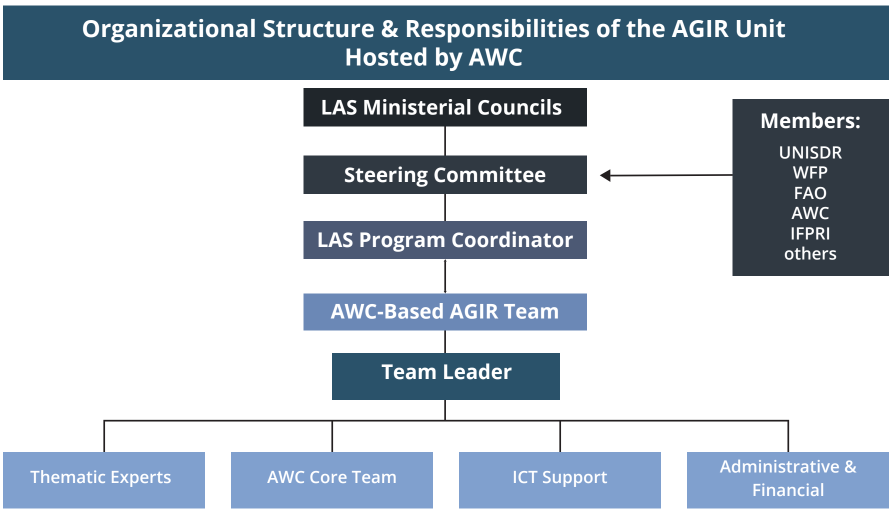


Figure 1: Organizational Structure of the SDG Climate Facility

AGIR Analysis in this report seeks to provide more evidence on understanding how emerging climate-related risks interact with structural challenges. The report also highlights the need of promoting inter-disciplinary actions that can help improve the role of science in decision-making.

3. Regional Climate Change Patterns and Hydro-Meteorological Risks (LAS/AWC-AGIR Regional Change Detection Analysis)

Satellite imagery and GIS maps for land cover changes are key to many diverse applications such as environment, forestry, hydrology, agriculture and geology. Methods for monitoring vegetation change range from intensive field sampling with plot inventories to extensive analysis of remotely sensed data which has proven to be more cost-effective for large areas, and even for small site assessment and analysis. Evaluation of the dynamic attributes (types and rates of change) on satellite image data may allow the types of change to be regionalized and the approximate sources of change to be identified or inferred.

3.1 Precipitation and PET trends

Almost in all the Arab countries, the average annual water resource is less than 1000 m^3/capita (World Bank definition of water scarcity), but some have less than 500 m^3/capita which defines acute water scarcity. The average is only 274 m^3 in North Africa (Algeria, Egypt, Libya, Morocco, Tunisia) and rises to 1786 m^3 because of high rainfall areas and shared water resources in the Near East (Iraq, Jordan, Lebanon, Palestine, Syria), although this figure hides the extremes across these countries. In the Arabian Peninsula (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE, Yemen), the average annual per capita water resource is only 84 m^3.

The main datasets used in this study are Precipitation and Evapotranspiration, which have been derived from the Center for Environmental Data Analysis - Climate Research Unit (CRU) time-series (TS) version 3.21 gridded data, launched at 2016. The CRU.TS.3.21 datasets are month-by-month variations in climate over the last century or so. These are calculated on high-resolution (0.5x0.5 degree) global grids, which are based on an archive of monthly mean temperatures provided by more than 4000 weather stations distributed around the world. They allow variations in climate to be studied. CRU TS 3.21 includes variables such as cloud cover (CLD), diurnal temperature range (DTR), frost day frequency (FRS), daily mean Potential evapotranspiration (PET), daily mean temperature (TMP), monthly average daily maximum temperature (TMX), monthly average daily minimum temperature (TMN), monthly total precipitation (Pre), Vapor pressure (VAP) and wet day frequency (WET) for the period 1901-2014. The method used to evaluate evapotranspiration is the Food and Agricultural Organization (FAO) grass reference evapotranspiration equation. It is a variant of the Penman-Monteith method. The PET data is available in the daily reference evapotranspiration (monthly average). To obtain the total monthly evapotranspiration, the result must be multiplied by the number of days in the month. The CRU TS 3.21 global data files are available from the BADC Archive at:
http://badc.nerc.ac.uk/browse/badc/cru/data/cru_ts/cru_ts_3.21/data.

The following figures from 2-12 illustrate the change detection in temperature, rainfall and PET maps, observed in the Arab Region, from 1961 till 2014.

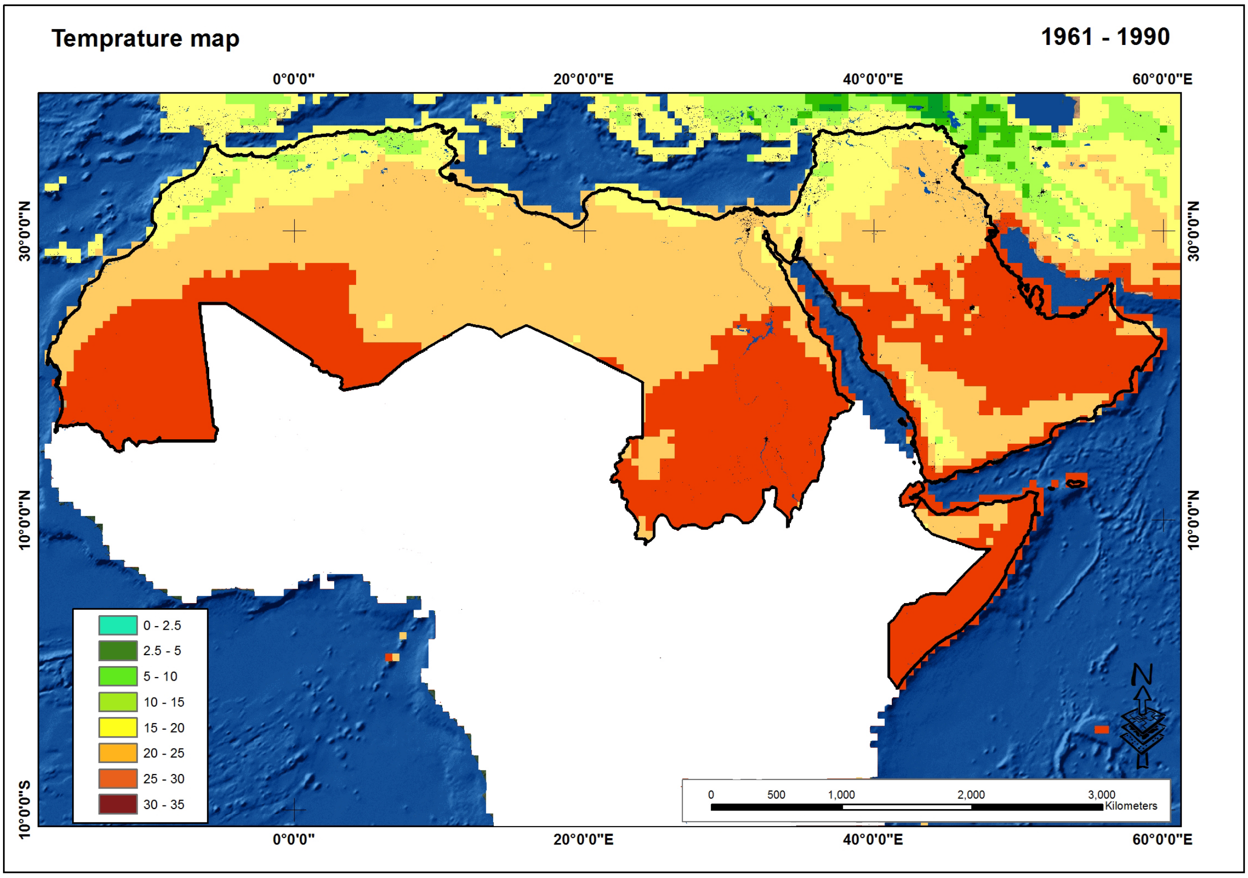


Figure 2: Mean Temperature map for the years 1961-1990 (AGIR/LAS-AWC)

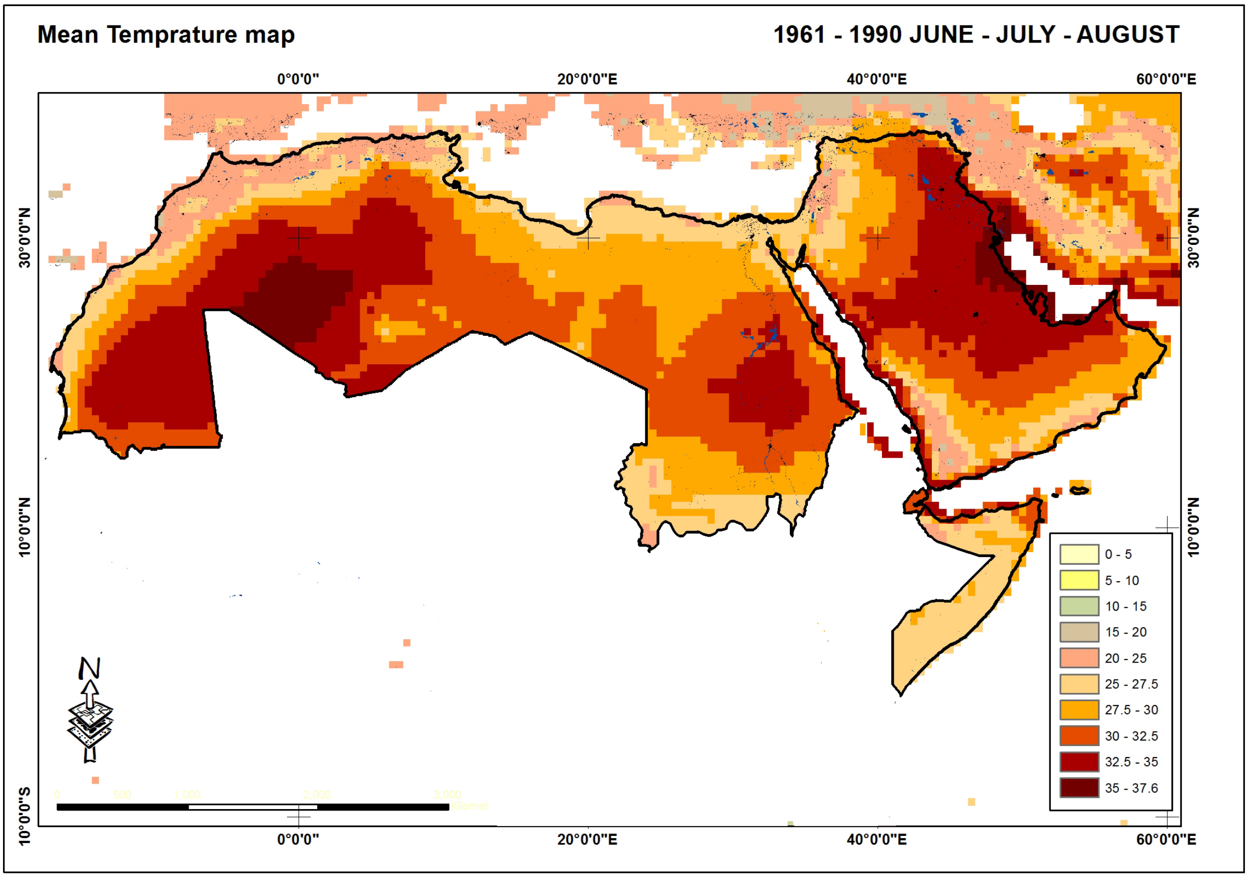


Figure 3: Mean Temperature map for the years 1991-2014 (AGIR/LAS-AWC)

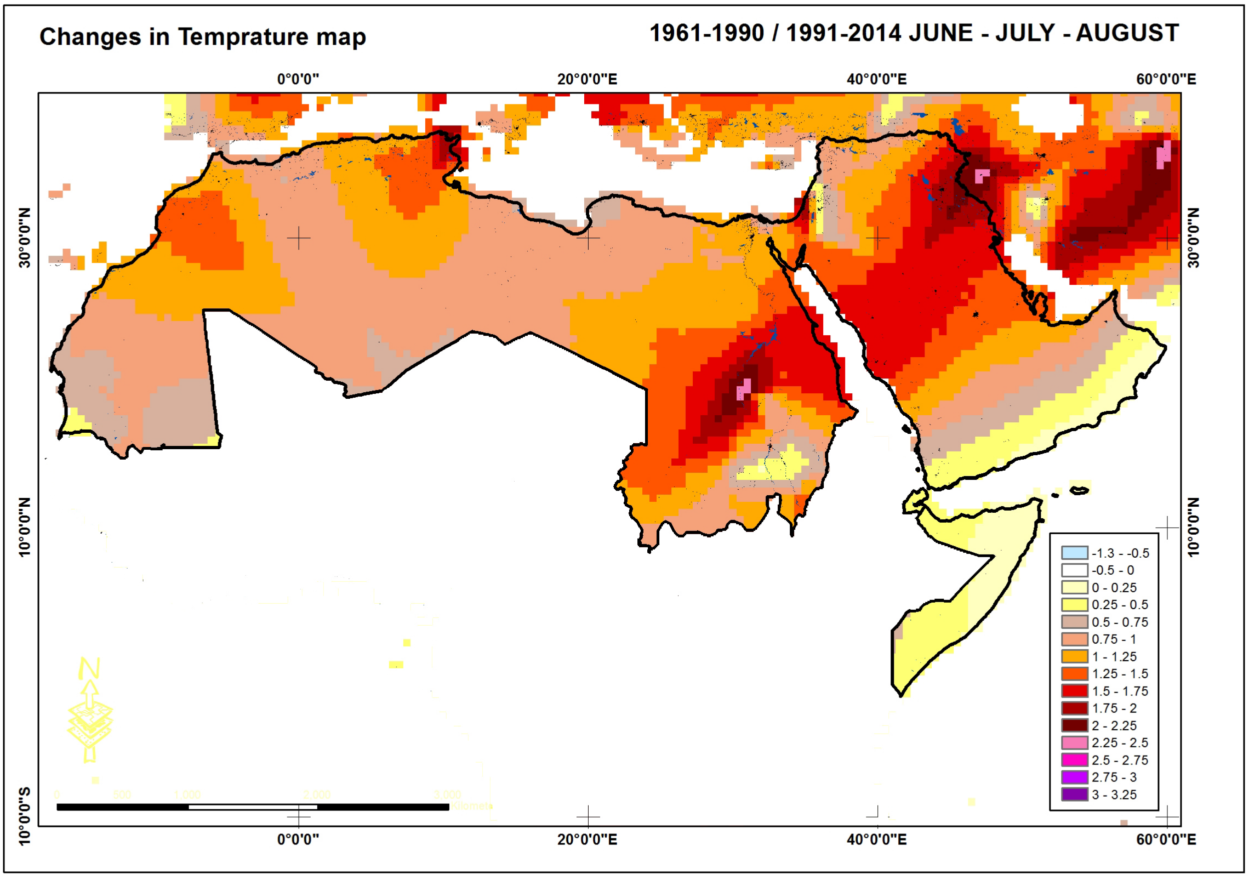


Figure 4: Changes in Mean Temperature (1961-1990)-(1991-2014) (AGIR/LAS-AWC)

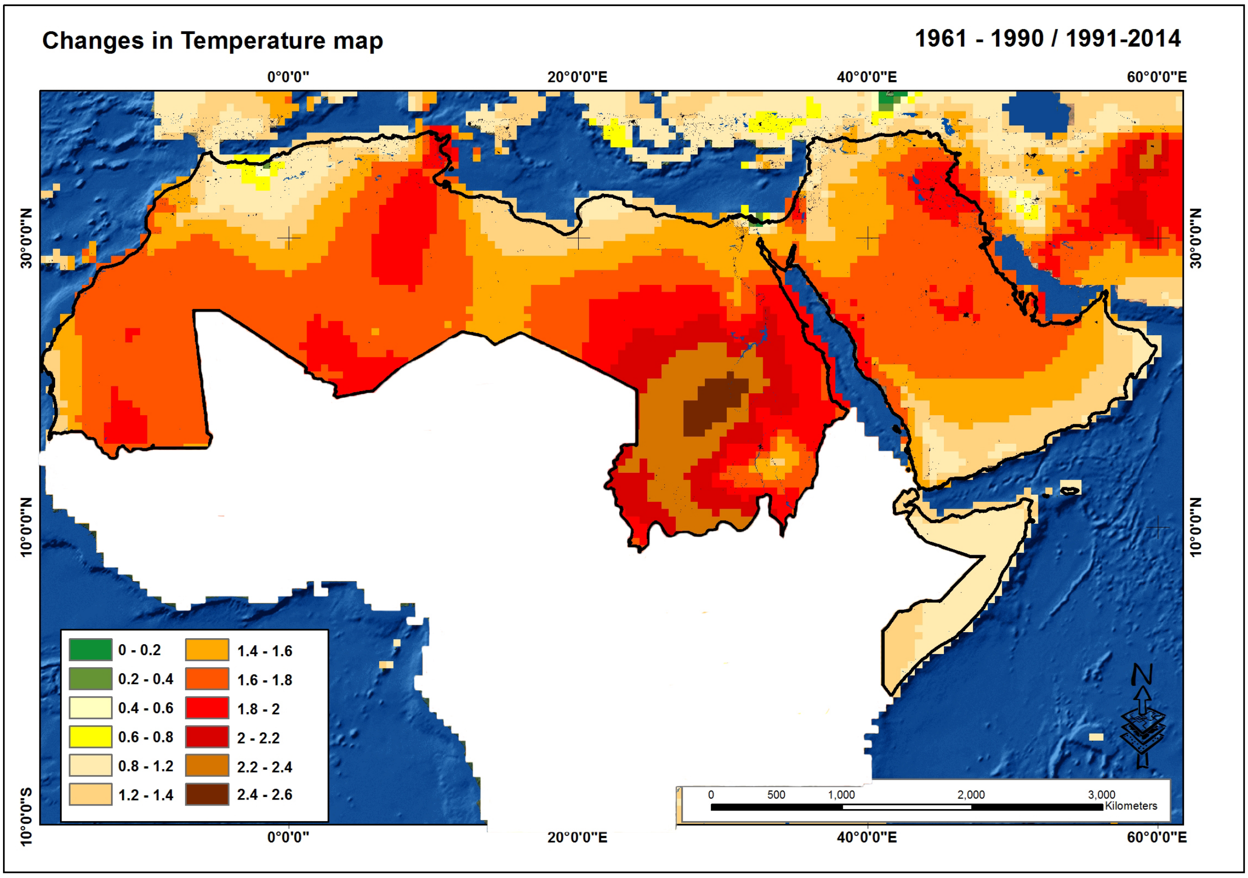


Figure 5: Changes in Summer Temperature in JJA months (1961-1990)-(1991-2014) (AGIR/LAS-AWC)

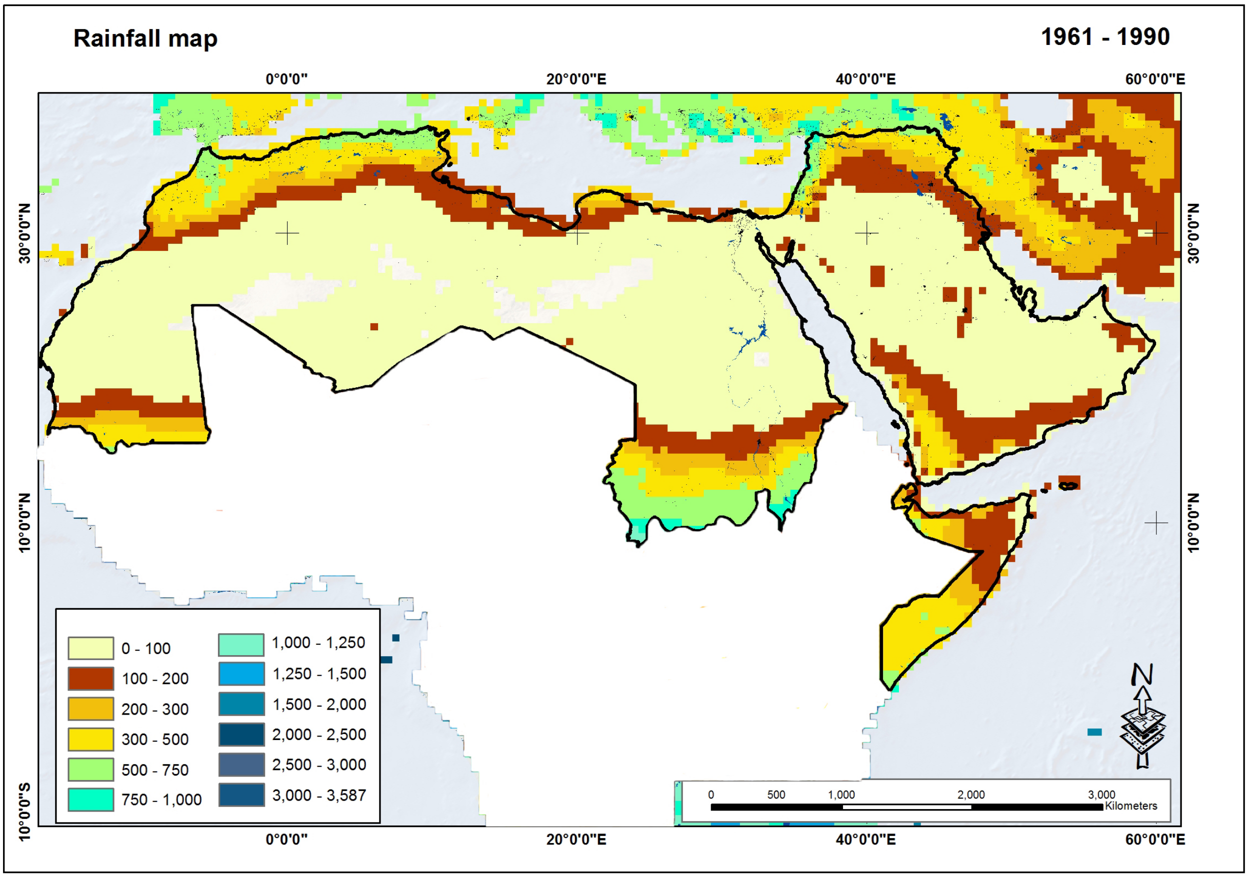


Figure 6: Rainfall map for the years 1961-1990 (AGIR/LAS-AWC)

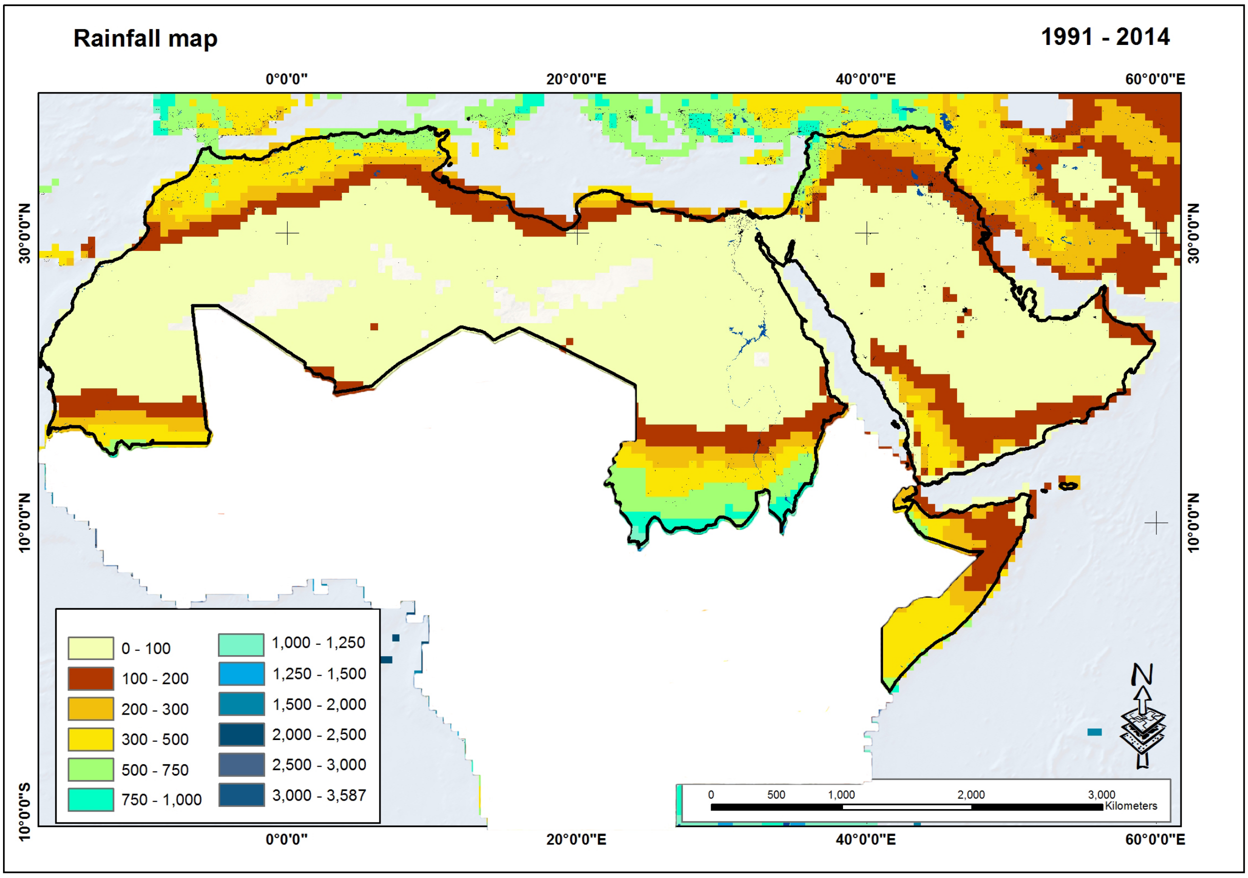


Figure 7: Rainfall map for the years 1991-2014 (AGIR/LAS-AWC)

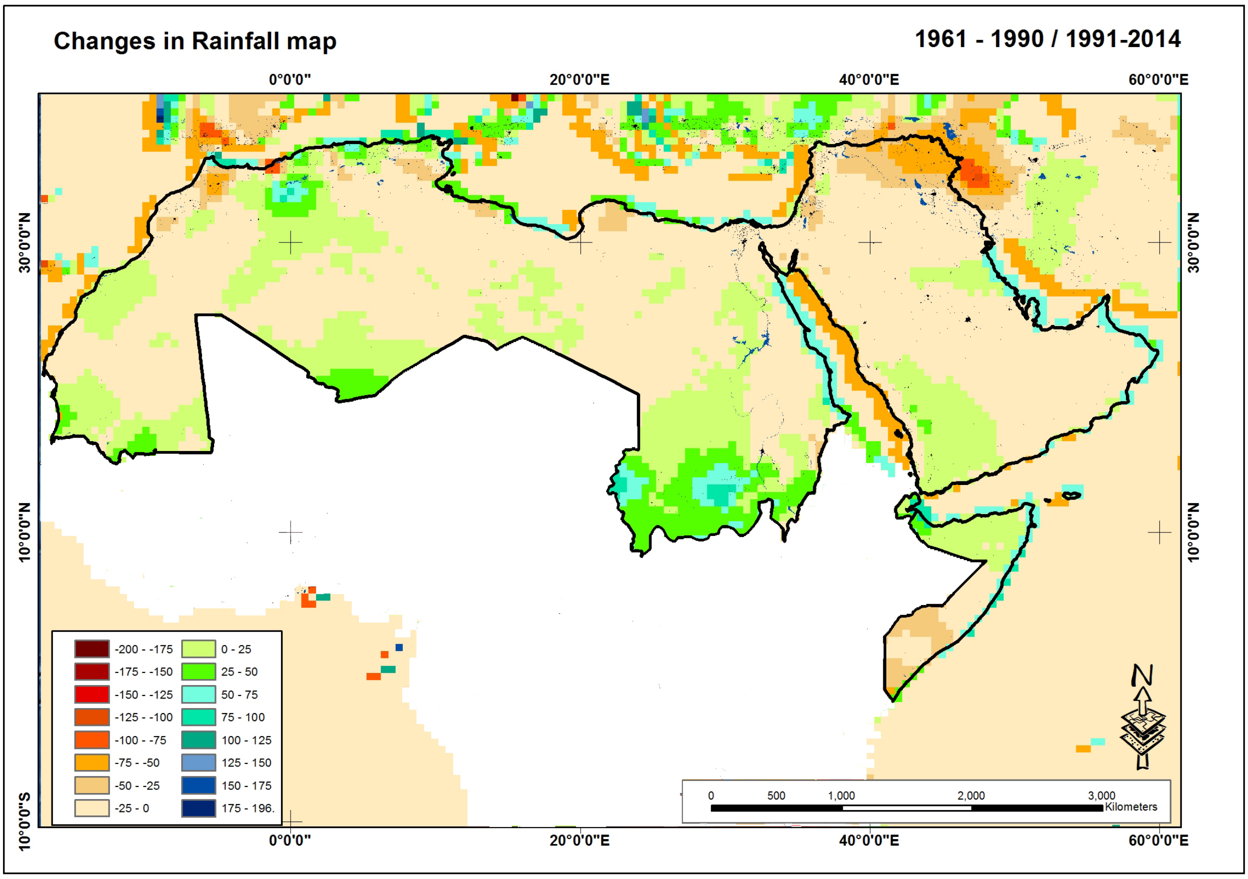


Figure 8: Change in rainfall (1961-1990)-(1991-2014) (AGIR/LAS-AWC)

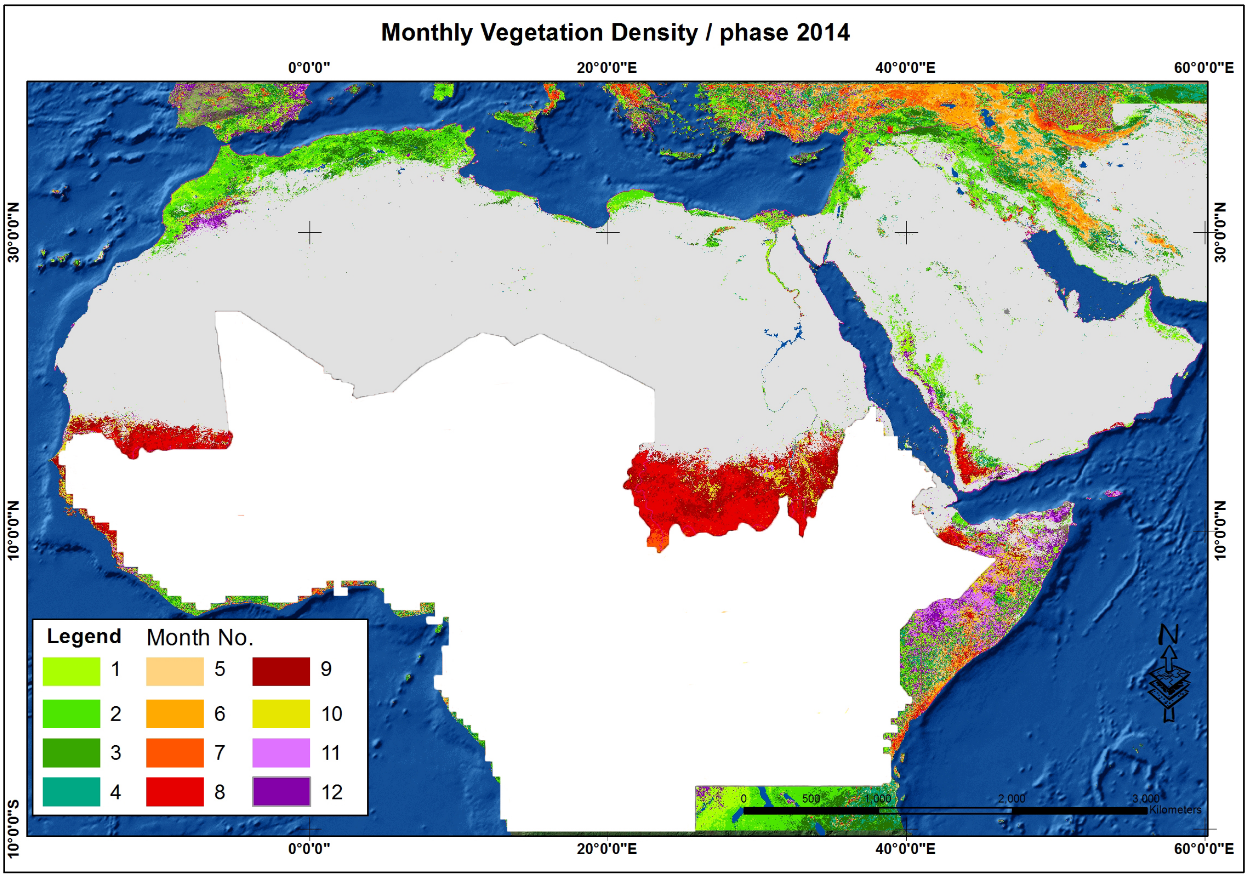


Figure 9: Rainfall variability (2014) (AGIR/LAS-AWC)

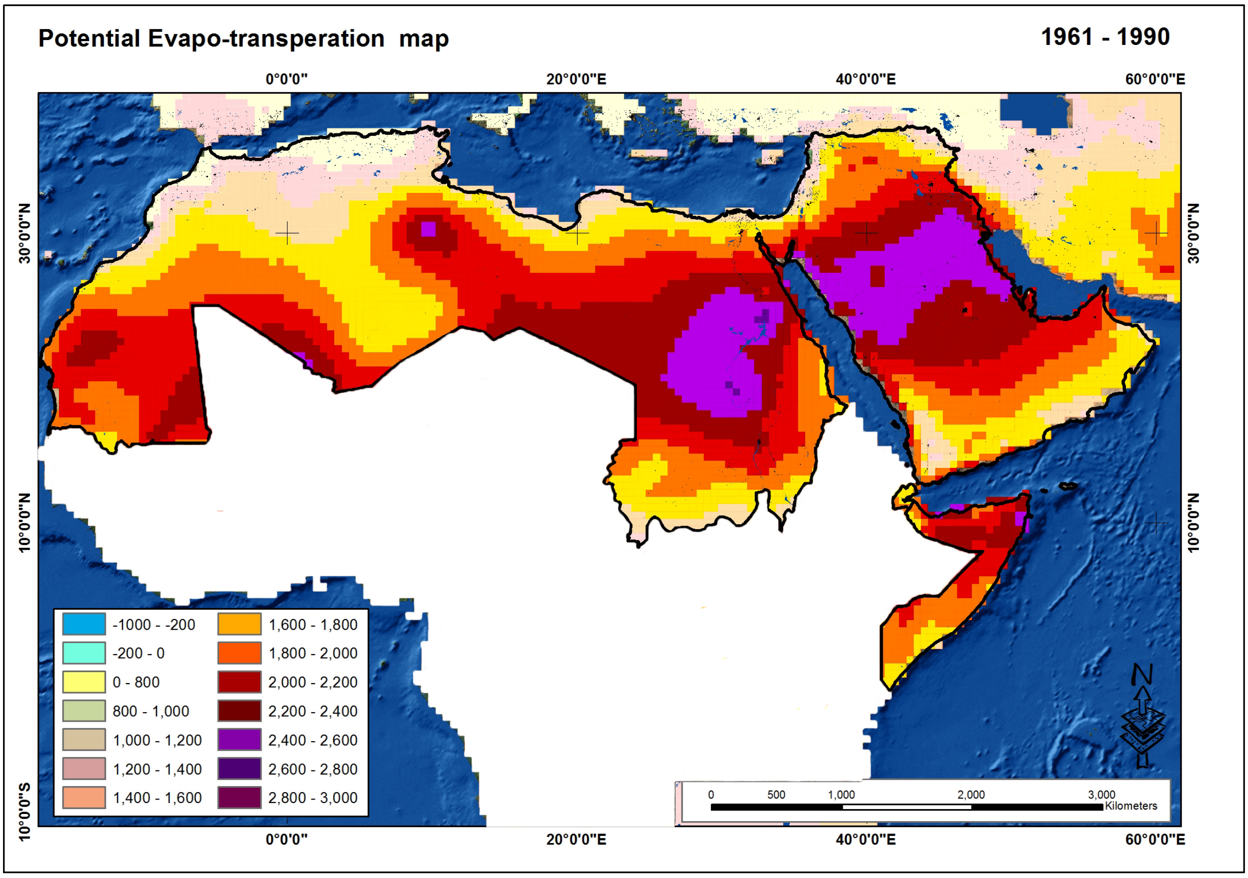


Figure 10: PET map for the years 1961-1990 (AGIR/LAS-AWC)

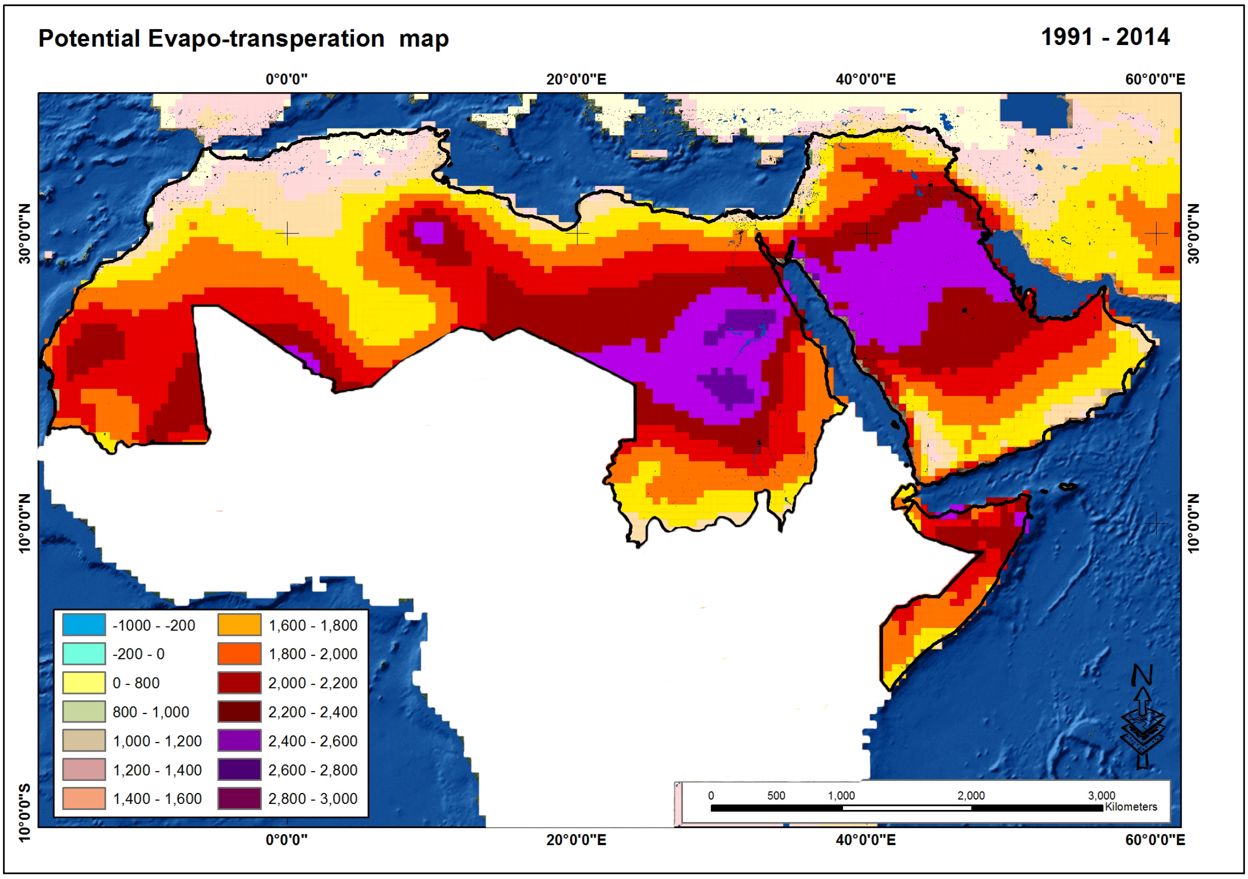


Figure 11: PET map for the years 1991-2014 (AGIR/LAS-AWC)

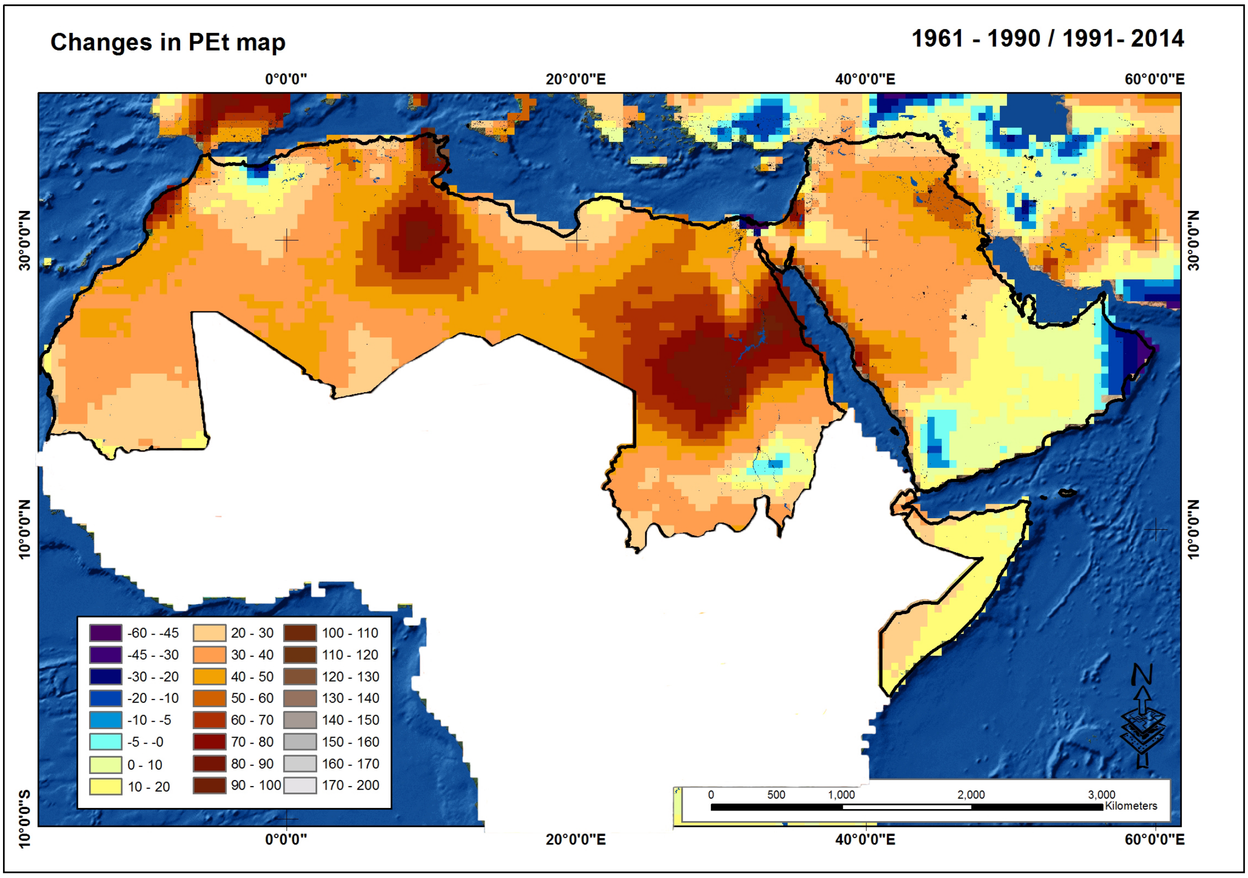


Figure 12: Change in PET (1961-1990)-(1991-2014) (AGIR/LAS-AWC)

Based on the previous figures, the main changing patterns in climatic parameters in the Arab region observed during the period “1991-2014” compared to the period between “1960-1990”, could be summarized as follows:

- Warming in temperature and heat extremes of about 0.2° per decade has been observed in the region from 1961–1990, in accordance with the expected increase in global mean temperature over the same period (Seneviratne et al., 2012).
- According to (Verner, Dorte, ed. 2012), the strongest warming is expected to take place close to the Mediterranean coast where temperature has increased with an average of 0.8-1.4°C. There, but also in inland Algeria, Libya and large parts of Egypt, warming by 3°C in a 2°C world is projected by the end of the century. Hence, according to the latest results performed by AGIR team, temperature is increasing in Sahara “The Great Desert”, steppe areas and Sudan by 1.6 to 2.6°C. While in general “summer months June-July-August (JJA)” reflected higher level of increase by at least 0.5°C from the mean. The analyzed data provide evidence for significant warming trends throughout the entire Arab region, reflected generally in more and stronger warm extremes and fewer and weaker cold extremes. Similarly, the study of Donat et al (2014) also confirms that warming trends were generally stronger during the past 30 years (since 1981) compared to the previous period (since 1966).
- Rainfall is declining annually in the Arab Mashreq countries by around 25-75 mm , while increasing in all other areas in the Arab Maghreb, relatively by around 25–50 mm, mainly in Atlas Mountain areas. Meantime, rainfall is increasing in Sudan (25–75 mm) and southern west corner of Arabian Peninsula and south Egypt by around 25 mm annually.

- Rainfall variability in the Mediterranean reflected in high vegetation green cover observed during January and February in most rainfed areas except for some parts where it extends till March. Yet in Somalia, a shorter season was observed. While Monsoon areas the highest vegetation green cover is observed during July and August.
- Evapotranspiration results showed an increase by 50 to 120 mm in Sudan, Upper Egypt, Tunisia and parts of Palestine and Morocco. Additionally, an increase by 20 to 60 mm is shown in Arab Mashreq and some areas in Algeria and eastern parts of Arabian Peninsula. Meanwhile, a slight increase of 10-30 mm was observed in the rest of the region while only a small part of Atlas Mountains is showing a decline of 10 to 45 mm.

To summarize, the obtained results provide evidence of significant changes in the occurrence of climate extremes during the past five decades. There are consistent warming trends across the region. Significant warming trends are also found in the absolute temperature values. The changes in the precipitation-based indices are generally less significant and spatially inconsistent.

Consequently, this large increase in the heat-waves combined with warmer average temperatures will put intense pressure on the already scarce water resources with major consequences on regional water and food security. Crop yields could decrease by up to 30% at 1.5–2°C and by almost 60% at 3–4°C. At the same time, migration and climate-related pressure on resources might increase the risk of conflict, putting food, water and energy security at risk.

3.2 Aridity Index

The availability of water for both people and ecosystems is a function of supply and demand. The long-term balance between supply and demand fundamentally determines whether ecosystems and agricultural systems are able to thrive in a certain area. This section assesses projected changes in the aridity index (AI), an indicator designed to identify regions with a structural precipitation deficit (supply-demand balance deficit). Aridity Index defined as the ratio between mean annual precipitation (P) and mean annual potential evapotranspiration (PET), —a standardized measure of water demand, Figure (13), after (Verner, Dorte, ed. 2012).

Figure 14-15 show aridity index maps for the Arab region for the years (1961-1990) and (1991-2014). Changes in AI are primarily driven by changes in precipitation causing an increase in AI (wetter conditions) south of 25°N (i.e., the Sahel and the most southern part of the Arabian Peninsula) and a decrease in AI (drier conditions) north of 25°N. The relative increase in AI values in the southern region is similar to the relative increase in annual mean precipitation (about 50% wetter conditions), as the change in potential evapotranspiration is small. It is to be noted that this relative increase in AI south of 25°N is imposed on an already very low AI value, which results in AI values still classified as arid.

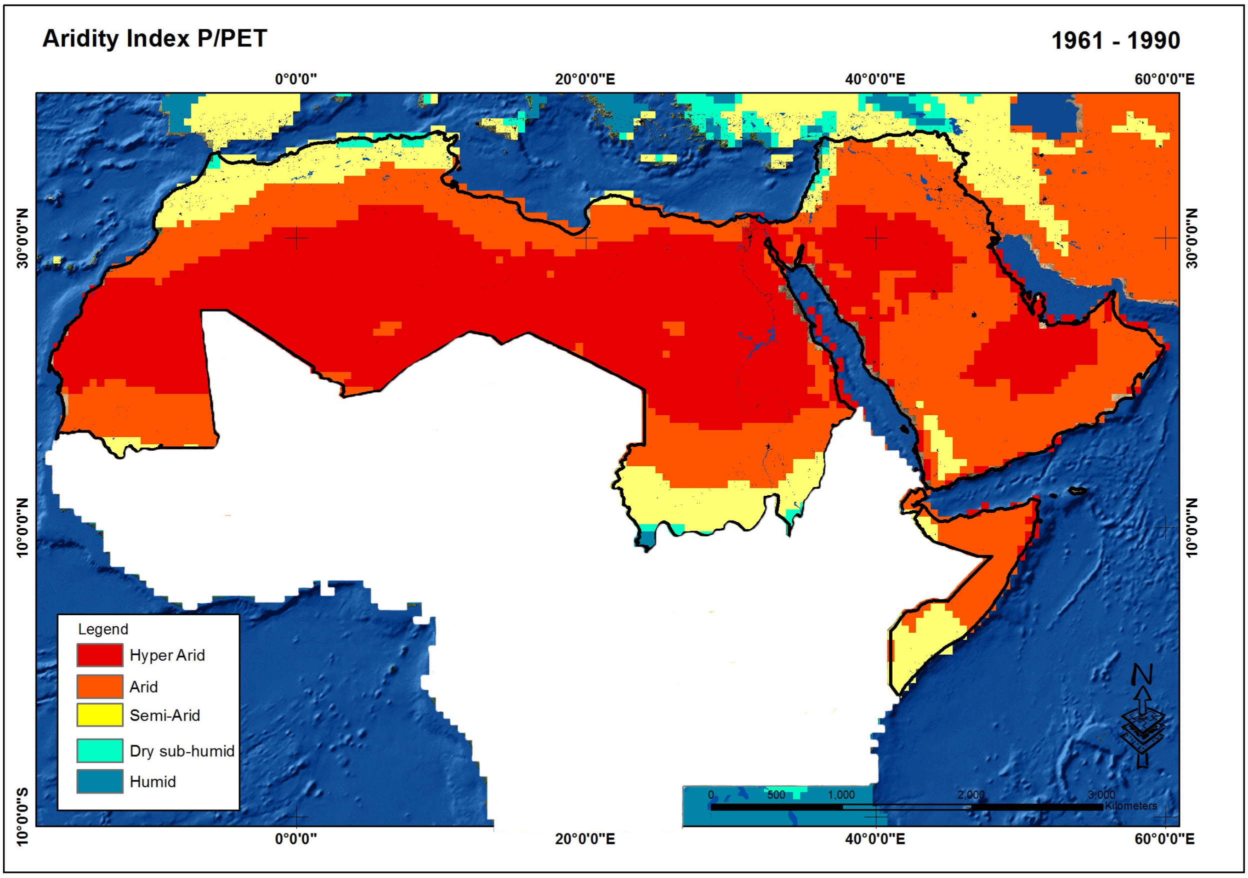


Figure 14: Aridity Index map for the years 1961-1990 (AGIR/LAS-AWC)

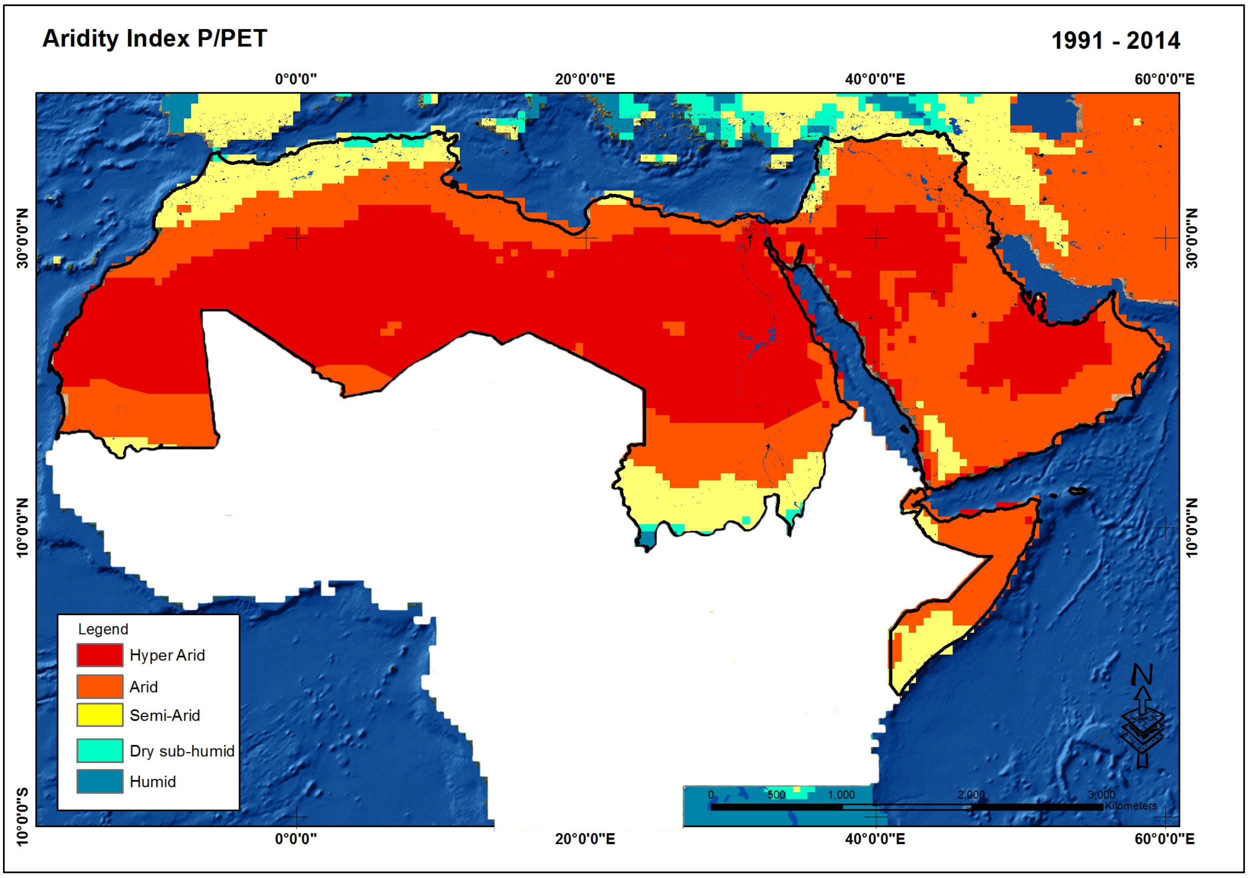


Figure 15: Aridity Index map for the years 1991-2014 (AGIR/LAS-AWC)

For the Agriculture sector to adopt high temperatures and precipitation variability, the following measures could be embraced: select and introduce more drought and heat resistant species and hybrids; adopt sustainable agricultural practices and integrated pest management techniques; promote mixed-use farming e.g., animal and vegetable production; and change planting dates and cropping patterns according to precipitation and temperature variations and irrigation water availability. A shift in the cropping pattern in coastal zones could be to introduce crops tolerant to higher levels of humidity and temperature (i.e., citrus, tropical fruit trees), and tolerant to higher salinity concentrations (i.e., legumes, cucurbits and solanaceous rootstocks).

A shift should also take place to more efficient irrigation systems such as drip irrigation or sprinklers, and to adjust irrigation schedules as well as water quantities according to the increasing crop water demand. For inland and valley areas, the cropping pattern shift could be to less water consuming crops, (e.g., barley instead of wheat, snake cucumber instead of cucumber, figs instead of kaki, grapes instead of peaches); and to more drought-and-heat tolerant crops (such as industrial hemp, avocado and citrus) as opposed to bananas.

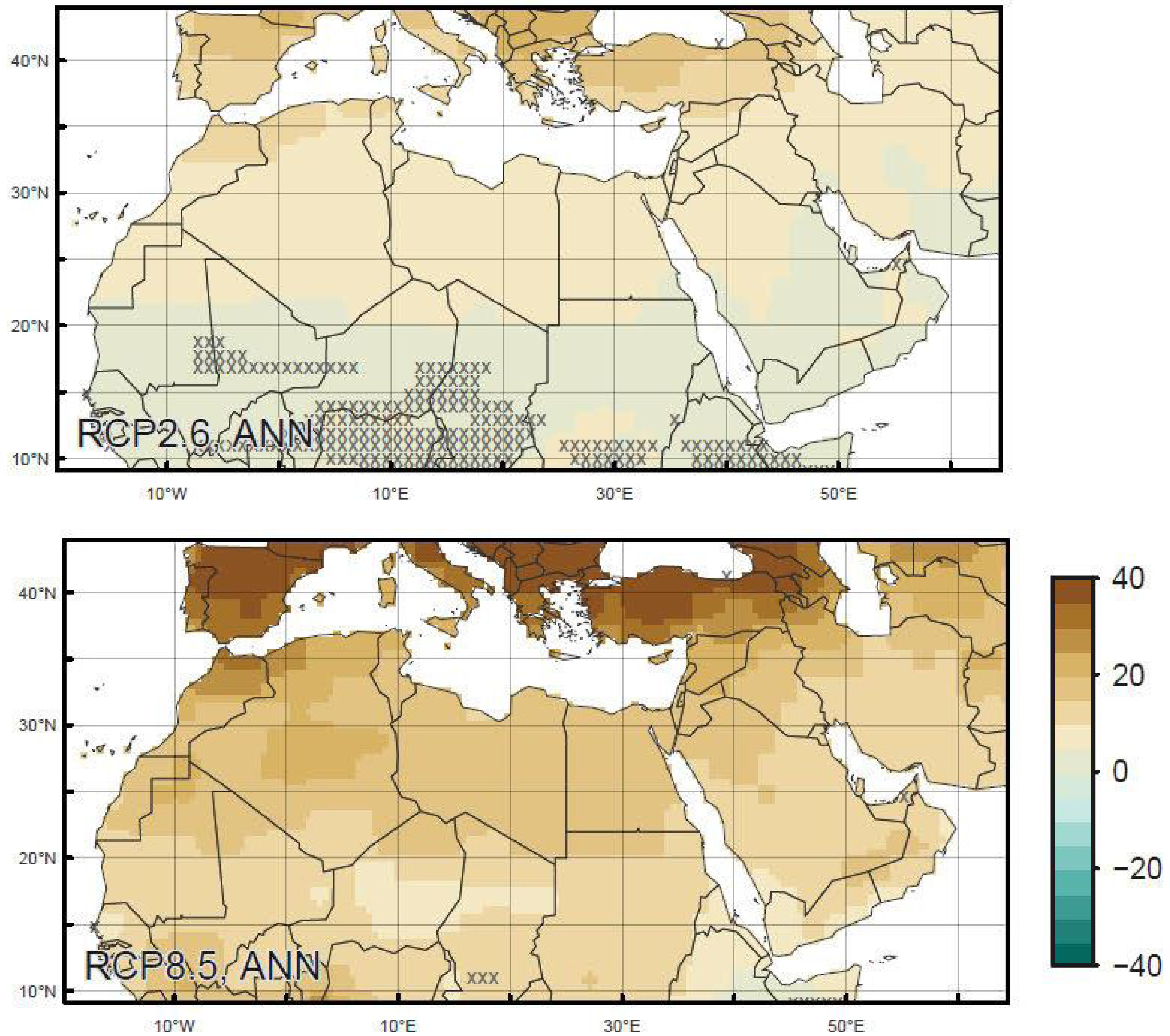


Figure 16: Multi-model mean of the percentage change in the annual-mean (ANN) of monthly potential evapotranspiration for RCP2.6 (2°C world, left) and RCP8.5 (4°C world, right) for the Middle East and North African region by 2071–99 relative to 1951

3.3 Land Cover/ Land Use

Knowledge of land use and land cover is important for many planning and management activities concerned with the surface of the earth. The availability and accessibility of accurate and timely land cover/land use information play an important role in many global land development, and many scientific studies and socio-economic assessments. Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Land cover maps provide information to help managers best understand the current landscape and detect changes over time. Land cover provides information that are essential inputs for environmental and ecological models and the primary reference for ecosystem control and management.

Land cover can be determined by analyzing satellite and aerial imagery. The need for accurate and up-to-date information about land cover types is necessary and is required at different spatial and temporal scales for the purpose of development. Land use shows how people use the landscape – whether for development, conservation, or mixed uses. The different types of land cover/land use can be managed or used quite differently.

The following (Figures 17-24) present land cover maps (irrigation, rainfed, rangelands and forest areas) for the Arab Region for the year 2009 & 2014.

- The Global Land Cover SHARE (GLC-SHARE 2014) which is a relatively new land cover database at the global level created by FAO, Land and Water Division, in partnership and with contribution from various partners and institutions. It provides a set of eleven major thematic land cover layers resulting by a combination of “best available” high resolution national, regional and/or sub-national land cover databases. The GLC-SHARE 2012 Beta-Release 1.0 (Figure 17) is published by FAO in 2014 and is completely free and open access to the data and metadata products is available at FAO Geo-Network www.fao.org/geonetwork.

- At the meantime, ESA (2016) is a new dataset that includes the three land cover maps corresponding to the different epochs: 2000 (from 1998 to 2002), 2005 (from 2003 to 2007), and 2010 and (from 2008 to 2012). http://maps.elie.ucl.ac.be/CCI/viewer/ (Figure 18)

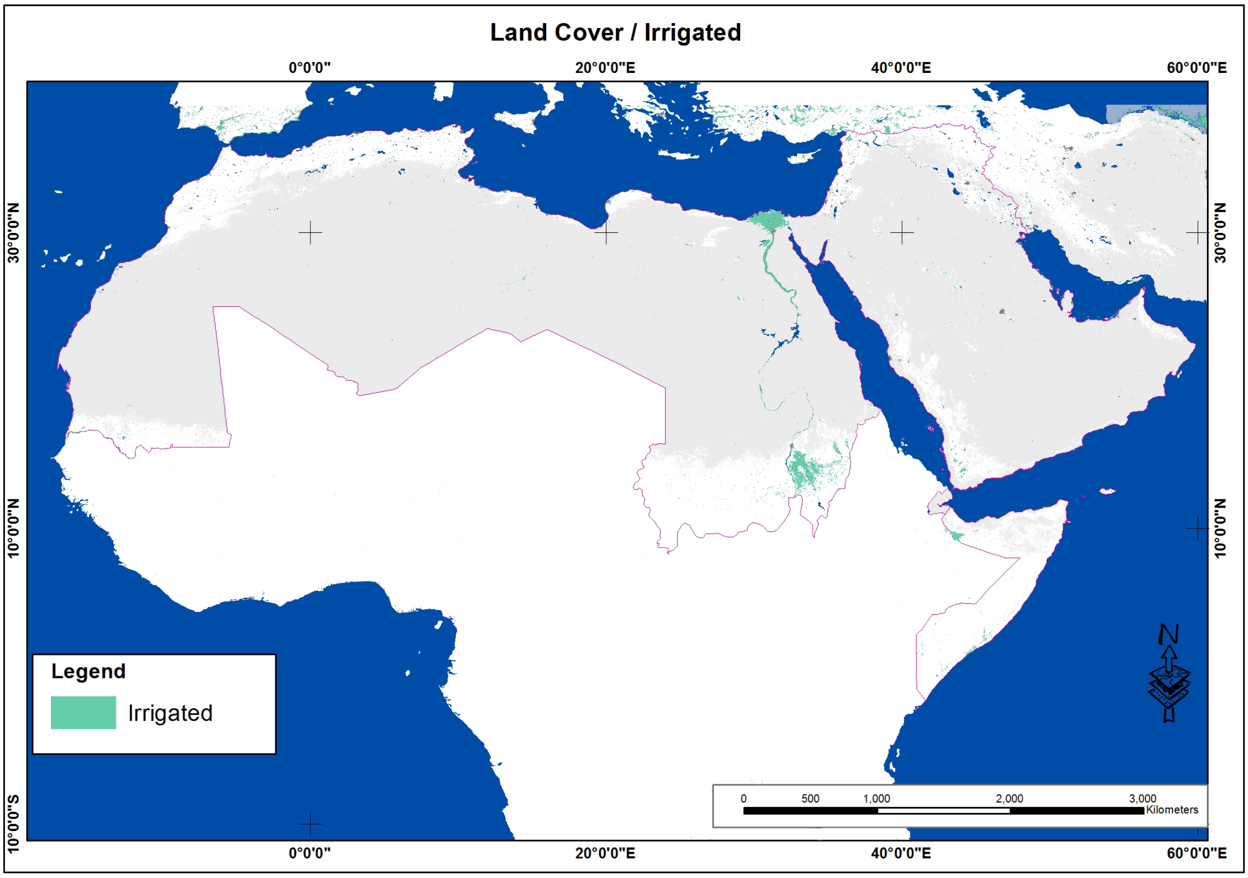


Figure 17: Land cover – Irrigation map GLC-SHARE 2014

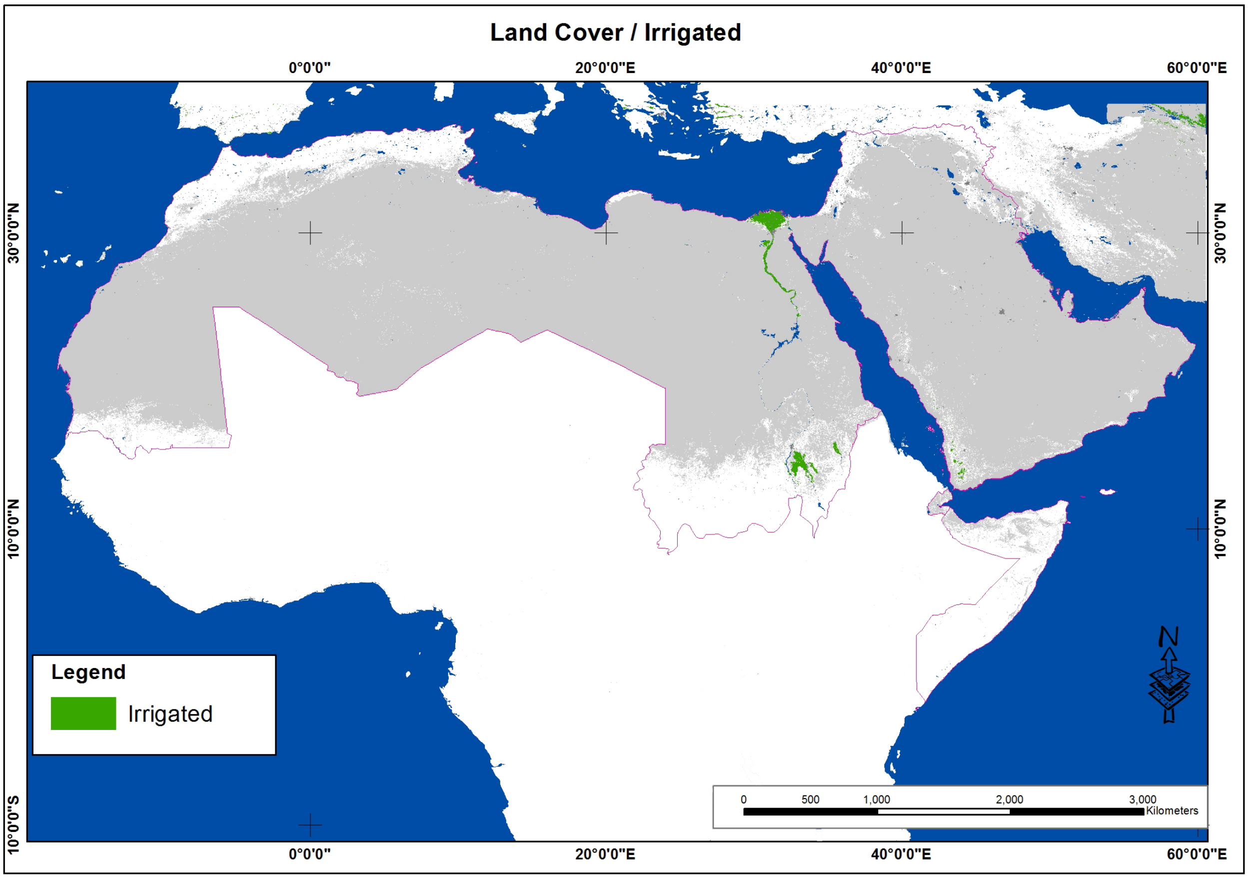


Figure 18: Land cover – Irrigation map ESA 2009

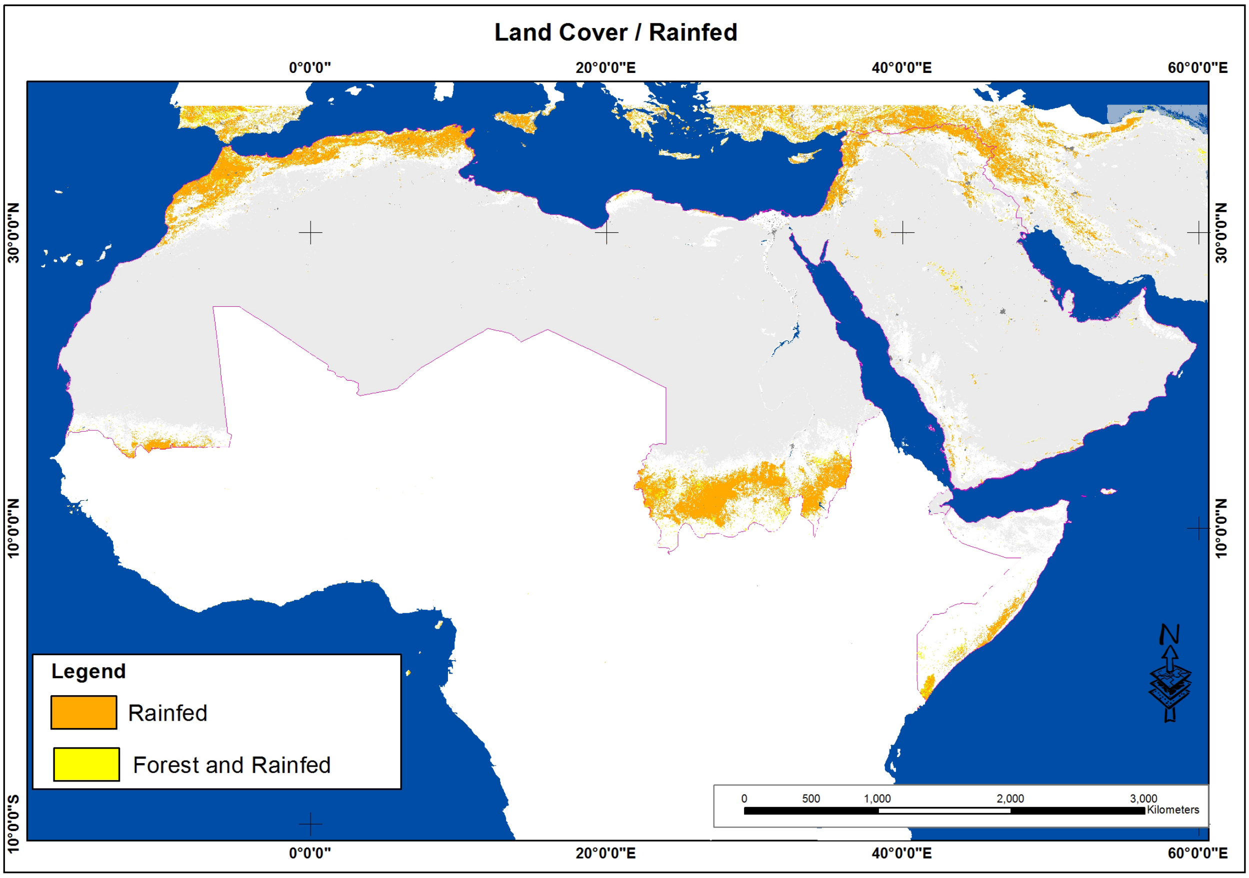


Figure 19: Land cover – Rainfed map GLC-SHARE 2014

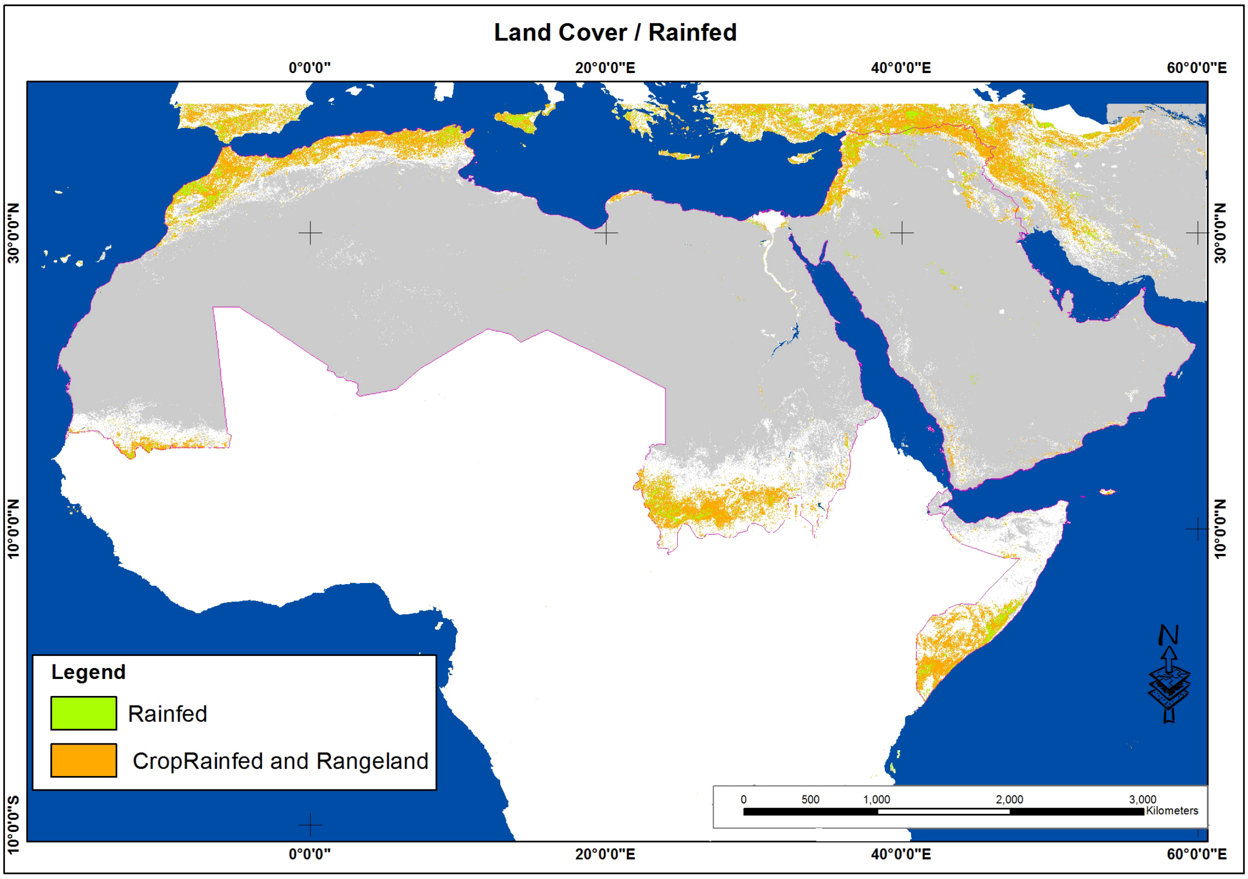


Figure 20: Land cover – Rainfed map ESA 2009

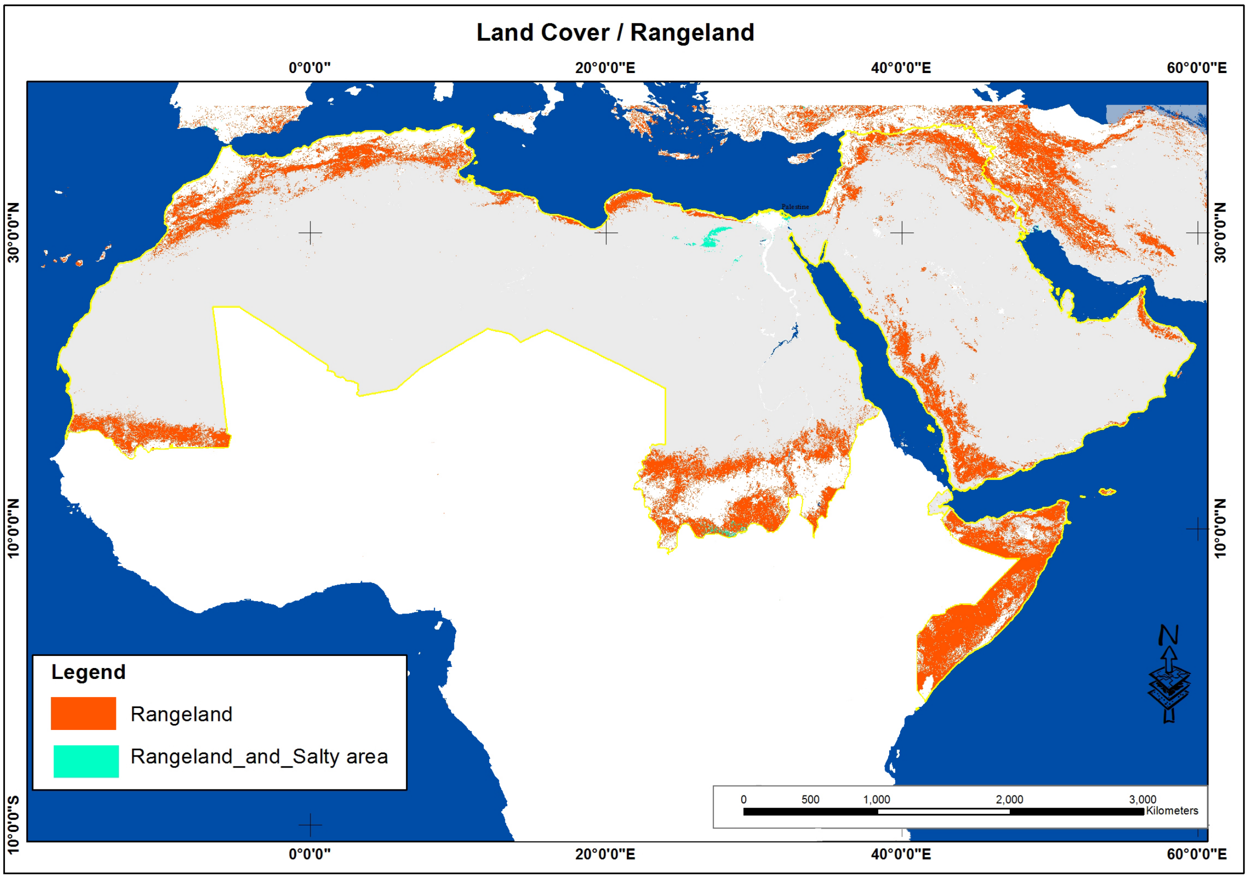


Figure 21: Land cover – Rangelands map GLC-SHARE 2014

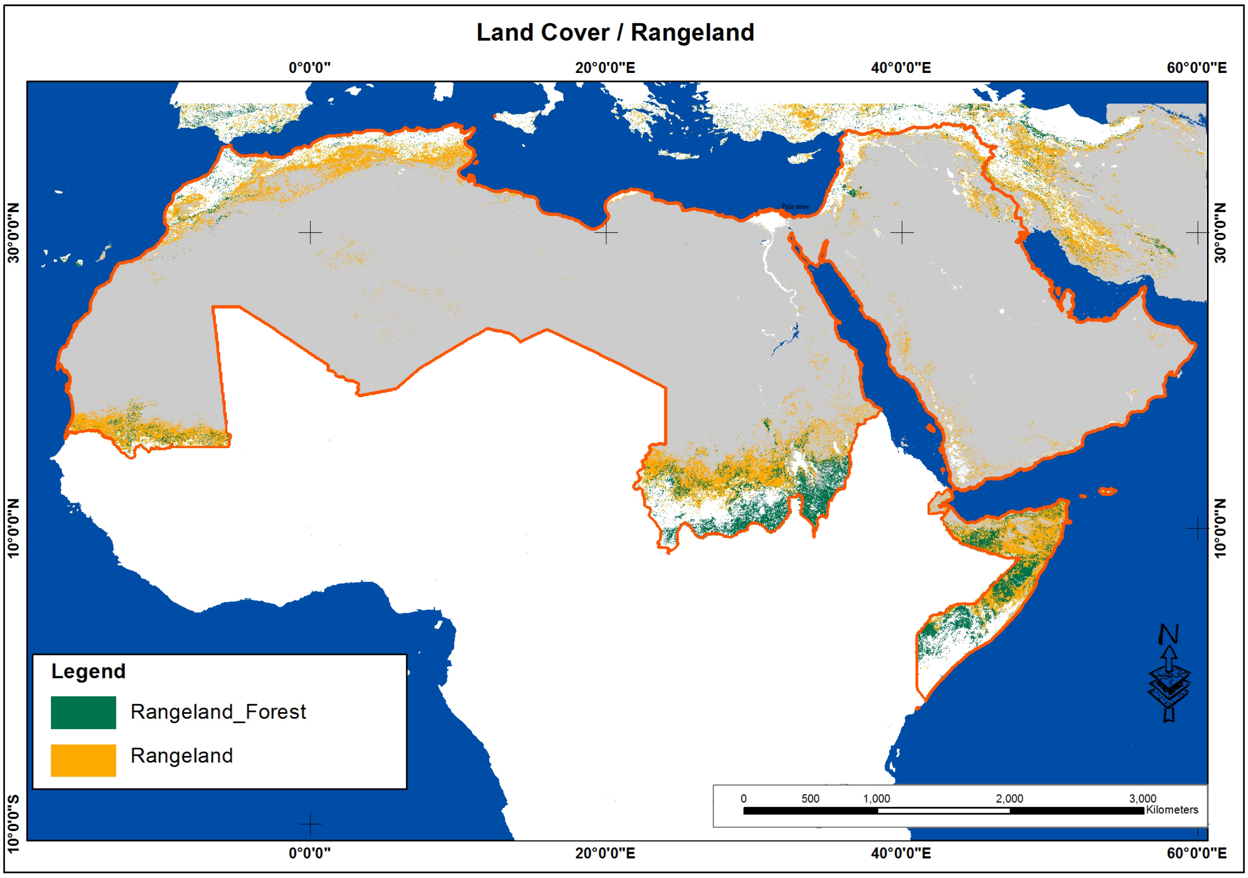


Figure 22: Land cover – Rangelands map ESA 2009

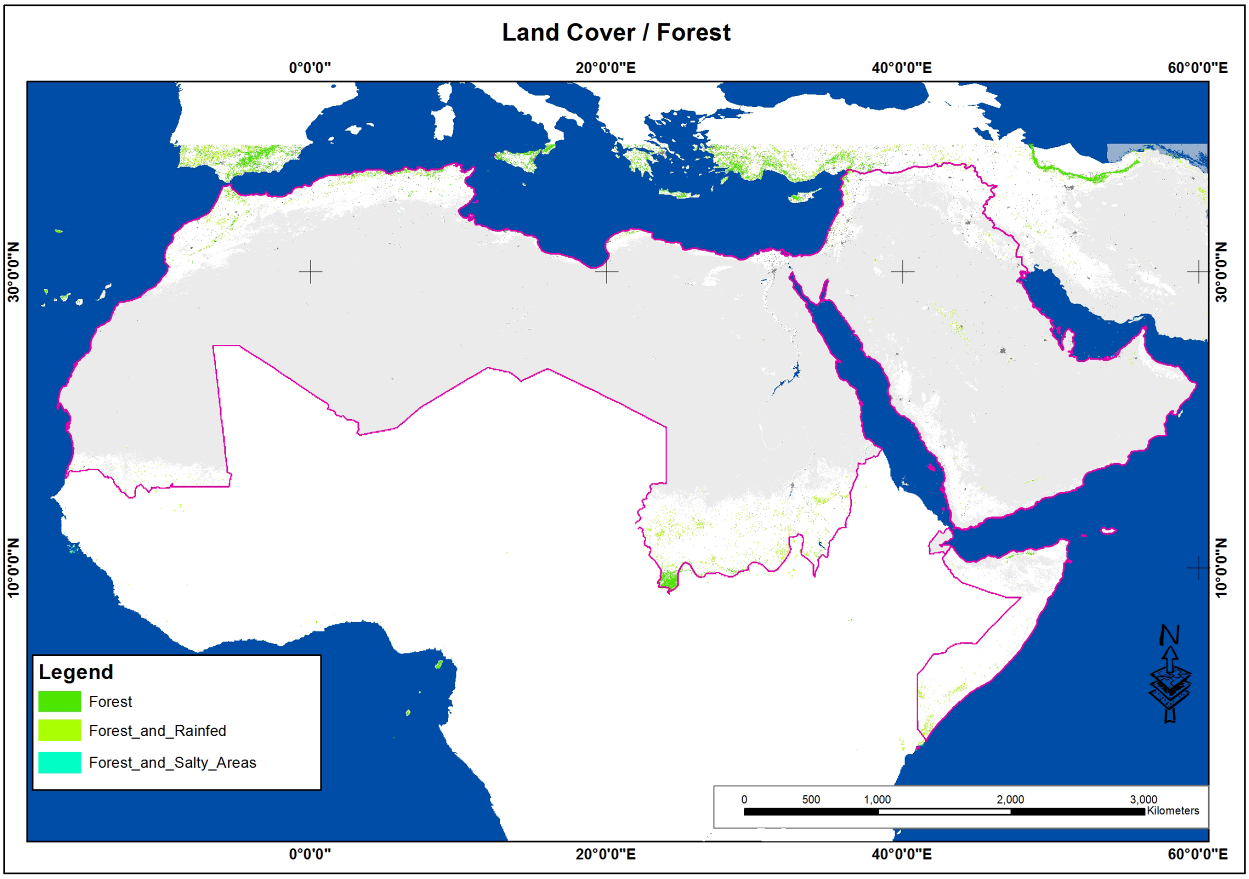


Figure 23: Land cover – Forests map GLC-SHARE 2014

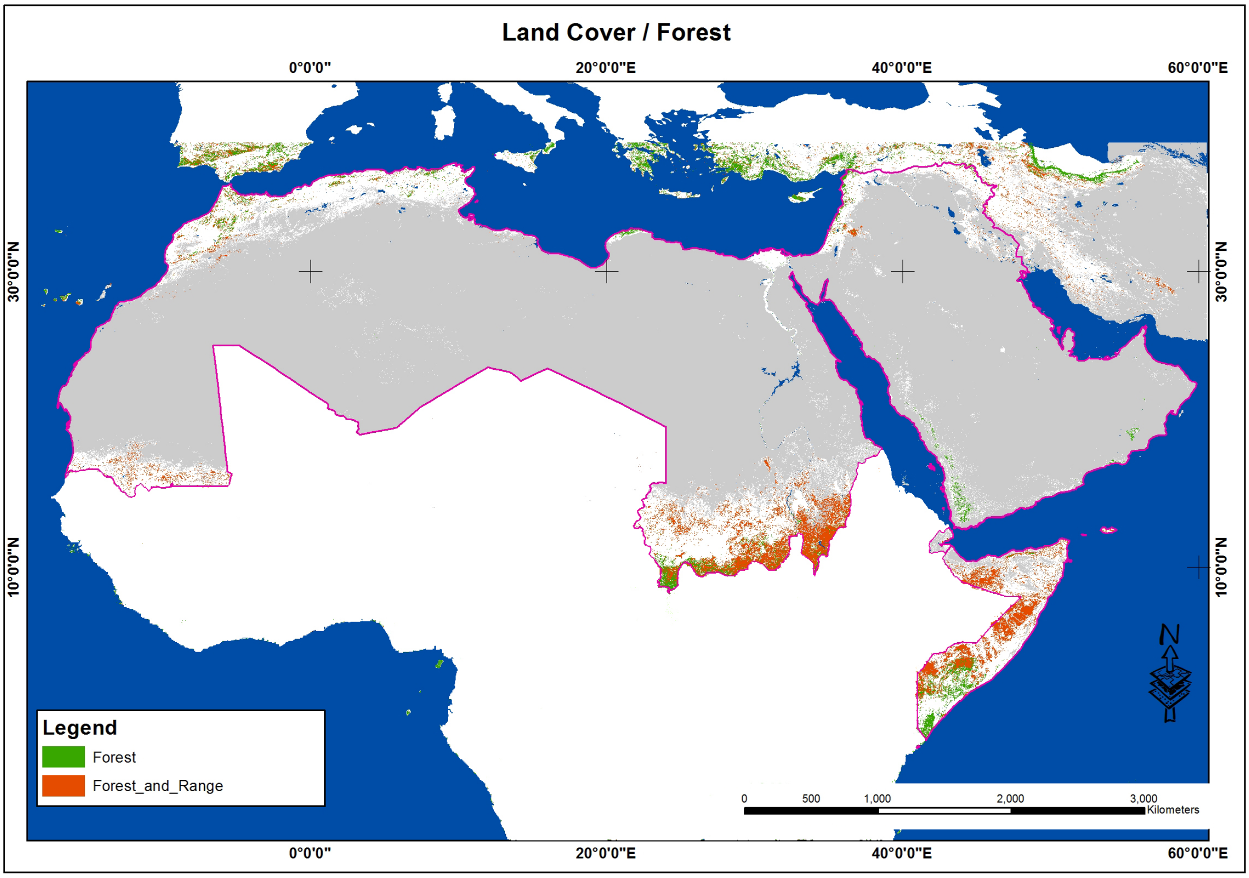


Figure 24: Land cover – Forests map ESA 2009

Healthy and productive land resources form the basis of societal livelihood systems. Entire populations are directly dependent on the ecosystem services provided by land resources for their well-being. In 2011, it was estimated that up to 25-30% of the world's land and soil resources can be classified as highly degraded land with lost opportunities estimated at around $300 billion. Overcoming the challenges associated with land degradation is thus of great importance. With the adoption of the SDGs by the United Nations in 2015, countries committed to strive towards achieving a land-degradation neutral world by 2030 (SDG Target 15.3). Land degradation in the Arab Region is happening extensively mainly due to widespread misuse of land resources and is proceeding at accelerating rates.

Urban expansion in **Egypt** during the 1984-2006 period was at the expense of the most fertile soils, as the high productive soils (Class 1) lost 798 Km^2, the moderate productive soils lost 311 Km^2, while the low productive soils lost 672 Km^2 during the same period.

Meanwhile, **Saudi Arabia** experienced an overall increase in green cover during the period 1987-2012 which is attributed to agricultural expansion through the development of non-renewable groundwater in the cultivation of strategic crops such as wheat.

Failures of resource management policies are aggravated by over-grazing, over-exploitation of water and land resources, over-cultivation of marginal lands, deforestation, and the use of inappropriate technologies. Natural resource degradation, especially where agriculture is practiced, is a real threat in all countries of the region and remains a major limitation to the reliable supply of food. In most countries, salinization, water and wind erosion, loss of vegetation cover, soil physical degradation are the main threats to the soil's capacity to provide ecosystem services (FAO, 2015).

Additionally, urban encroachment on agriculture land in the Arab region is a continuously increasing phenomenon that affects the overall fertile agriculture land along with national food production, groundwater aquifer recharges, and increased surface runoff causing floods. Even with these risk factors, mismanagement of water resources and unsustainable land practices are rife across the region.

Increased drought events and periods will be reflected in more environmental stresses including desertification, land degradation, reduced biodiversity, water scarcity, increased days of dust storms and forest fire areas, etc. Results in (Figure 25) summarize the impacts of drought, land degradation, and drought and land degradation combined on agriculture production losses in the last 12 years of the studied period (2000-2012). Estimated losses in rainfed, rangeland, forest production and total vegetation cover will be significant. Total production losses for vegetation cover could be up to 143.17 million Ha which amounts to 32.1 % of the total production vegetation cover in the Arab Region. Losses values are expected to double by the year 2025. These losses will increase social vulnerability (poverty, unemployment, change land use pattern and its production, affect public services and the slandered of leaving, etc…) and increase instability in local communities and national as well (e.g. food shortage, conflicts, displacements and migration, crimes, etc..). Prevention efforts should include enhanced monitoring and assessment efforts, recovery measures and building resilience.

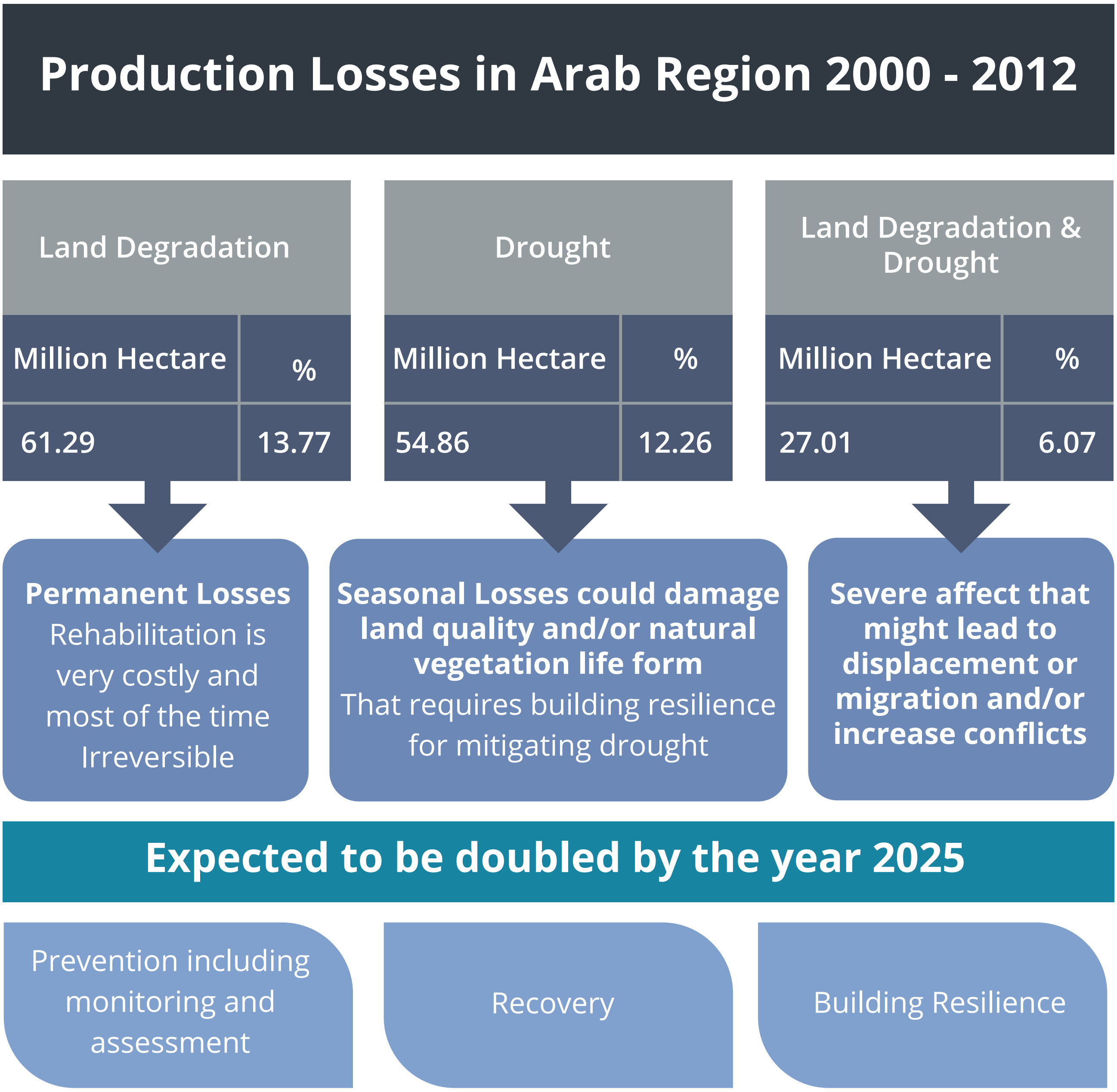


Figure 25: Summary of Agriculture Cover Production Losses in the Arab Region

3.4 Impacts of Extreme Events on Food Security and Food Production

In 2012, Verner, Dorte, ed. illustrated that the crop yields in the Arab region may decrease by up to 30 percent at 1.5–2°C warming in Jordan, Egypt and Libya and by almost 60 percent (for wheat) at 3–4°C warming in Syria. The strongest crop reductions are expected for legumes and maize as they are grown during the summer period. With 70% of agricultural production being rainfed, the sector is highly vulnerable to temperature and precipitation changes, not to mention the associated potential consequences on food, social security and rural livelihoods.

Forty-three percent of the Arab region population live in rural areas and poor rural farmers are particularly vulnerable to hunger and malnutrition as a direct consequence of yield loss and high food prices. Reduced crop productivity associated with heat and drought stress is expected, with strong adverse effects on regional, national, household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (high confidence) (IPCC, 2014). The present risk is approaching medium, but in the near term (2030–2040) will come to above medium, and due to the increased demand in the future will be growing to become very high.

In combination with non-climatic pressures, the decline in rural livelihood options in the Arab region could trigger further urban migration, potentially exacerbating urban vulnerability and intensifying the potential for conflict. With the growing rate of population, the increase in demand for irrigation water will be difficult to meet and will exhaust the non-renewable groundwater and surface water as well. This will eventually lead to rising food prices that often follow production shocks and long-term declines, rendering the growing number of urban poor who are increasingly vulnerable to malnutrition.

Syria Hit hard by Extreme Drought

The conflict in Syria has also damaged vast farming areas, displaced thousands of Syrian farmers and triggered a sharp increase in the cost of agricultural inputs including seeds, fertilizers, pesticides, fuel and farm equipment and reduced availability of these necessary inputs. Sporadic water availability is still a general complaint of the farmers in irrigated areas.

Extreme weather conditions during Syria's seventh year of conflict has caused domestic cereal production to decline sharply. Wheat production in 2018 fell to a 29-year low of 1.2 million tons, about two-thirds of 2017 levels. Farmers have reported it as the worst agricultural season in living memory in Al-Hasakeh, the northeastern region that typically provides almost half of the country's wheat. Barley, a more drought-tolerant crop, fared better but production still fell to its lowest level since 2008.

During the agriculture season of 2007–2008 and due to severe drought in Syria, 75% of the country's farmers suffered total crop failure, where wheat production dropped by 39.8% from 0.43 to 0.25 million tons from the year 2000 to the year 2009 in Al-Hassaka governorate in the eastern part (Kattana, 2011). Barley production which is considered an important crop for rainfed areas in the country, and is used as fodder for animals has decreased in the years 2005-2009 by up to 40%, besides the absence of natural pastures. The estimated number of sheep population has dropped from 2.47 million heads in the year 2005 to 1.5 million heads in the year 2009, and the livestock population was 50% below the pre-drought level more than a year after the drought ended (Kattana, 2011 and Erian *et al.*, 2012).

In Syria, the crop production decline (prior to the current armed conflict) already exceeded by 25% the projected CC impacts on food production that was estimated by IPCC during the period 2030–2049. Accordingly, the expected decline in production after 2050 might take place earlier, and the risk of extremely severe yield impact might also increase depending on the level of warming. This projected impact is occurring in the context of rapidly rising crop demand. It has affected the stability of Syria rural communities and could cause similar instability situations in other areas as indicated by Erian *et al.* (2006).

It is to be taken into consideration that the top nine wheat importers are all in the Middle East and that 65% at least of the fresh water is coming from surrounding countries. As the region's population continues to climb, water availability per capita is projected to plummet; rapid urban expansion across the Arab world increasingly threatens the region, overburdening existing infrastructure and outpacing local capacities to expand service.

Consequently, based on the above, it can be concluded that all people of the drylands in the Arab region are vulnerable to the impacts of climate change and variability on water availability and food security. Conflicts and cities are made worse by the rapid growth, partly driven by displacement and migration by rural and fragile poor communities. Climate change in rural areas will take place in the context of many important economic, social, and land use trends (Erian *et al.*, 2014).

3.5 The Economic Values of Vegetation losses

The assessment of the economic vegetation losses in the Arab region, after Erian *et al*. (2014), is based on the combined impact of agriculture drought and land degradation on the Arab region vegetation cover. This includes Rangelands, Rainfed croplands, and Forest areas that represent 97% of the total vegetation cover areas in the Arab region with a total permanent cover of 454.87 million hectares. The total estimated losses on land and rural permanent and seasonal jobs could be illustrated as follows:

The Arab region is under growing food insecurity, increasingly food gap, and increased drought at a time when 28% of its population is already under in poverty.

In the Arab region, drought and desertification are usually coupled with high sensitivity of vegetation cover and crops to climate change. This vulnerability will usually result in rapid land use changes and increasing land degradation. Several cases in the region clearly show the increasing interaction between climate, land, water, food, migration, urbanization, and economic, social, and political stress. This risk-resilience nexus embraces abilities to properly adapt to climate change

- About 22.08 million hectares of Rainfed croplands that value around 6.2 billion US$ are lost within the range of 10 to 12 years, leaving 14.5 million workers jobless. Countries of relatively larger Rainfed cropland losses could be ranked as follows: Sudan, Somalia, Syria, Iraq, Morocco, Yemen, Mauritania, Saudi Arabia, Algeria, Libya, Egypt, Tunisia, Palestine, Jordan, Lebanon, Oman and very minor areas in United Arab Emirates, Kuwait, Djibouti and Qatar, as shown in (Figure 26).
- About 43.8 million hectares of Rangelands that value around 4.9 billion US$ are lost within the range of 10 to 12 years, leaving 2.5 million workers jobless. Countries of relatively larger Rangeland losses could be ranked as follows: Somalia, Sudan, Iraq, Syria, Mauritania, Yemen, Djibouti, Saudi Arabia, Libya, Algeria, Morocco, Jordan, Tunisia, Oman, Egypt, Palestine, Lebanon and minor areas in Qatar, Kuwait and UAE, as shown in (Figure 27).
- About 1.35 million hectares of forests that value around 0.32 billion US$ are lost in approximately 10 to 12 years, leaving 0.17 million workers jobless. Countries of relatively larger losses in forests could be ranked as follows: Algeria, Sudan, Somalia, Syria, Tunisia, Morocco, Iraq, Saudi Arabia, Lebanon, Yemen and Oman. In the Mediterranean region, higher fire risk, longer fire season, and more frequent large and severe forest fires are expected as a result of increasing heat waves in combination with drought (Duguy *et al.*, 2013).
- In total for all Arab countries, about 67.28 million hectares of Vegetation Cover, that value around 11.51 billion US$ are lost in approximately 10 to 12 years, leaving 22.79 million workers jobless and are in need of about 59 billion US$ for creation of alternative job opportunities. Countries of relatively larger losses in total vegetation cover in the Arab Region could be ranked as follows: Djibouti, Algeria, Sudan, Somalia, Egypt, Iraq, Jordan, Syria, Libya, Oman, Qatar, Kuwait, Mauritania, Morocco, Lebanon, Yemen, Saudi Arabia, Tunisia, West Bank, and United Arab Emirates (Figure 28).

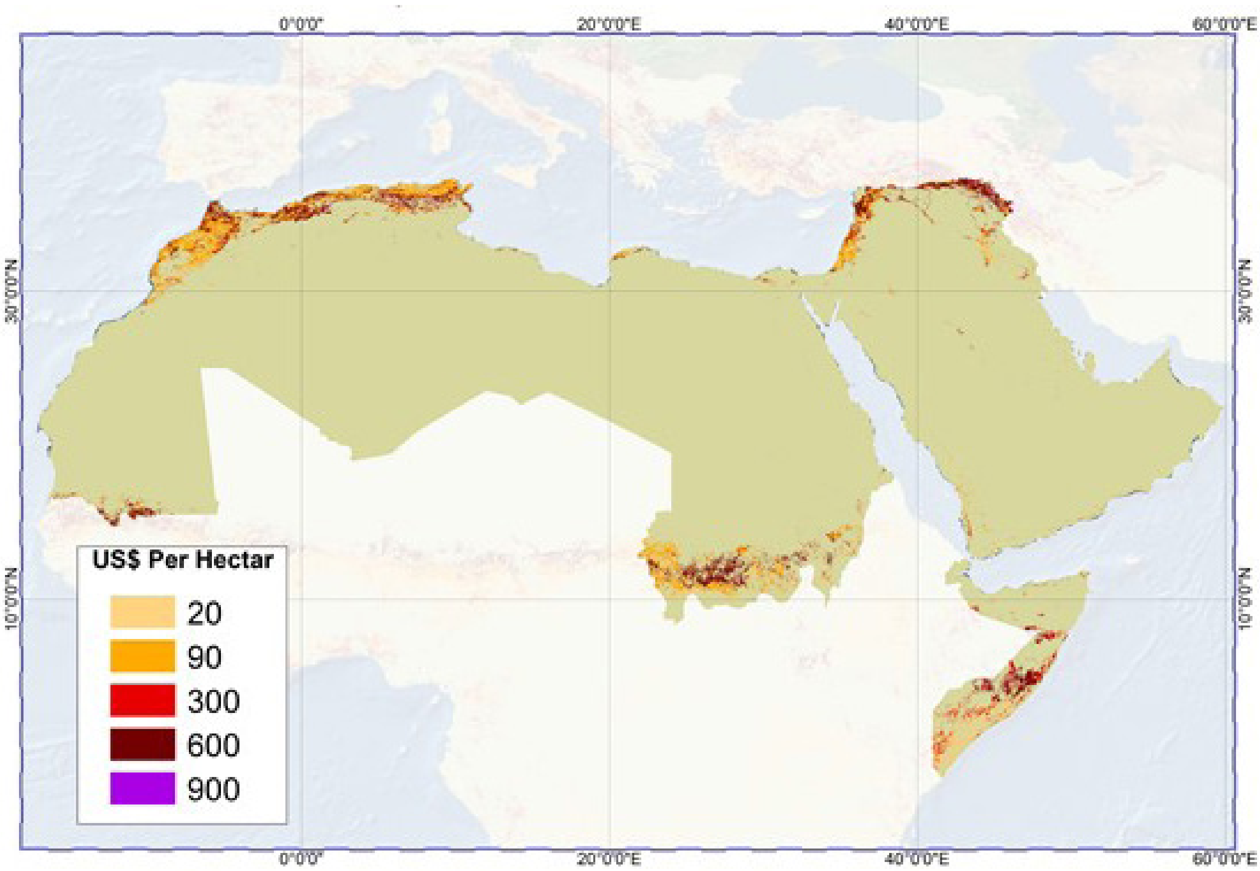


Figure 26: Vegetation losses in Rainfed Cropland areas, after Erian et al., 2014

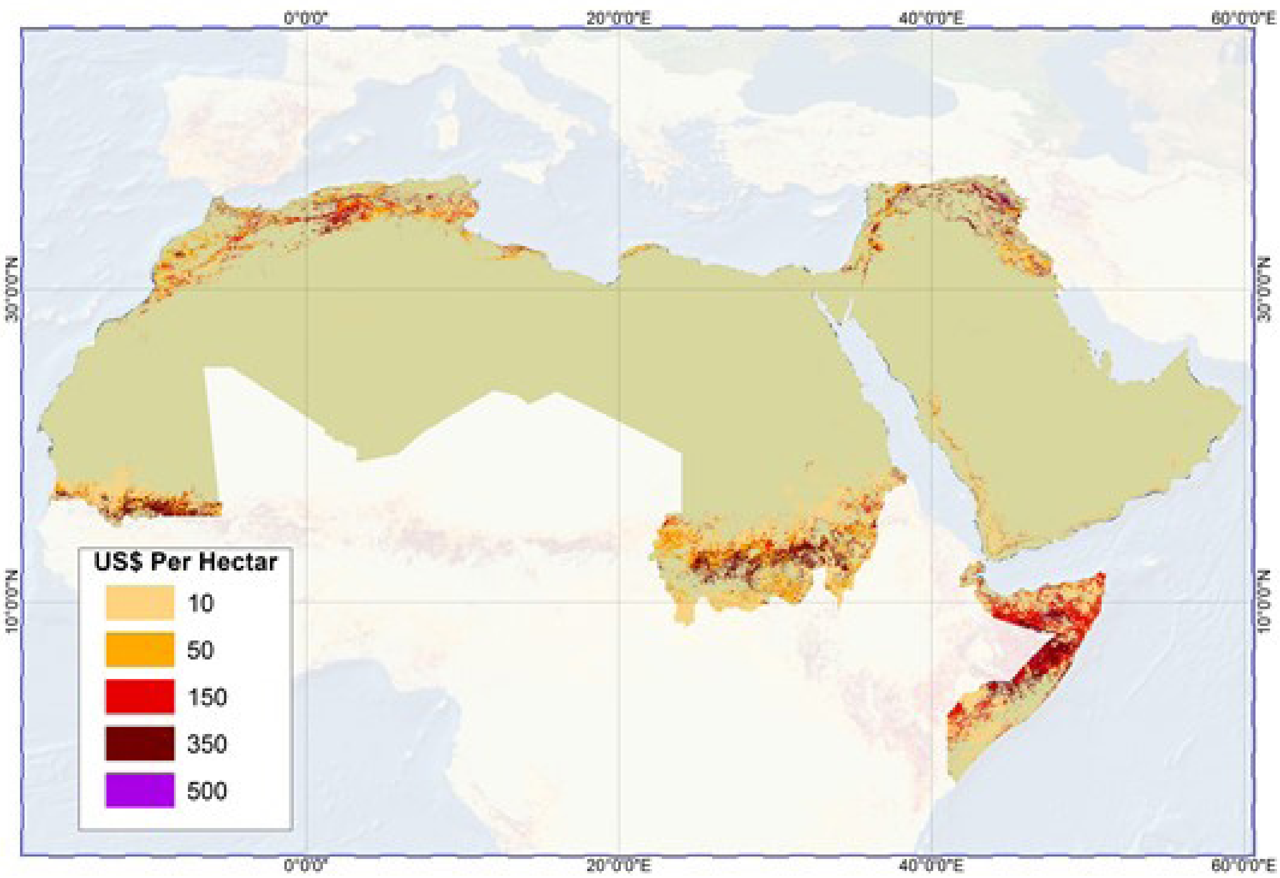


Figure 27: Vegetation losses in Rangeland Cropland areas, after Erian et al., 2014

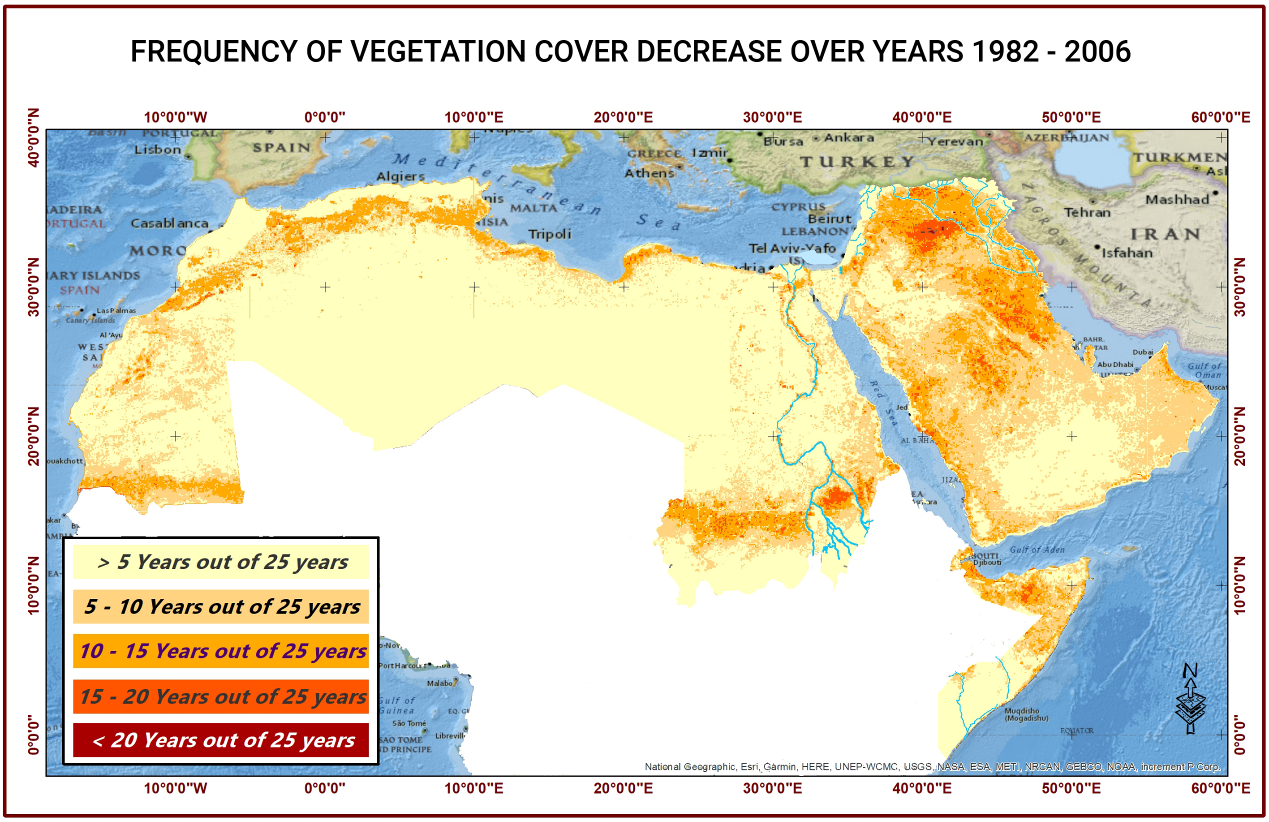


Figure 28: Frequency of Vegetation Cover Decrease over the years

3.6 Social Vulnerability and Human Security

To date, there is no agreed definition of social vulnerability in the Arab Region. Yet in 2016, the Arab Water Council undertook several trials to shed light on this controversial topic through consultations with regional stakeholders. Considerable efforts were made to strengthen the understanding of social vulnerability in the Arab region and to reach common consensus on what social vulnerability might mean for the Arab region. One of the most agreed upon definitions among stakeholders was as follows: «Social vulnerability is the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed» (AWC, 2017). This involves a combination of factors that determine the degree to which someone's life and livelihood are at risk by a discrete and identifiable event in nature or society.

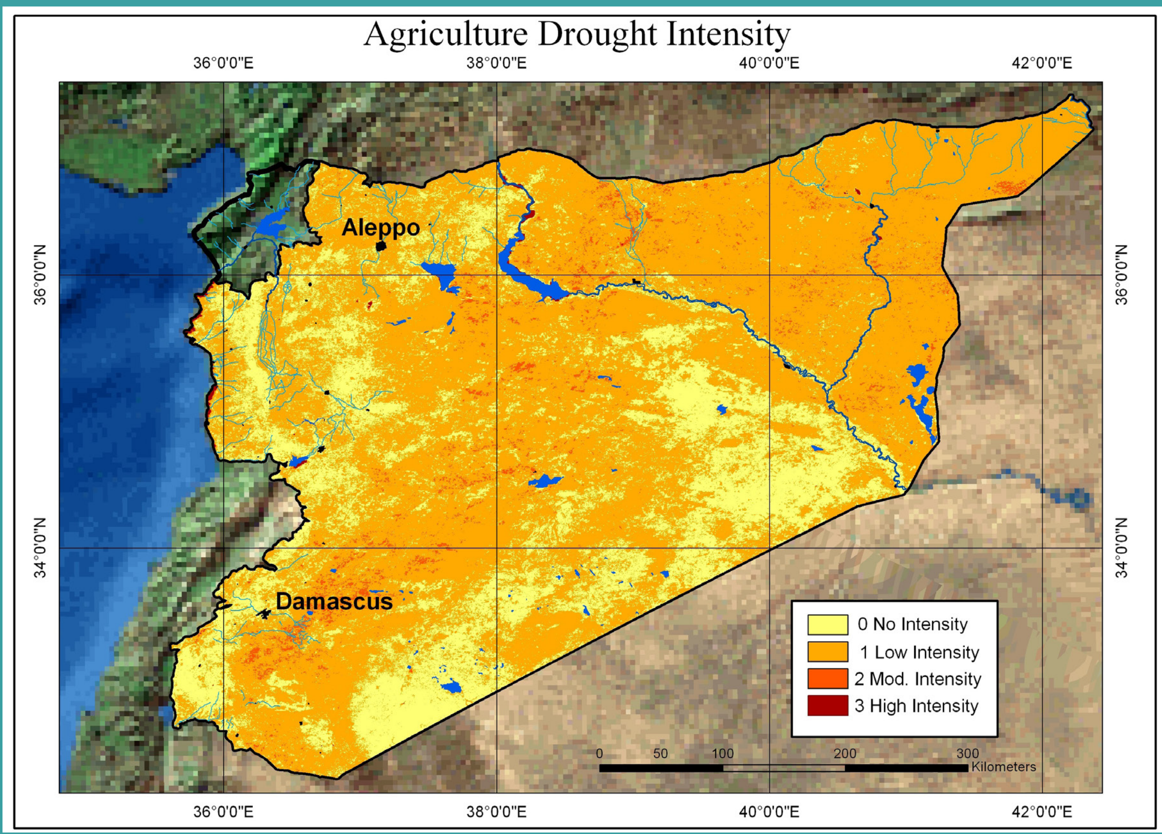
Traditionally, most stressors and shocks, including their impact, have been understood primarily from a physical world, such as infrastructure, while the socio-economic and environmental aspects have been less understood and researched. Recently, however, partly as a result of the emerging concept of social vulnerability, the discourse on shocks and stressors has come to also involve socio-economic factors.

Rainfall performance influences farmers' cropping and pasture availability for pastoral livelihoods, and therefore is directly linked to questions of food security, animal welfare and, thus, human security for all forms of livelihoods. Social and material practices combine with natural processes and evolve into novel forms of hazard – both potential and actual disasters.

The majority of the poor, through their desperate, and sometimes inappropriate, use or overuse of the few resources available to them, both degrades their environments and places them in a harmful situation, largely through the lack of reasonable alternatives for daily survival. Many disasters today are also closely linked to current conditions of environmental degradation (Varley, 1994).

Many vulnerable groups do not have the resources to avoid the impacts of floods, storms, and droughts, a fact that can lead to migration and resettlement. Migrants themselves may be vulnerable to climate change impacts in new destination areas, particularly in urban centers in developing countries.

Migration and mobility are adaptation strategies in all regions of the world that experience climate variability. Specific populations that lack the ability to move also face higher exposure to weather-related extremes, particularly in rural and urban areas in low and middle-income countries. Expanding opportunities for mobility can reduce vulnerability to climate change and enhance human security.

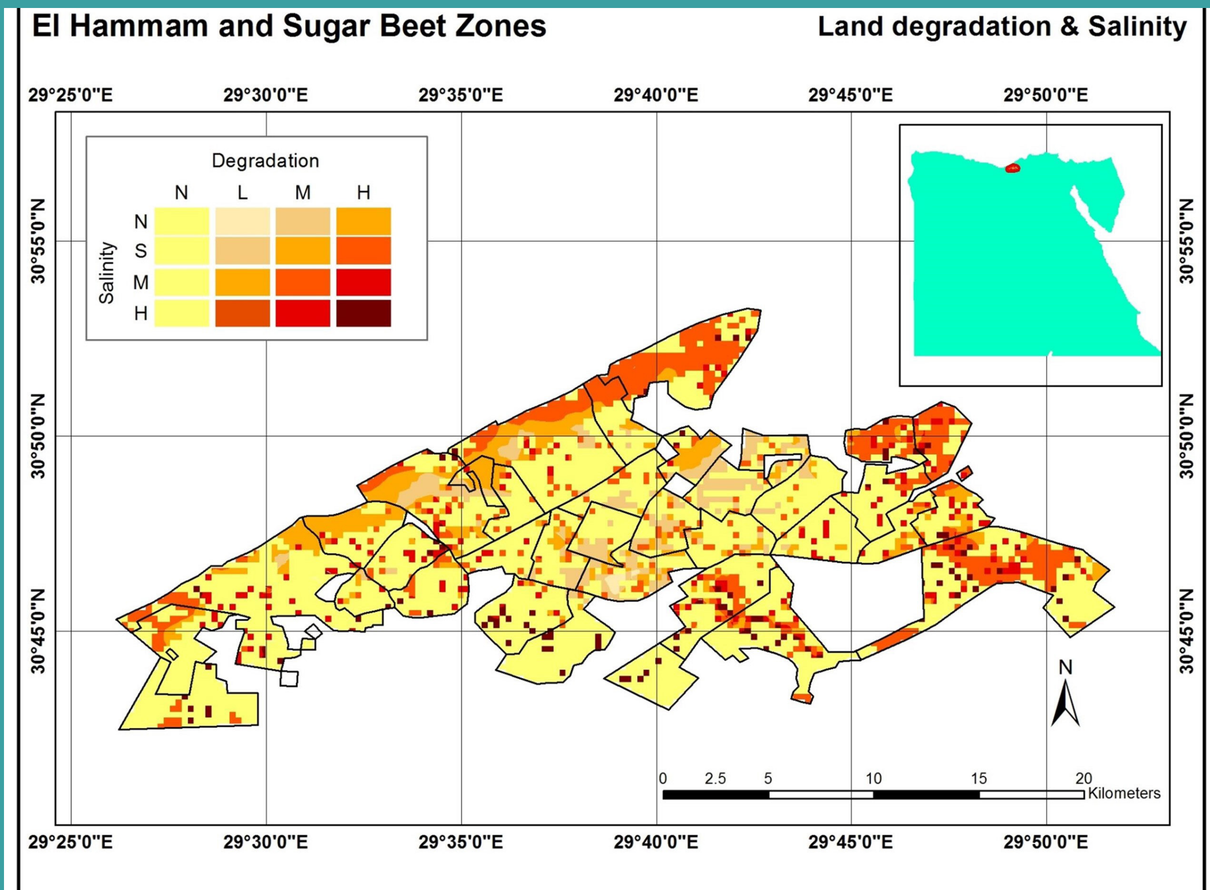


Agriculture Drought Intensity Map of Syria for the Period 2000-2010

Prior to the eruption of Conflict in Syria in 2011 and during the years 2007 to 2011, some 1.3 million people (206000 households) of a population of 22 million have been severely affected by the extreme drought events. Migration out of the affected areas targeted the urban settlements in the so-called mass migration towards Syria's cities in search of work and new sources of income. Many of the immigrants will end up with difficult laboring work and extreme hardship (Nashawatii, 2011 and Erian *et al.*, 2011).

Climate change threatens human security because it undermines livelihoods and compromises culture and individual dignity. Situations of acute insecurity, such as famine, conflict, and socio-political instability, almost always emerge from the interaction of multiple factors. For many populations that are already socially marginalized, resource-dependent, and have limited capital assets, human security will be progressively undermined as the climate changes. Poverty, discrimination of many kinds, and extreme natural and technological disasters undermine human security.

Human insecurity almost never has a single cause, but instead emerges from the interaction of multiple factors. Climate change is an important factor threatening human security through: (1) Undermining livelihoods; (2) Compromising culture and identity; (3) Increasing migration that people would rather have avoided; and (4) Challenging the ability of states to provide the conditions necessary for human security.



Land Degradation Map in Sugar Beet and El Hammam Zones, Nubariya Province, Egypt

Social Vulnerability, Drought Risks and need for Building Resilience in Sugar Beet and El Hammam Zones, Nubariya Province, Egypt

Since the beginning of the land distribution at 1989 up till now the total population increased by 537%, the first increase of which took place during the first 10 years. The main reason could be that the young graduates established their families and the number of children increased to 46% of the total community. Fifteen years later, many changes took place in the region and the total dropped owners of lands represented 14% of the total people that received the lands at the beginning of the project.

The majority of dropped farmers were due to irrigation problems, lack of adequate services, agricultural services and reduction of land production in many places due to land degradation (mainly soil salinity in high lands and water logging in low lands) and the deterioration in infrastructure and standard of living.

The evidence on the effect of climate change and variability on violence is contested. Although there is agreement about direct causality, low per capita incomes, economic contraction, and inconsistent state institutions are associated with the incidence of violence. These factors can be sensitive to climate change and variability.

Poorly designed adaptation and mitigation strategies can increase the risk of violent conflict. Evidence shows that large-scale violent conflict harms infrastructure, institutions, natural capital, social capital, and livelihood opportunities. Since these assets facilitate adaptation to climate change, there are grounds to infer that conflict strongly influences vulnerability to climate change impacts.

Climate and the Multiple Causes of Conflict in Darfur, Sudan

Climate variability or climate change are popularly reported to be significant causes of the conflict in Darfur region that began in 2003 (Mazo, 2009). Five detailed studies dispute the identification of the Darfur conflict as being primarily caused by climate change (Kevane and Gray, 2008[1]; Brown, 2010[2]; Hagen and Kaiser, 2011[3]; Sunga, 2011[4]).

CC directly related impacts include drought, vegetation losses, ecosystem deterioration, limited economic development and inadequate provision of public services and social protection. Other factors contributing to the conflict are poor governance and policy failures, political instability, and misuse of official development assistance.

1 Kevane, M. and L. Gray, 2008: Darfur: rainfall and conflict. Environmental Research Letters, 3(3), 034006, doi:10.1088/1748-9326/3/3/034006.
2 Brown, I.A., 2010: Assessing eco-scarcity as a cause of the outbreak of conflict in Darfur: a remote sensing approach. International Journal of Remote Sensing,31(10), 2513-2520.
3 Hagan, J. and J. Kaiser, 2011: The displaced and dispossessed of Darfur: explaining the sources of a continuing state-led genocide. British Journal of Sociology, 62(1), 1-25.
4 Sunga, L.S., 2011: Does climate change kill people in Darfur? Journal of Human Rights and the Environment, 2(1), 64-85.

Government should develop contingency plans and mobilize financial resources for the potential permanent replacement of severely affected communities, mainly most resource-poor, small-scale farmers and poorer households. Additionally, and to avoid the conflict related to multiple challenges at the climate-poverty-development nexus, the Arab region should increasingly focus on the root causes of poverty, and climate change and build development pathways towards greater social and environmental sustainability, equity, resilience, and justice.

3.7 Multi-dimensional Inequality and Social Vulnerability

Climate change interacts with existing inequalities to affect particular population groups more than others and may also undermine poverty alleviation efforts. Poor countries will likely face critical challenges, including the destruction of entire communities and millions of premature deaths. They will suffer the most, they will suffer disproportionately, as they are already. Therefore, climate variability and change, as well as climate-related disasters, contribute to and exacerbate the economic inequality in urban and rural areas. Variable expenditures on water and sanitation among the Arab States showed that in Kuwait, 18.4 % of the national budget is directed towards water and sanitation programs as compared to 1.9% in Tunisia and 1.3% in Egypt. The percentage of GDP directed to sanitation and hygiene is as high as 10.9% in Jordan and as low as 0.06% in Sudan. The cost recovery for operation and maintenance for water and sanitation services reaches 83% in Jordan and 80% in Tunisia, 75% for Egypt and UAE, and 9% for Iraq.

Mounting inequality is not just a side effect of weather and climate change/variability but also the interaction of related impacts with multiple deprivations at the specific intersections of gender, age, race, class, caste, indignity, and (dis)ability (Nightingale, 2011, Kaijser and Kronsell, 2013).

Specific Gender Inequalities intensify vulnerability to Climate Change. The drivers of gender-based vulnerability to climate change can be separated into three general areas of inequality: access to resources, opportunity for improving existing livelihoods and developing alternative livelihoods, and participation in decision-making. In the rural areas of Arab countries, structural inequalities and socio-cultural norms most often disadvantage women, and especially poor women, in these three areas, thus intensifying their exposure and sensitivity to climatic changes. As a result, rural women are more likely to have lower adaptive capacity than men. Their lower adaptive capacity results in exacerbated well-being, impacts on individuals, households, and communities. Inequality between males and females increases as females assume many of the new burdens associated with climate change. Promoting gender equity, by tackling both discriminatory norms and inequalities in access to resources, is thus a vital component of effective climate change adaptation strategies

As men in rural areas move to cities to seek employment when they lose their traditional livelihoods due to depleting natural resources, **rural women would be under pressure to take over their husbands' activities on top of their own daily activities.**

In Yemen and Sudan, daily activities for women and children include the necessity of traveling increasing distances to fetch potable water (e.g. up to 4 km in the West Kordofan state in Sudan). This additional labour has forced girls in rural areas to drop out of schools[1].

1 Twining-Ward, T., Khoday, K., Tobin, C., Baccar, F., Mills, J.T., Ali, W. and Murshed, Z. (2018). Climate change adaptation in the Arab States. Bangkok: UNDP

3.8 Climate Change and Sustainable Development

Poverty is a complex social and political problem, intertwined with processes of socio-economic, cultural, institutional, and political marginalization and deprivation, in low-, middle-, and even high-income countries. Climate change-driven impacts are one of many important causes of poverty. They often act as a threat multiplier, meaning that the impacts of climate change compound other drivers of poverty. Climate-change impacts are projected to slow down economic growth, make poverty reduction more difficult, further erode food security, and prolong existing poverty traps and create new ones, particularly in urban areas and emerging hotspots of hunger.

Poor households that are net buyers of food are expected to be particularly affected due to food price increases, especially in countries with food insecurity issues although the increase in agriculture products could benefit agricultural self-employment.

This complexity makes detecting and measuring attribution to climate change exceedingly difficult. Even modest changes in seasonality of rainfall, temperature, and wind patterns can push transient poor and marginalized people into chronic poverty as they lack access to credit, climate forecasts, insurance, government support, and effective response options, such as diversifying their assets. Such shifts have been observed among climate-sensitive livelihoods in informal settlements and urban slums.

Some trans-boundary impacts of climate change, such as changes in shared water resources, have the potential to increase rivalry among states. **The presence of robust institutions can manage many of these rivalries** such that human security is not severely eroded.

Upstream water development projects for shared rivers constitute an enormous threat to water security for the whole region. Severe impacts are already encountered by Syria, Iraq and potentially Egypt.

Extreme events, such as floods, droughts, and heat waves, especially when occurring in a series, can significantly erode poor people's assets and further undermine their livelihoods in terms of labour productivity, housing, infrastructure, and social networks. Indirect impacts, such as increases in food prices due to climate-related disasters and/or policies, can also harm both rural and urban poor people who are net buyers of food.

In the Arab Region, populations are growing at unprecedented rates. The total population of the Arab world is likely to hit 700 million people by 2050; this is roughly twice the size of today's population. This growth will increase the demand for scarce resources, including water and land (World Bank, 2012). With continued desertification, the crop land (Ha/ person) could be dropped to 0.15 in the year 2040 resulting in a food gap up to US$ 100 B provided that this huge volume of food is available in the world market. The water shortage problems already experienced could reach the crisis level with 44% shortage expected in the year 2040. This will be cumulated if current trends in land degradation continued (Figure 29). Arab countries' capacity to respond to climate change-related pressures is hampered, inter alia, by limited knowledge on possible impacts, limited regional assessments of vulnerabilities and costs, limited coordination at national and regional levels, and lack of awareness or consensus on policy options and possible response measures. Unless serious and collective measures are properly planned and implemented, the climate variability impacts in the region will increase and the climate of Arab countries will experience unprecedented extremes, higher rates of poverty and unemployment percentage. This will reduce the quality of life, socio-economic disturbance, increase food insecurity, causing high rates of conflicts and displacement that will cause high instability.

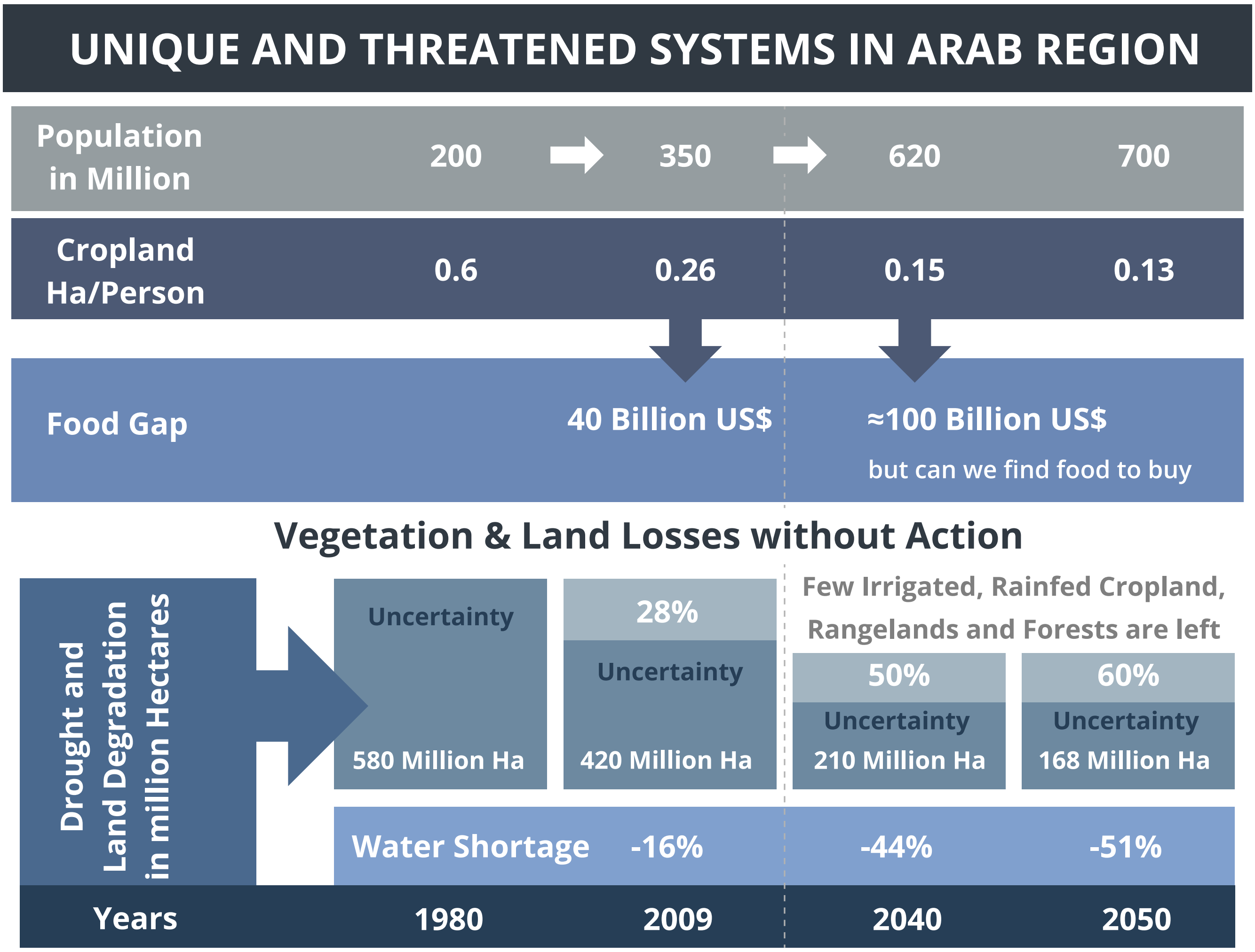


Figure 29: IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

THREE CASE STUDIES FROM DIFFERENT REGIONS OF THE ARAB WORLD

CASE STUDY 1[1]:

Effects of Agricultural Drought Hazard and Land Degradation on Crop Losses in the Arab Region

Background

Land degradation constitutes one of the major problems facing a healthy environment and sustainable management of natural resources. The severe sensitivity of vegetation to climate change may result in rapid land use changes and severe vulnerability to land degradation. In the Arab region, land degradation is considered an extremely serious problem, as most countries are suffering from desertification in various types and degrees.

In this case study, areas in the Arab region that are subject to different severe levels of both land degradation (LD) and agricultural drought hazard (ADH) were identified, and the impacts on their land cover were estimated. Finally, crop losses resultig from combined drought and land degradation were calculated with the associated economic impacts.

Agricultural Drought Hazard in the Arab Region

The studied area covers 22 countries and represents approximately 1.34 billion hectares of land. The total rainfed areas are covering 439 million hectares (representing 32.8% of the total studied area). These rainfed areas could be sub-divided into 3 main land use types, the rainfed croplands area, the rangelands area and the forests that represent 7.4%, 19.83% and 5.6% of the total studied area respectively.

The agricultural drought hazard (ADH) map was produced and classified into 4 major groups:

- C1: No ADH covering 885.74 million Km^2 of the study area, representing 66.21%.
- C2: Slight ADH covering 2.4 million Km^2 of the study area, representing 17.88%.
- C3: Moderate ADH covering 1.6 million Km^2 of the study area, representing 11.91%.
- C4: Severe ADH covering 0.53 million Km^2 of the study area, representing 4.01%.

Total effected areas by ADH are ≈ 452 million hectares representing 33.76% of the total Arab Region area, but the severely affected (moderate and severe) areas are ≈ 213 million hectares representing 15.92% of the total study area.

1 "Effects of Drought and Land Degradation on Vegetation Losses in Africa, Arab Region with Special Case Study on: drought and conflict in Syria, South America and Forests of Amazon and Congo Rivers Basins", Background paper prepared for the 2015 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR "Agriculture Drought in Latin America", Special Document for UNISDR Global Assessment Report 2015.

Countries could be sorted by ADH coverage and severity % as follows:

Country	ADH Severity			ADH total Coverage (1+2+3)	High Severity (1+2)
	Severe =1	Moderate =2	Slight =3		
Lebanon	15.16	24.67	49.79	89.62	39.83
Gaza Strip	9.69	35.09	44.82	89.60	44.78
Qatar	18.15	33.34	34.88	86.37	51.49
Morocco	2.9	31.14	50.18	84.22	34.04
Kuwait	47.12	26.71	9.29	83.12	73.83
West Bank	3.8	19.96	57.23	80.99	23.76
Syria	19.87	30.02	29.90	79.79	49.89
Tunisia	10.6	20.17	39.03	69.80	30.77
Iraq	21.95	27.31	19.61	68.87	49.26
Djibouti	9.08	38.74	20.51	68.33	47.82
Somalia	18.56	34.01	3.96	56.53	52.57
Western Sahara	0.17	12.43	31.08	43.68	12.60
Saudi Arabia	4.09	11.50	24.12	39.71	15.59
United Arab of Emirates	0.14	6.69	32.85	39.68	6.83
Sudan	1.74	13.21	18.35	33.30	14.95
Yemen	1.87	11.80	15.79	29.46	13.67
Jordan	3.65	6.44	18.64	28.73	10.09
Algeria	3.34	9.41	12.77	25.52	12.75
Mauritania	1.03	9.61	14.13	24.77	10.64
Oman	0.18	3.40	15.85	19.43	3.58
Libya	0.6	2.86	13.34	16.80	3.46
Egypt	0.89	3.09	11.92	15.90	3.98

Case Study 1-Table 1. Severity and Total Agriculture Drought Hazard (ADH) Coverage in the Arab Region during the period 2000/2011

Affected Population by Agricultural Drought Hazard

The total affected population by ADH in the Arab region is 194.3 million people that represent ≈54% of the total Arab region population. At least 100 million people are slightly affected, 67 million people are moderately affected, and 27 million people are severely affected. (Case Study 1-Table 2).

Country	Total Population	Affected Population		Level of Affection					
		Total		Highly		Moderately		Slightly	
	People (million)	People (million)	%	People (million)	%	People (million)	%	People (million)	%
Palestine	4.33	3.79	88.8	0.47	13.1	1.18	28.95	2.14	46.85
Lebanon	4.14	3.66	88.4	0.62	14.9	0.98	23.7	2.06	49.8
Morocco	32.31	28.49	88.2	1.08	3.4	8.28	25.6	19.13	59.2
Kuwait	2.65	2.18	82.5	1.02	38.7	0.8	30.2	0.36	13.5
Qatar	1.95	1.6	82	0.23	11.7	0.69	35.1	0.69	35.4
Syria	22.53	18.15	80.6	4.51	20	7.26	32.2	6.39	28.3
Iraq	31.13	22.41	72	6.85	22	9.19	29.5	6.38	20.5
Djibouti	0.77	0.55	70.6	0.07	9.1	0.32	41.7	0.15	19.8
Algeria	35.41	24.7	69.8	2.97	8.4	8.65	24.4	13.08	37
Tunisia	10.73	7.49	69.8	1.18	11	2.26	21	4.06	37.8
Jordan	6.51	3.94	60.5	0.44	6.8	0.76	11.7	2.74	42.1
Benin	9.60	5.2	54.2	0.98	10.2	1.57	16.4	2.65	27.6
United Arab of Emirates	5.31	2.88	54.1	0.01	0.1	0.64	12	2.23	42
Western Sahara	0.52	0.26	50.1	0	0.3	0.08	14.6	0.18	35.2
Sudan	34.21	16.76	49	1.28	3.7	7.2	21.1	8.28	24.2
Somalia	10.09	4.76	47.2	1.41	14	2.91	28.9	0.44	4.4
Mauritania	3.36	1.45	43.2	0.09	2.7	0.64	19.1	0.72	21.4
Saudi Arabia	26.53	11.03	41.6	0.79	3	3.17	12	7.06	26.6
Yemen	24.77	10.15	41	1.23	5	4.31	17.4	4.61	18.6
Libya	6.73	2.48	36.8	0.28	4.2	0.74	11.1	1.45	21.6
Oman	3.09	0.98	31.6	0.04	1.3	0.2	6.5	0.74	23.8
Egypt	83.69	21.39	25.6	1.42	1.7	5.02	6	14.95	17.9
TOTAL	360.37	194.3	53.9	26.97	7.48	66.85	18.55	100.47	27.88

Case Study 1- Table 2. The total Affected Population by Agriculture Drought Hazard in the Arab Region (millions)

Land Degradation in the Arab Region

Total effected areas by LD are ≈ 600 million hectares which represents 44.84% of the total Arab Region area. The severely affected (moderate and severe) areas are ≈ 205 million hectares representing 15.35% of the total study area. Countries could be sorted by LD coverage and severity % as follows:

Country	LD Coverage %	LD Severity %
Kuwait	83	44.7
Djibouti	82.2	69.3
Saudi Arabia	68.7	28.9
Comoros	64.2	50.2
Iraq	64.1	51
Syria	63.1	51.6
Somalia	50.2	39.1
Egypt	47.3	10.7
Yemen	46.3	20.4
Qatar	45.9	13.3
Libya	45.8	6.2
Bahrain	41.1	24.2
Algeria	40.5	2.9
Palestine	39.4	28.03
Oman	38	9.5
Mauritania	36.9	8.9
United Arab of Emirates	35.3	6
Sudan	33.3	14.95
Jordan	29.1	9.3
Tunisia	27.3	13
Morocco	14.5	3.6
Lebanon	9.5	7.1

Case Study 1- Table 3. Severity and Total Land Degradation (LD) Coverage in the Arab Region during the period 2000/2011

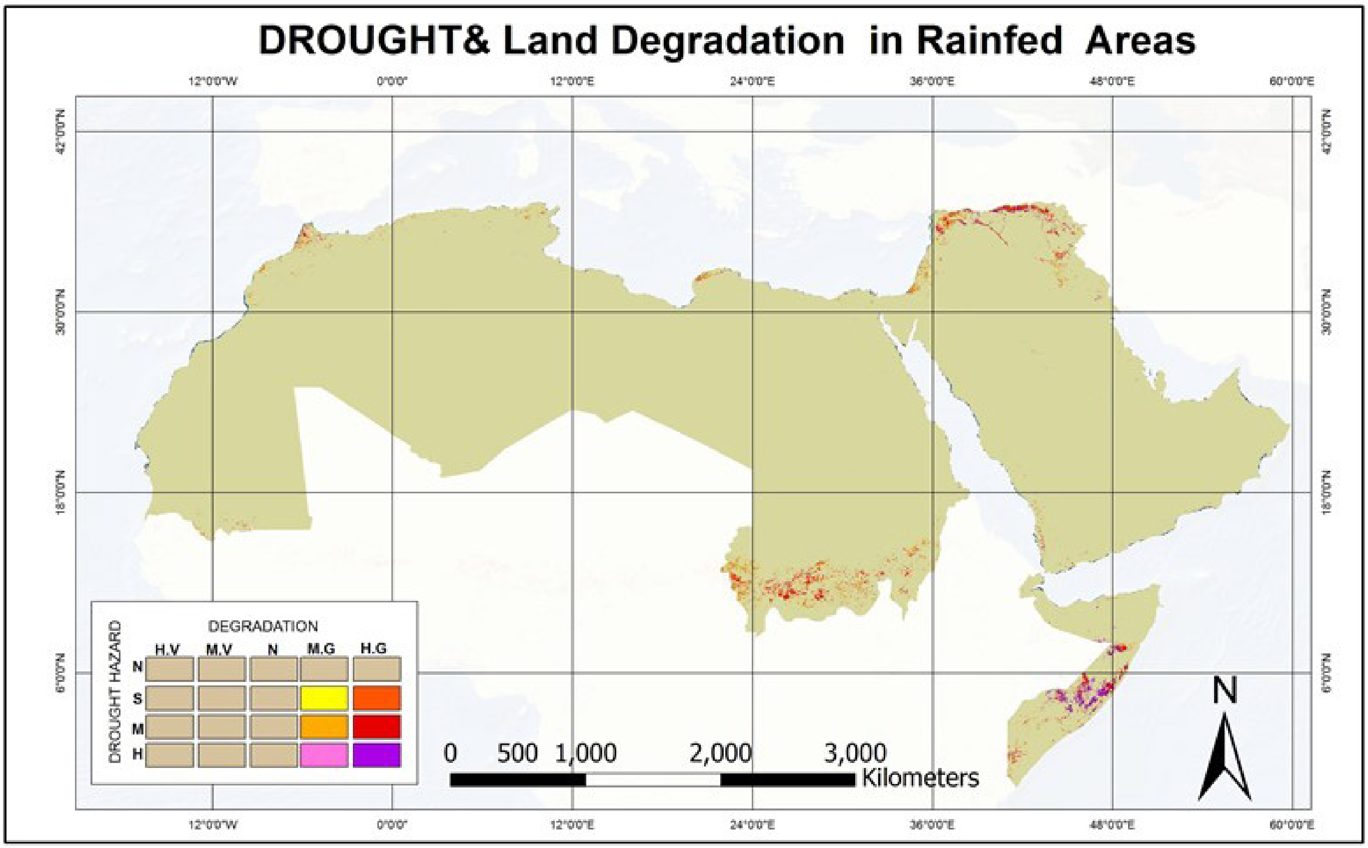
The Combined Effect of both Agricultural Drought Hazard (ADH) and Land Degradation (LD) on Land Use

Combined ADH with LD

The combining of the ADH and LD maps in the Arab Region could be classified in 6 classes as follows (Case Study 1- Figure 1):

- Class 1: High severity ADH and High severity LD (H ADH_ H LD) that covers an area of about 4.82 million hectares representing 0.36% of the total Arab region area.
- Class 2: High severity ADH and Moderate severity LD (H ADH_ M LD) that covers an area of about 18.73 million hectares representing 1.41% of the total Arab region area.
- Class 3: Moderate severity ADH and High severity LD (M ADH_ H LD) that covers an area of about 5.54 million hectares representing 0.41% of the total Arab region area.
- Class 4: Moderate severity ADH and Moderate severity LD (M ADH_ M LD) that covers an area of about 18.68 million hectares representing 1.41% of the total Arab region area.
- Class 5: Slight severity ADH and High severity LD (M ADH_ H LD) that covers an area of about 3.31million hectares representing 0.25% of the total Arab region area.
- Class 6: Slight severity ADH and Moderate severity LD (M ADH_ M LD) that covers an area of about 15.32 million hectares representing 1.15% of the total Arab region area.

Countries could be ranked according to severity coverage as follows: Syria, Algeria, Sudan, Oman, Tunisia, Comoros, Jordan, Djibouti, Yemen, Somalia, Lebanon, Libya, Palestine, Mauritania, Egypt, Iraq, Kuwait, Morocco, Qatar, Saudi Arabia, UAE and Western Sahara.



Case Study 1- Figure 1. Agricultural Drought Hazard combined with Land Degradation in the Arab Region

Exposing Land Use to combined ADH and LD

The total affected land used areas (Rangelands, Rainfed croplands and Forests) by combined ADH and LD cover approximately 66.36 million hectares, representing 4.96% of the total Arab region area. Countries and their local communities that depend on such areas for earning their living could be considered under a real threat.

The detailed impacts of combined ADH and LD on rangelands, rainfed croplands and forests could be summarized as follows:

- Impacts on Rangelands: The total affected area by combined ADH and LD covers 44 million hectares, representing 3.26% of Arab Region area, and affected countries could be ranked as follows: Sudan, Somalia, Iraq, Syria, Mauritania, Saudi Arabia, Yemen, Libya, Djibouti, Morocco, Algeria, Jordan, Tunisia, Palestine, Oman, Egypt, Lebanon, Qatar, UAE, Kuwait, Western Sahara and Comoros.
- Impacts on Rainfed Croplands: The total affected areas by combined ADH and LD cover 20.6 million hectares, representing 1.54% of the total studied area, and countries could be ranked as follows: Somalia, Sudan, Syria, Iraq, Jordan, Morocco, Yemen, Mauritania, Saudi Arabia, Algeria, Libya, Egypt, Tunisia, Palestine, Lebanon, Oman, UAE, Kuwait, Djibouti, Qatar, Bahrain, Comoros and Western Sahara.
- Impacts on Forests: The total affected Forests area by combined ADH and LD cover 1.78 million hectares, representing 0.14% of the total studied area, and affected countries could be ranked as follows: Syria, Algeria, Sudan, Oman, Tunisia, Comoros, Jordan, Djibouti, Yemen, Somalia, Lebanon and Libya.

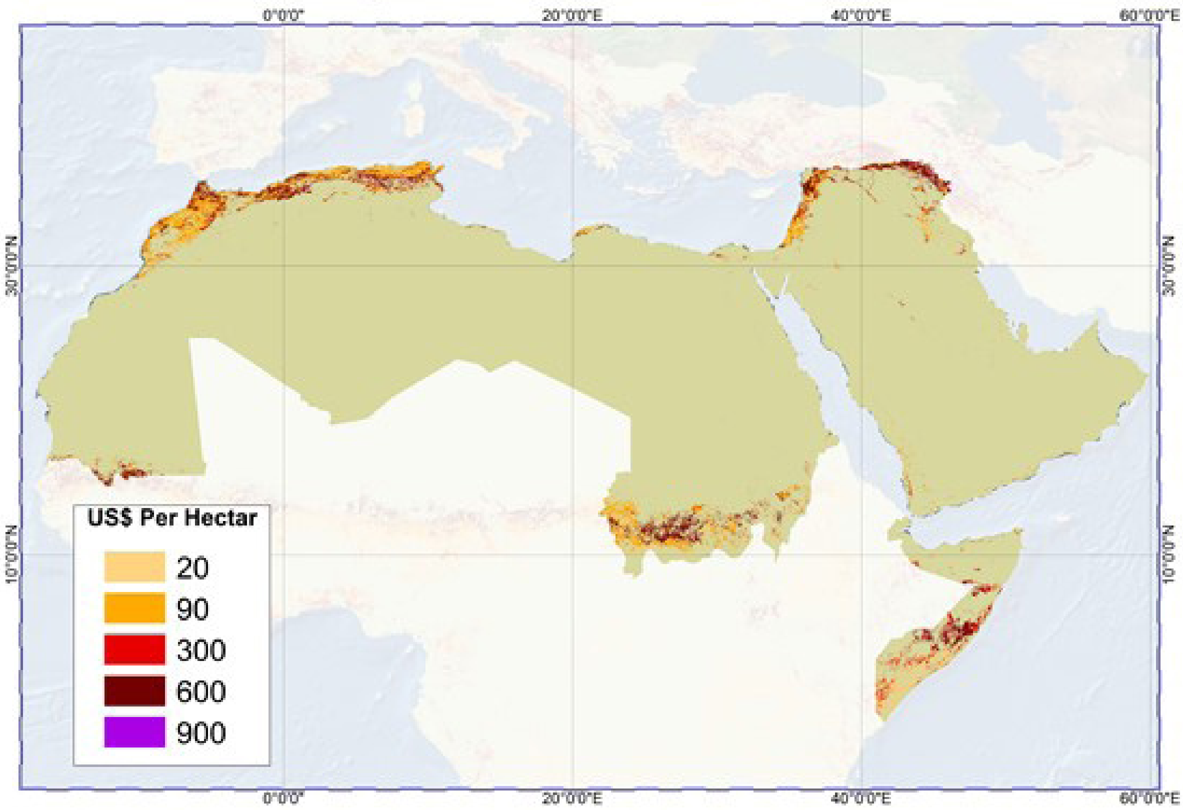
Assessing Vegetation Losses by combined Drought and Land Degradation Hazards

Assessment of the economic vegetation losses is based on the combined impact of ADH and LD on Arab region vegetation cover that includes Rangelands, Rainfed croplands, and Forests areas, representing 97% of the total vegetation cover (Case Study 1-Figure 2a & b).

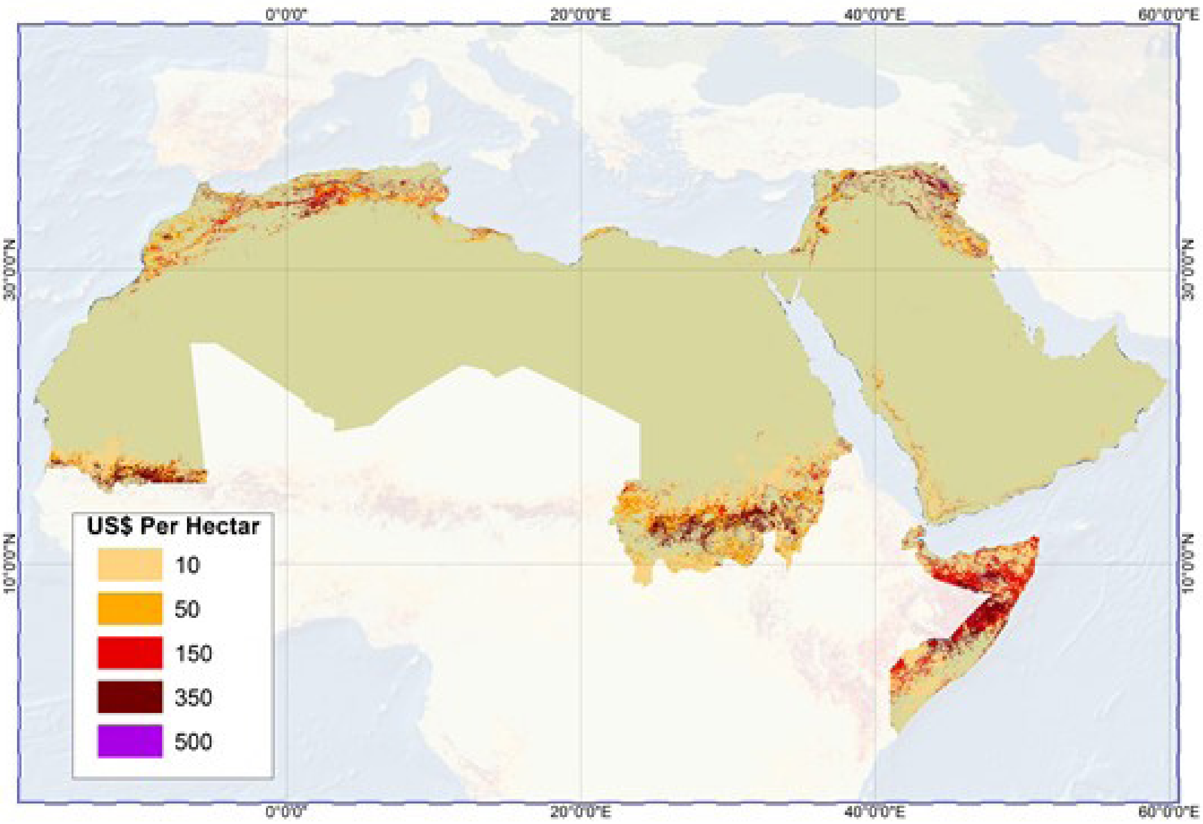
The total estimated losses on land and rural permanent and seasonal workers that lost their jobs in the Arab region could be summarized as follows:

- About 22.08 million hectares of Rainfed croplands that value 6.2 billion US$ are lost in ≈10 to 12 years, leaving 14.5 million workers jobless. Countries of relatively larger losses could be ranked as follows: Sudan, Somalia, Syria, Iraq, Morocco, Yemen, Mauritania, Saudi Arabia, Algeria, Libya, Egypt, Tunisia, Palestine, Jordan, Lebanon, Oman and very minor areas in United Arab Emirates, Kuwait, Djibouti and Qatar.
- About 43.8 million hectares of Rangelands that value 4.9 billion US$ are lost in ≈ 10 to 12 years, leaving 2.5 million workers jobless. Countries of relatively larger losses could be ranked as follows: Somalia, Sudan, Iraq, Syria, Mauritania, Yemen, Djibouti, Saudi Arabia, Libya, Algeria, Morocco, Jordan, Tunisia, Oman, Egypt, Palestine, Lebanon and minor areas in Qatar, Kuwait and UAE.
- About 1.35 million hectares of Forests that value 0.32 billion US$ are lost in ≈ 10 to 12 years, leaving 0.17 million workers jobless. Countries of relatively larger losses could be ranked as follows: Algeria, Sudan, Somalia, Syria, Tunisia, Morocco, Iraq, Saudi Arabia, Lebanon, Yemen and Oman.

- In total for all Arab countries, about 67.28 million hectares of Vegetation Cover, that value 11.51 billion US$ are lost in ≈ 10 to 12 years, leaving 22.79 million workers jobless and are in need of about 59 billion US$ for creation of alternative job opportunity. Countries of relatively larger losses in the Arab Region could be ranked as follows: Djibouti, Algeria, Sudan, Somalia, Egypt, Iraq, Jordan, Syria, Libya, Oman, Qatar, Kuwait, Mauritania, Morocco, Lebanon, Yemen, Saudi Arabia, Tunisia, West Bank, and United Arab Emirates.



Case Study 1-Figure 2a - Vegetation Losses in Rainfed Cropland Areas



Case Study 1-Figure 2b - Crop Losses in Cropland Areas

Conclusions

Drought is an extremely serious problem in the Arab region, and will be an increasingly serious threat as countries in the region are already suffering from increased conflicts, displacements and instability, alongside growing fragility of ecosystem services, with trends of land degradation, soil depletion and reduced water security.

The Arab region is under growing food insecurity, increasing food gap, and increased drought, at a time when 28% of its population is already under in poverty. Drought and desertification across much of the area with high sensitivity of vegetation cover and crops to climate change has usually resulted in rapid land use changes and high vulnerability to land degradation. It is, however, expected that the region will further observe continuing and increasing interaction between climate, land, water, food, migration, urbanization, and economic, social, and political stress. Due to the complexity of the events, it is very difficult to analyze and to draw precise causal arrows. This risk-resilience nexus embraces enhancing abilities to prevent impacts of future drought cycles on human development trends in the Arab region and how the influence of drought and/or climate change could affect Arab states.

CASE STUDY 2[2]:

Drought and Conflict in Syria

Agriculture and Food Security in Syria

As in other Arab countries, the uprising in Syria was triggered by a series of social, economic and political factors, including growing poverty caused by rapid economic liberalization and the removal of state subsidies after 2005, growing rural–urban divide, widespread corruption, rising unemployment and lack of political freedom. Economic situation has also deteriorated due to the effects of a severe drought between 2006 and 2010. More recently, media and analysts have indicated that climate change may have played an indirect role in the Arab Spring and the Syrian uprising.

With regard to the agriculture and food security in Syria, the following summarizes the main challenges (CFSAM, 2018):

- Extreme weather conditions during Syria's seventh year of conflict have caused domestic cereal production to decline sharply. Wheat production in 2018 fell to a 29-year low of 1.2 million tons, about two-thirds of 2017 levels. Farmers have reported it as the worst agricultural season in living memory in Al-Hasakeh, the northeastern region that typically provides almost half of the country's wheat. Barley, a more drought-tolerant crop, fared better but production still fell to its lowest level since 2008.
- The conflict in Syria has also damaged vast farming areas, displaced thousands of Syrian farmers and triggered a sharp increase in the cost of agricultural inputs including seeds, fertilizers, pesticides, fuel and farm equipment and reduced availability of these necessary inputs. Sporadic water availability is still a general complaint of the farmers in irrigated areas.
- While improved security, stability and the re-opening of supply routes have led food prices to decline by around 40 percent compared to last year, prices remain almost seven times higher than before the crisis. With unemployment rates reaching up to 60 percent, families grapple with reduced purchasing power, restricting their ability to cover their basic food needs.
- There remain also areas of serious concern where continued conflict is driving new displacements. It is estimated that around 5.5 million Syrians remain food insecure and require some form of food assistance, a decline of around 20 percent from the year before. In addition, some 500,000 to 800,000 people in the northern governorate of Idleb may be food-insecure.
- WFP is currently reaching around 3 million people with food assistance and plans to make a gradual shift from general food assistance, in the form of food rations, to more market-based programmes where markets are functional and supply routes are strong. This will have the added benefit of stimulating the local market.
- FAO's programmes helped farmers grow enough wheat to feed an additional 1.7 million people in 2017, keep livestock diseases at bay, and are contributing to rebuilding agricultural infrastructure and income-generating opportunities as well as supporting micro-gardens and other small-scale production initiatives among Syrian refugees in neighboring countries.

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2 "Effects of Drought and Land Degradation on Vegetation Losses in Africa, Arab Region with Special Case Study on: drought and conflict in Syria, South America and Forests of Amazon and Congo Rivers Basins", Background paper prepared for the 2015 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR "Agriculture Drought in Latin America", Special Document for UNISDR Global Assessment Report 2015.

This case study explores the risk-resilience nexus as a means of building sustainable responses that address recovery needs while also taking into account future drought risks. This helps strengthen resilience of communities and engages emerging resilience-based approaches and framework as a means of bridging humanitarian and development responses to the crisis. Data gathered for this case study were, however, limited to the period prior to eruption of the current armed conflict in 2011 to highlight impacts for the major drought took place between 2005-2009. It was also used to demonstrate the dire need of building resilience to climate change in the Arab countries.

Characterizing Drought Crises in Syria

Syria was hit by an intense and prolonged drought episode as a consequence of the very low values of precipitation registered during the two hydrological years comprized between 2005 and 2009. This drought event had major socio-economic impacts in several countries located within the affected area, namely: Iraq, Jordan and Iran in areas neighbouring Syria. The economic impact was mostly due to the steep decline in agricultural productivity in the highly populated areas of the Euphrates and Tigris river basins. The occurrence of the two strongest prolonged droughts in the last decade (1997-2000 and 2005-2009) raises some concerns that this could become the norm, rather than the exception, in the future.

During the year 2008, some 1.3 million people (6% of the total population), have been severely affected by drought, of which 800,000 have lost almost all their livelihoods and faced extreme hardship as a result of severe reduction in rainfall and increase in potential-evapotranspiration.

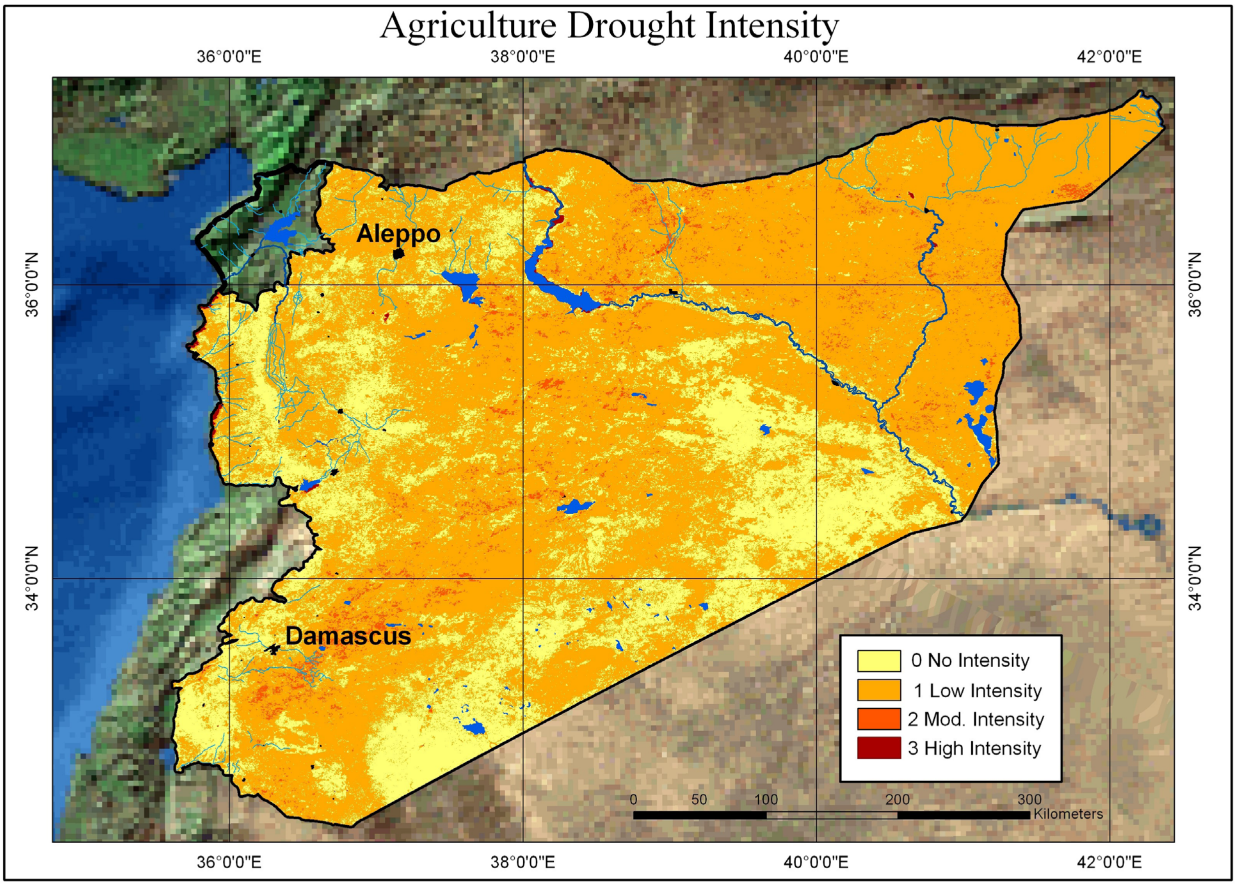
The drought that hit Syria in the last decade showed an advanced case of what has been indicated by Mariotti et al., (2008)[1] and IPCC (2012)[2]: There is medium confidence that droughts in the Mediterranean will intensify in the 21st century. The 20th century simulations indicate that the 'transition' towards drier conditions has already started to occur and has accelerated around the turn of the century towards the larger rates projected for the 21st century".

1 Mariotti, A., N. Zeng, J.H. Yoon, V. Artale, A. Navarra, P. Alpert, and L.Z.X. Li, (2008): Mediterranean water cycle changes: transition to drier 21st century conditions in observations and CMIP3 simulations. Environmental Research Letters, 3(4), Art. 044001 (8 pp.)

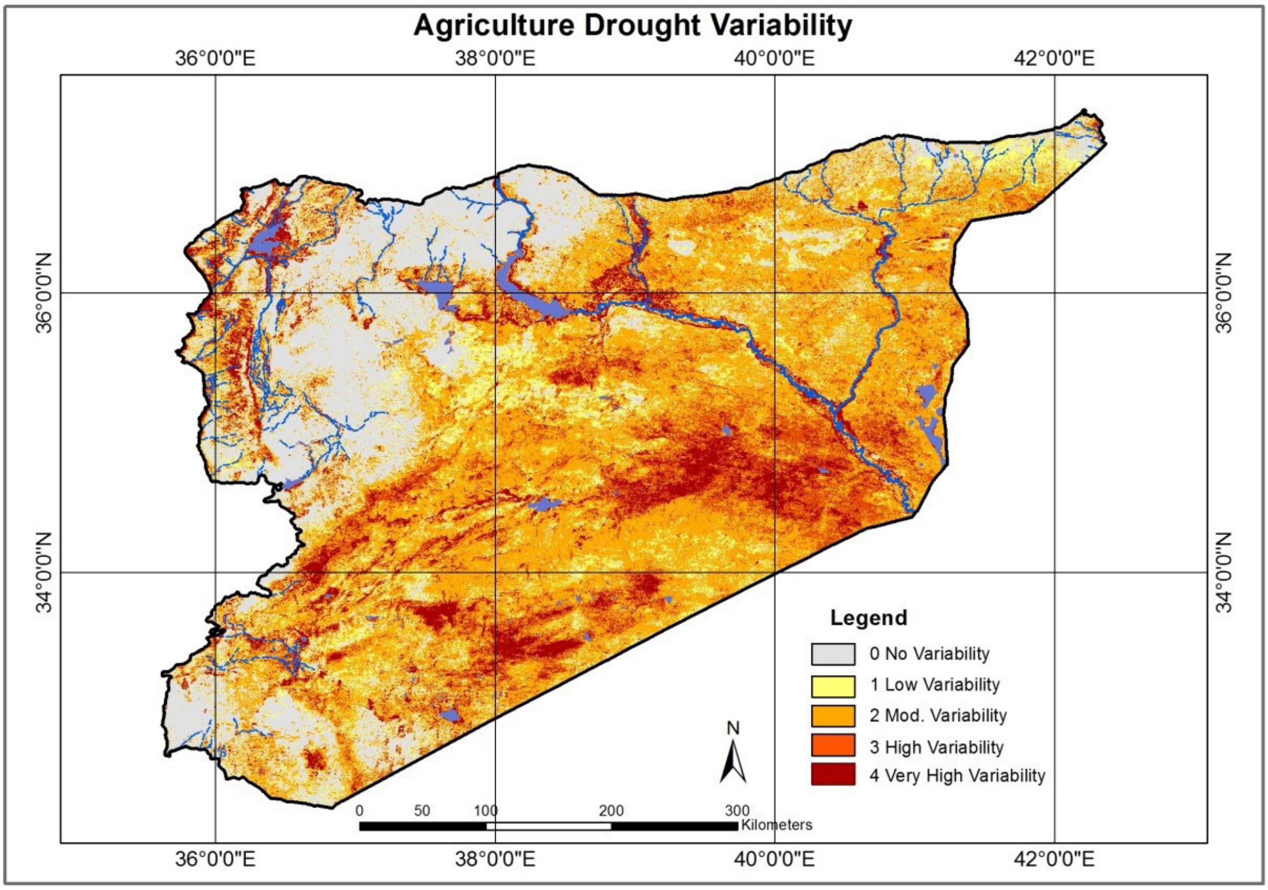
2 IPCC, (2012), Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.ESCWA (2005). -Regional Cooperation Between Countries in the Management of Shared Water Resources: Case Studies of Some Countries in the ESCWA Region. E/ESCWA/SDPD/2005/15.

Agricultural Drought Hazard in Syria

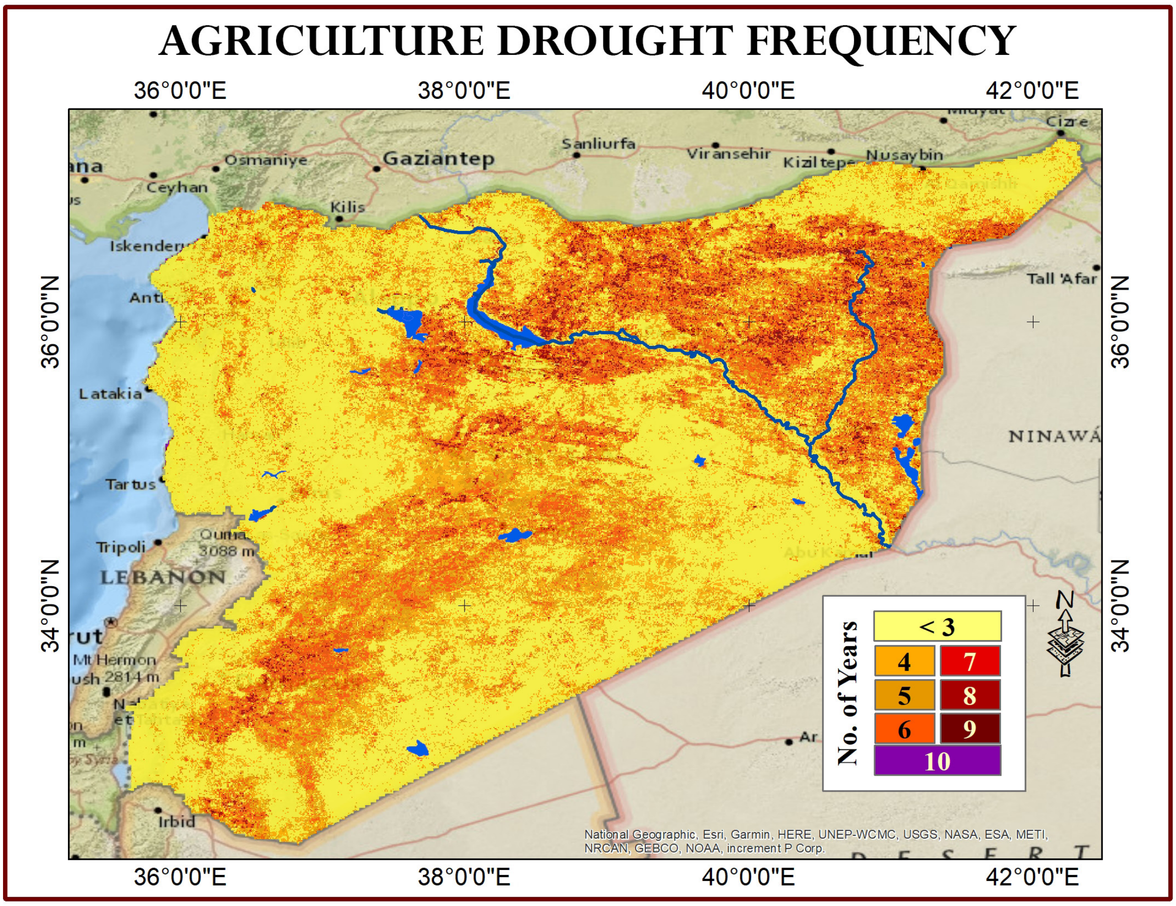
The preparation of the Agricultural Drought Hazard (ADH) map was developed by crossing the maps, namely: agricultural drought intensity (ADI) agricultural drought variability (ADV), agricultural drought frequency (ADF) and agricultural drought consecutive (ADC), as shown in (Case Study 2 - Figures 1-5). Results show that 74.4% of the total area of Syria is affected by ADH, slight hazard is covering an area of about 9.47 million hectares representing 51.17% of Syria total area, while an area of about 3.95 million hectares representing 21.3% of Syria is suffering moderate severity, an area of about 2.78 million hectares representing 1.5% of Syria is suffering high severity and an area of about 4.73 million hectares representing 25.55% of the total area of Syria is not affected.



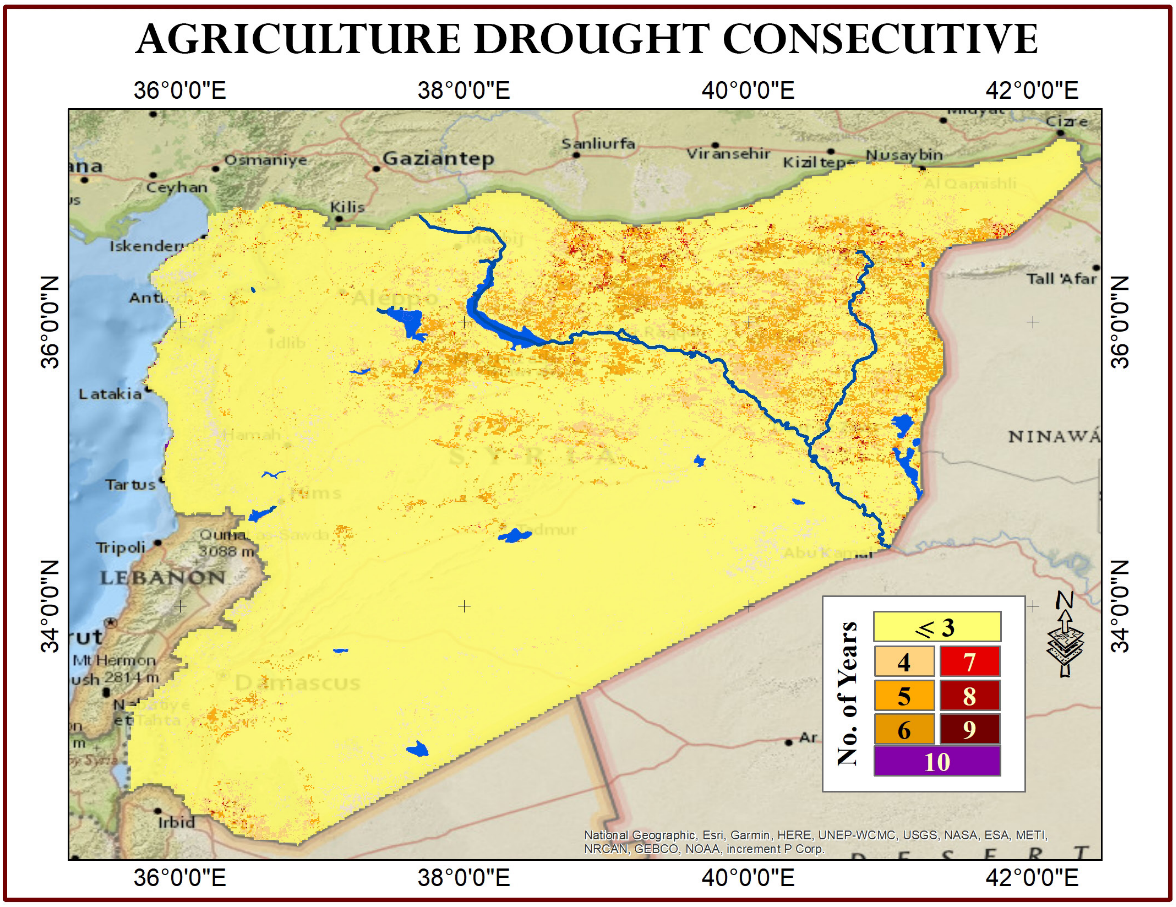
Case Study 2- Figure 1. Agricultural Drought Intensity Map of Syria for the period 2000 - 2010



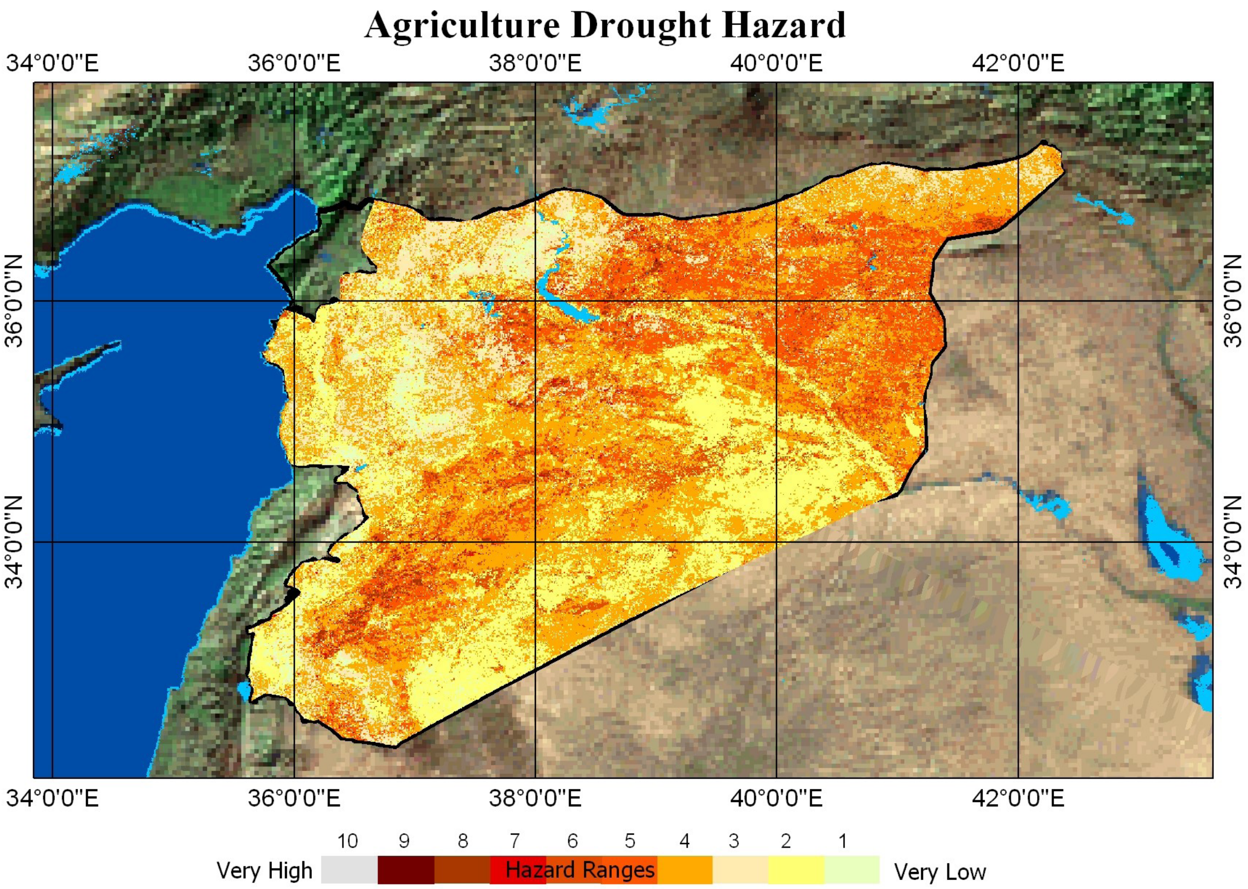
Case Study 2-Figure 2. Agricultural Drought Variability Map for the period 2000 - 2010



Case Study 2-Figure 3. Agricultural Drought Frequency Map for the period 2000 - 2010



Case Study 2-Figure 4. Agricultural Drought Consecutive Map for the period 2000 - 2010



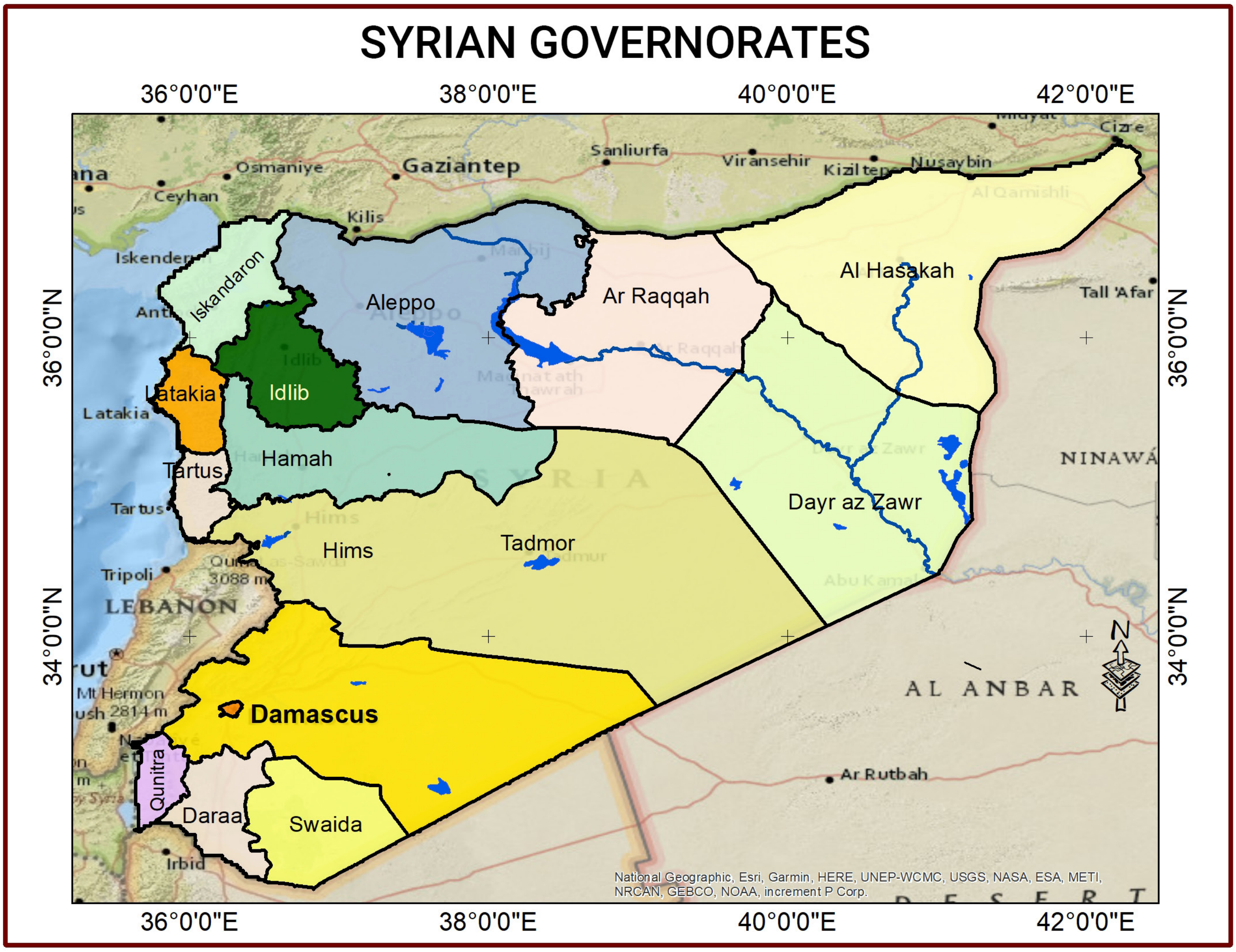
Case Study 2-Figure 5. Agricultural Drought Map of Syria

Characterizing Syria Socio-Economic Vulnerability

According to the information of the 2011, Syria was rated as moderate capacity level with main limitation in water availability, moderate vulnerability to drought with high coverage of agricultural drought hazard (ADH) of (75 – 85%), moderate drought hazard severity, and moderately affected vegetation cover. As the conflict started, Syria could be re-classified to extreme vulnerability to drought with high coverage of ADH, moderate drought hazard severity, severely affected vegetation cover, and very low- to low- capacity. Hence, required a special program for land recovery and building resilience to cope with drought and land degradation hazard severity (Erian *et al.,* 2012).

Socio-Economic Impacts and Risks in Syria Eastern Region

The eastern region of Syria (Al-Hasakah, Deir Al-Zour and Raqqa governorates), as shown in Figure (6) is considered as the most important areas of agricultural production in Syria and the most affected by drought. The region has an area of about 7.6 million hectares representing 41% of the total area of Syria, with a total population of about 3.5 million people, representing 17% of the population of Syria. The eastern region represents 22.4% of the total rural population of Syria and 30% of the agricultural sector (Kattana, 2011).



Case Study 2-Figure 6. Syria Governorates

The major impacts of drought could be described as follows:

a) Rural livelihoods:

- The severe shortage of rainfall that lasted for more than four agricultural seasons (2007/2008 – 2010/2011) has crippled agriculture in Eastern and North-eastern Syria; farmers who depended on only one crop had to move (Erian *et al.*, 2012; Kattana, 2011; UNISDR, 2011 and FAO, 2011).
- Increased respiratory infections, due to the nebular (dusty) atmosphere, particularly in the north-eastern areas that suffered from lack of water (for drinking and domestic use) and non-secure health services, lead to the spread of a variety of digestive diseases, diarrhea (especially in children), and kidney diseases (FAO, 2011).
- A rise in the rate of borrowing in rural households in the three provinces between 2006 and 2010, estimated by 350% (Erian *et al.*, 2012).

b) **Agricultural production:**

- The rainfed area has been declined from 1.12 to 0.98 million hectare, during the years 2000 to 2009 (Kattana, 2011).
- The region was previously contributing with about 58% of the total wheat production, 68-78% of the total cotton production, 62-72% of the total yellow corn production and 22% of the total sugar beet production, and has 30% of the goats, 36-41% of the sheep and 31-34% of the cows (Kattana, 2011).
- As result of drought, rainfed wheat production dropped in the eastern part of Syria by 25.9% during the years 2000-2009, from a total production of 2.6 to 2.1 million tons during the years 2005-2009 reaching 1.2 and 1.9 million tons in 2008 and 2009 respectively. During the agricultural season 2007–2008, and due to the severe drought in Syria, 75% of the country's farmers suffered total crop failure, where wheat production dropped by 39.8% (from 0.43 to 0.25 million tons) from the year 2000 to the year 2011 in Al-Hasakah governorate in the eastern part (Kattana, 2011).
- Barley production, which is considered an important crop for rainfed areas in the country, and is used as fodder for animals, has decreased by 40% during the years from 2005-2009. The absence of natural pastures; in addition to the doubling of feed prices have resulted in the sale of animals, accompanied by a large fall in the price of ewes sold or slaughtered, as well as young animals to the market. Additionally, this has resulted in weight loss and deterioration in animals, lowering in the number of newly born youngs due to low fertility rate and declining birth rate. Breeders were forced to sell a large proportion of female babies, besides the already high mortality rate of ewes and young animals (FAO 2011).
- The estimated number of sheep population has dropped from 2.47 million head in the year 2005 to 1.5 million heads in the year 2009. A year after the drought ended, livestock population was 50 percent below the pre-drought level (Kattana, 2011 and Erian *et al.*, 2012).

c) **Migration:**

- During the years 2007 to 2011, 1.3 million people (206,000 households) of a total population of 22 millions have been severely affected by the disaster, of which about 800,000 have lost almost all of their livelihoods facing extreme hardship. Migration out of the affected areas has increased, with estimates indicating that between 40,000 to 60,000 families, from which 35,000 from "Al-Hasakah governorate" alone, have been driven to urban settlements (the so- called mass migration) towards Syria's cities, such as Aleppo, Damascus and Deir Al-Zour, in search for work and new sources of income, many ending up with difficult labouring conditions (Nashawatii, 2011and Erian *et al.,* 2012).

d) Ecosystem Decline:

- Due to increase in drought's frequency, intensity and duration, the deficit in available water has been estimated to be about 651 million m^3 during the years 1995-2005, and is still increasing, with an expectation to rise to around 2 billions m^3 by the year 2030 only because of population growth and the increasing pace of development (Nashawatii, 2011).
- Decline in availability of irrigation water in the Al-Hasakah governorate is largely due to the hydrological drought of Khabour River, which has led to the decline in irrigated areas. Additionally, water scarcity has led to increasing pressures on groundwater resources bringing the water crisis to critical levels (FAO, 2011).
- Increase of moderate and severe land degradation estimated during the period 1999 to 2007 by 34.8% of the total area of Syria.

Building Resilience

Building on the Syrian experience, countries of the Arab World are in need for:

a) Strengthening commitment for comprehensive disaster risk reduction through mainstreaming Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) into national policies, legal frameworks, development plans and actions; decentralizing resources; community participation; developing capacities to identify, assess and monitor drought risks through national/local multi-hazard risk assessment; building capacities/systems to monitor, archive, and disseminate data; establishing regional early warning systems and networks.

b) Building resilience through knowledge, advocacy, research and training programs by making up to date information on drought risk accessible to all stakeholders, through educational material, curricula, approaches and public awareness.

c) Integrating disaster risk reduction into emergency response, preparedness and recovery actions by developing appropriate preparedness, contingency and recovery plans; reconstruction activities inclusive of all society groups and at all administrative levels; allocating budget locally for emergency; and coordination between national and local entities for timely information exchange during hazardous events and disasters.

CASE STUDY 3[3]:

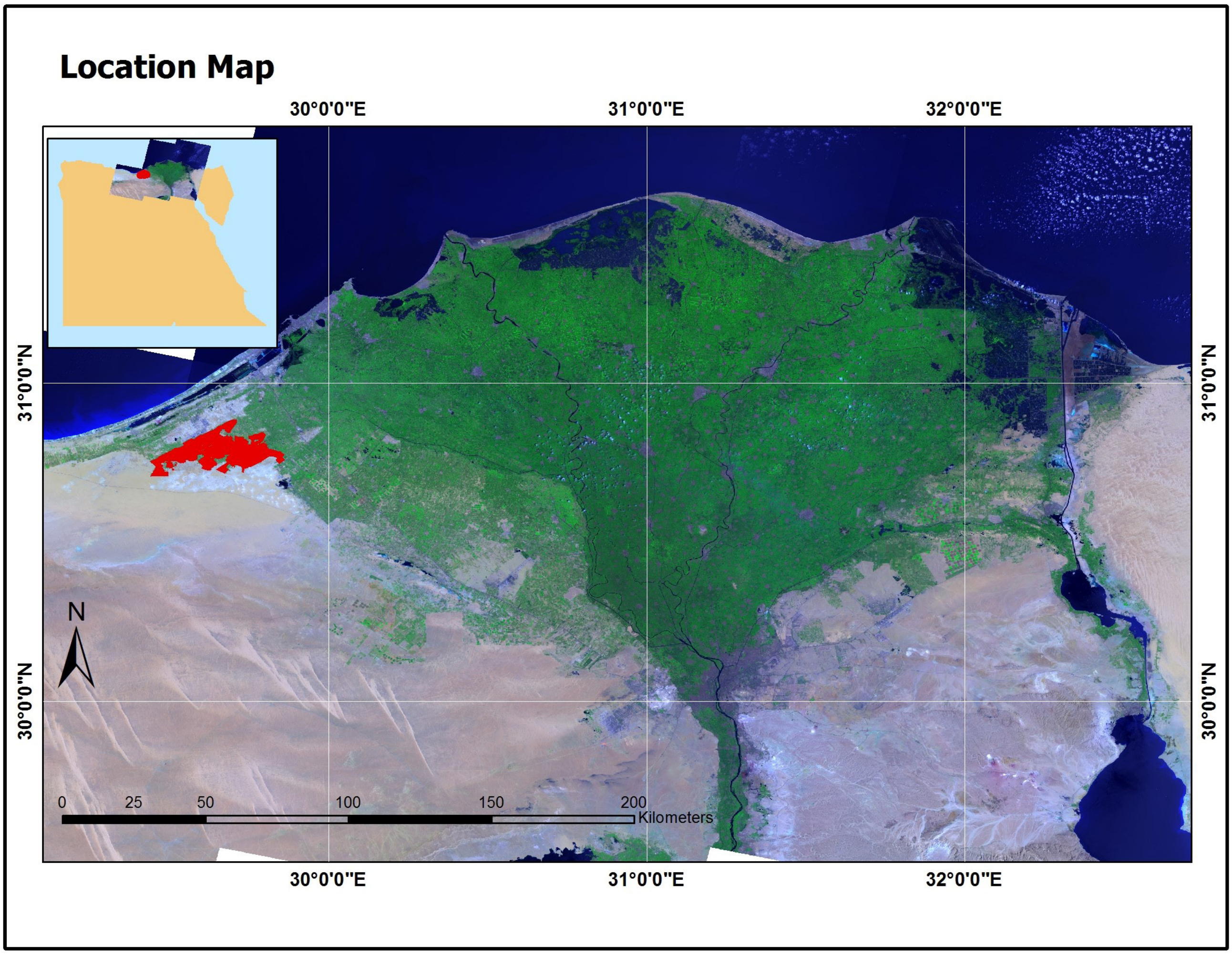
Social Vulnerability, Drought Risks and Need for Building Resilience in Sugar Beet and El-Hammam Zones, Nubariya Province, Egypt

Introduction

The case study covers a detailed characterization of the targeted community since the beginning of land reclamation, distribution to beneficiaries and current conditions. The aim is to build a baseline for the social and bio-physical vulnerability for the "Sugar Beet and El-Hammam Zones". The case study also focuses on assessing the current and potential risks of the drought and land degradation hazards on the community and recommends some practical interventions to improve the resilience of the study area.

Location, Topography and Soils

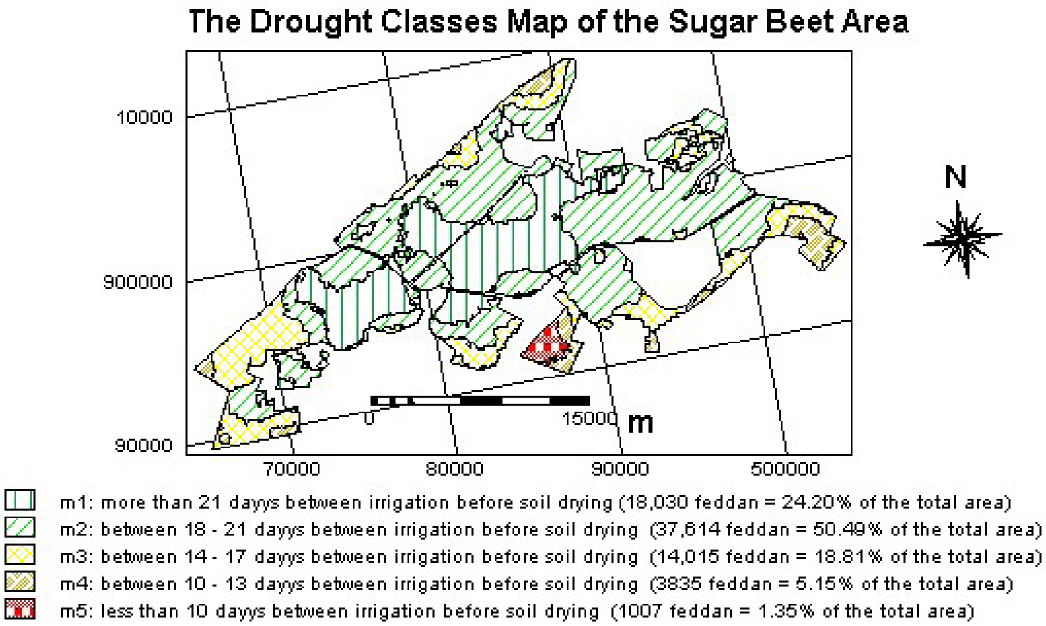
The study was carried out in an area at the end of the irrigation network in the north of the Delta, called Sugar Beet and El-Hammam Zones. The total study area is about 74500 fed. (Feddan= 4200 m^2). At the launching of the project, 100% of the land was assigned to graduates, either from universities or higher institutes. The Sugar Beet and El-Hammam Zones are considered recently reclaimed areas in Egypt.



Case Study 3-Figure 1. Location Map of the Studied Area

3 "Study on Displacement Resulting from Natural Disasters and Climate Change-Sugar Beet and El Hammam Areas, Nahariya Province, Egypt, RAED and Norwegian Refugee Council NRC, (2014-2015)

Due to soil quality limitation, all villages are considered in critical condition concerning their stability and settlement percentages. The average settling percentage in the study area is 30.5%. The maximum settling percentage is 80.2% and the minimum settling percentage is 6.8%. The main economic activity in the study area is agricultural. The production is less than 40 - 60% of the normal production due to (as a result of) low water-holding capacity of the soil and unsuitable irrigation schedule especially in summer time. “Wheat” is considered the main winter crop, followed by “Clover” and then “Beans.” In summer, “Tomato” is considered a major crop followed by “Maize” and different types of vegetables.

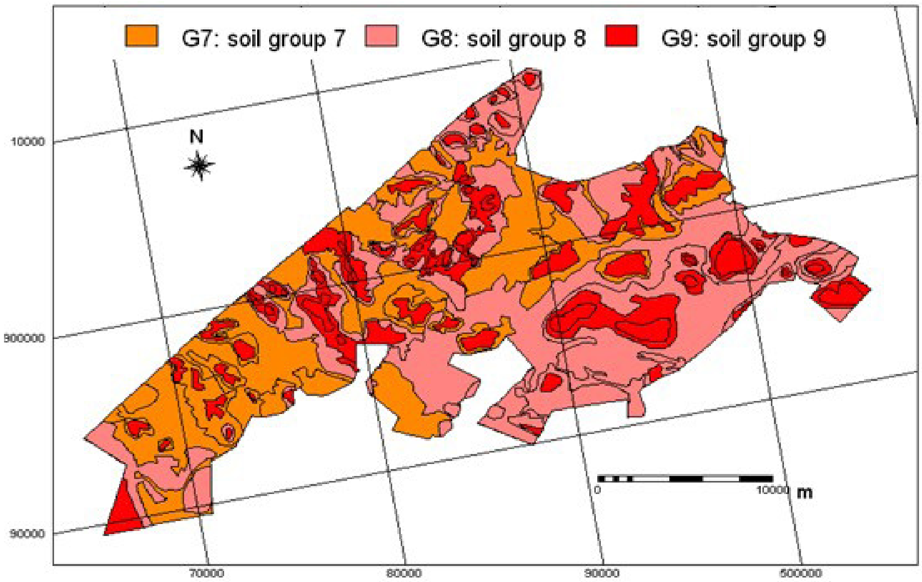


Case Study 3-Figure 2. The Drought Classes Map

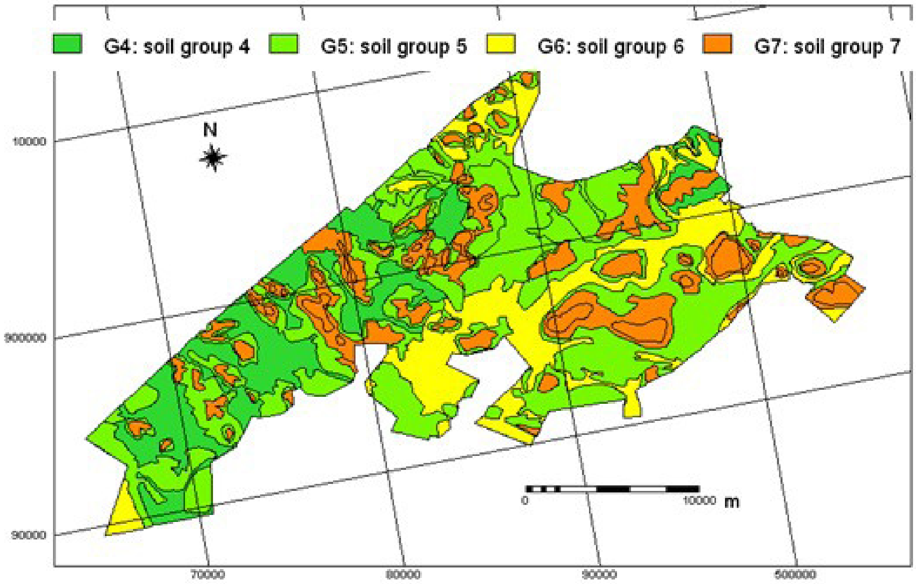
The severe- to very severe- land quality limitations show a negative and very significant correlation with the Wheat and Tomato production of (-0.585** & -0.521**) respectively due to increased soil salinity, as well as a negative and significant correlation with Maize production, of (-0.404*), as soil water-holding capacity is low.

The drought classes map of the Sugar Beet and El-Hammam Zones is shown in (Case Study 3-Figure 2) and the drought problem at level of consumption of 75% of available water of the study area is shown in (Case Study 3-Figure 3).

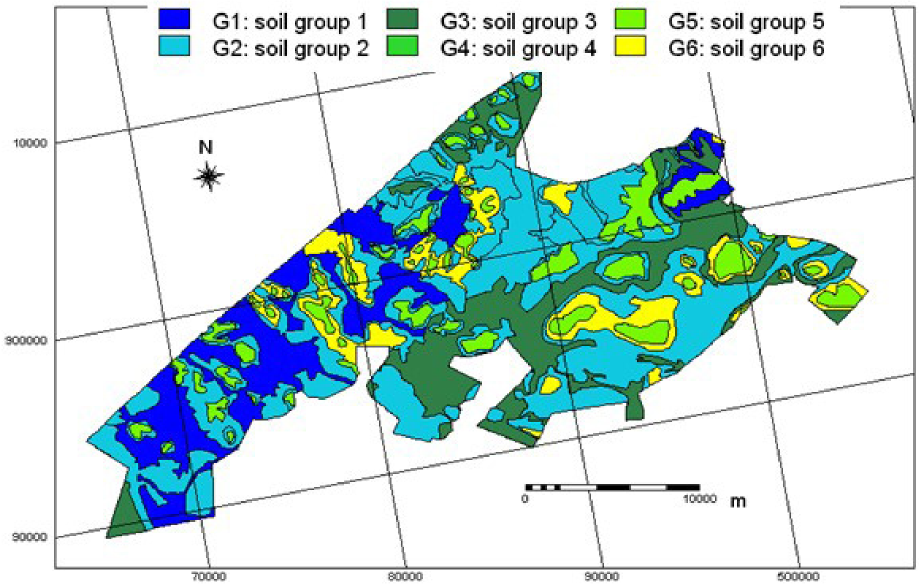
Case Study 3-Figure 3. Irrigation Stresses at several levels of consumption



A: Consumption of 50% of Available Water



B: Consumption of 75% of Available Water



C: Consumption of 100% of Available Water

Assessing Drought and Land degradation

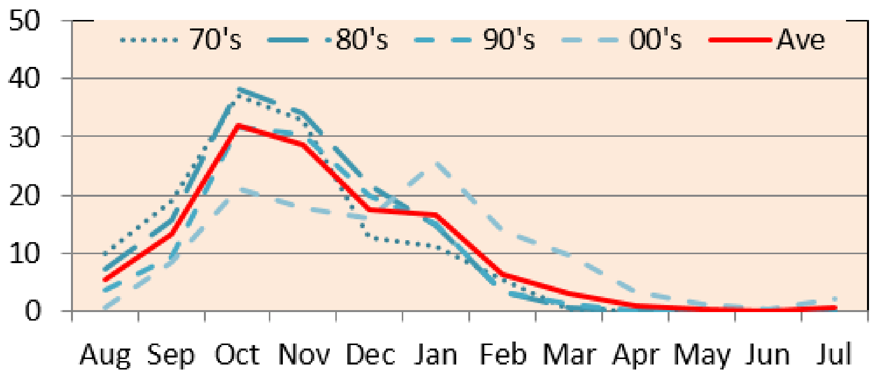
The Standardized Precipitation-Evapotranspiration Index (SPEI)

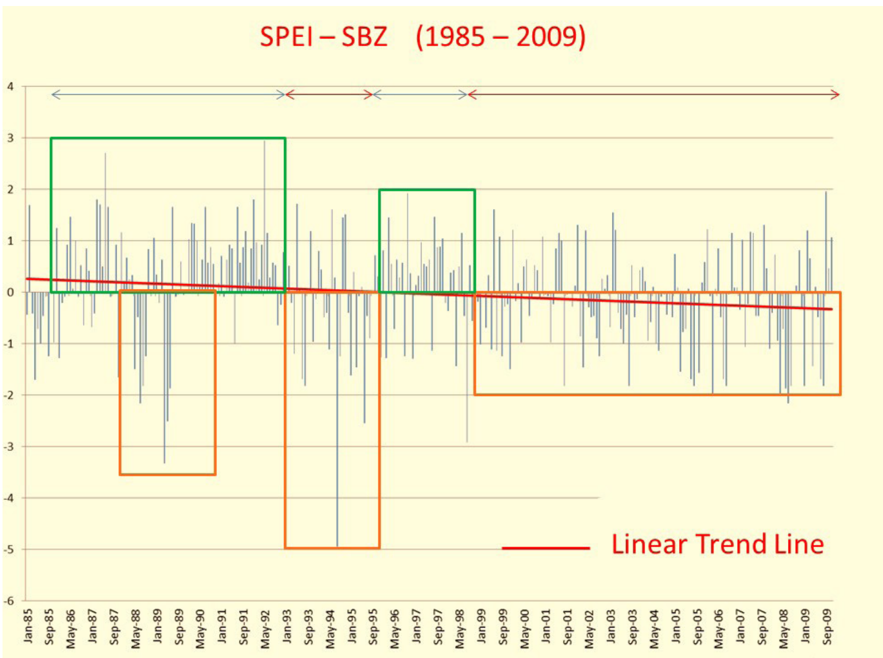
Rainfall in the study area has changed in both quantity and distribution during the last 40 years. The total amount has dropped down by approximately 14% to reach 9 million cubic meters with an annual average negative change of 0.4% per year, and is expected to cross 18 million cubic meters by year 2040. (Case Study 3-Figure 4) demonstrates the shift in rainfall distribution specially in the period 2000-2011.

Temperature in the study area has increased by 0.7°C in 40 years and is expected to increase by 1.5 to 2°C by year 2040. A drop in rainfall and irrigation efficiency over 25 – 30 million cubic meters by year 2040 (10% of the total area water requirements) is expected, where there will be a need to pump more water to the region, keeping in mind the increase in energy cost and the overall expected shortage in water in Egypt.

A crucial advantage of the SPEI over the most widely used drought indices is that it considers the effect of PET on drought severity, as well as its multi-scalar characteristics that enable identification of different drought types and impacts in the context of global warming. The Main SPEI curve for 25 years (1985 – 2009) is shown in (Case Study3-Figure 5) illustrates that the drought indicated as SPEI was dominant during the years 1985, 1986, 1988, 1989, 1993, 1994, 1995, 1998, 1999, 2000, 2005, 2007, 2008 and 2009, the general linear trend being towards the negative direction. This clearly illustrates that the study area was under continuous different levels of negative change.

Case Study 3-Figure 4. Precipitation pattern in Borg El-Arab for the years (1970 – 2010)





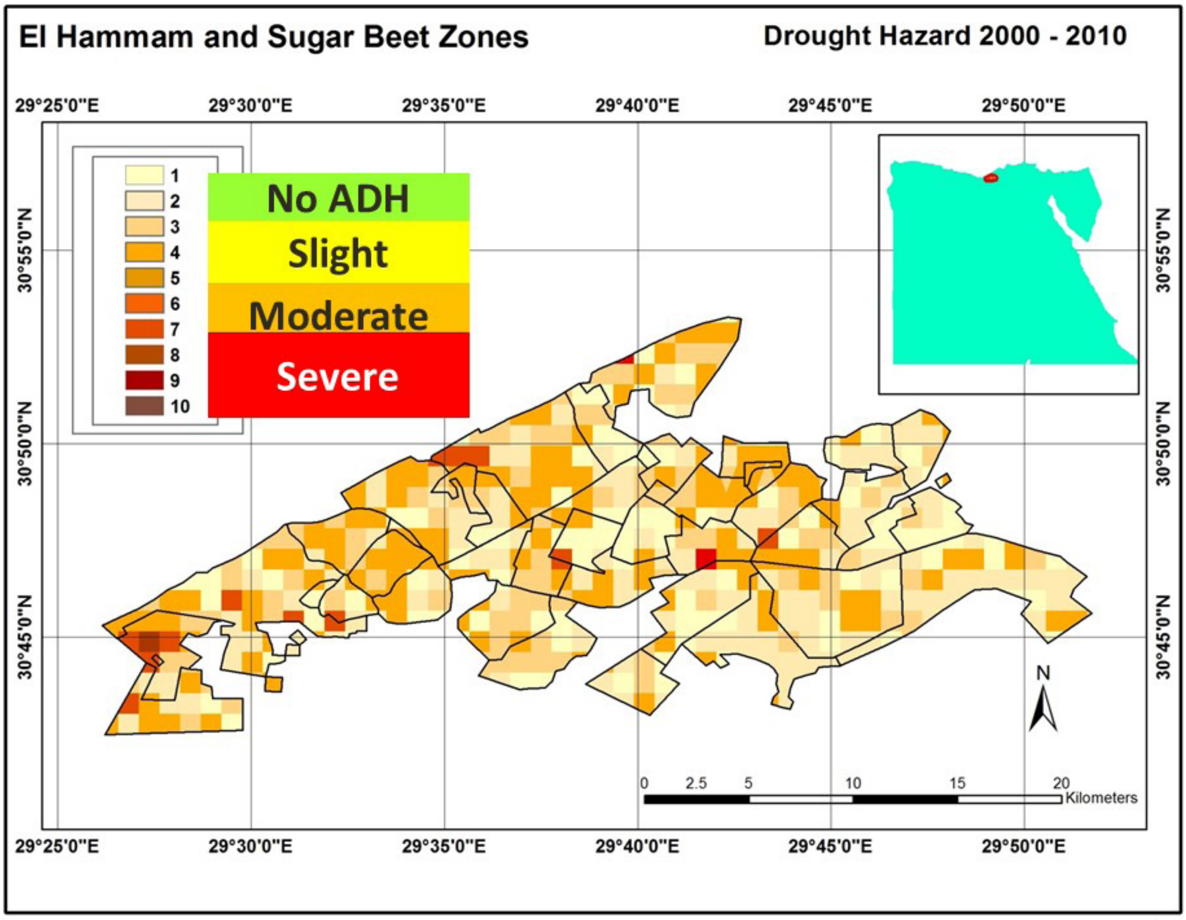
Case Study 3-Figure 5. The Main SPEI curve for 25 years (1985 – 2009)

Agricultural Drought Hazard Map

The four elements, namely, intensity, frequency, consecutive and variability were produced from monthly and different agricultural seasons maps using geographic information system (GIS) capabilities to develop the final ADH map (Case Study 3-Figure 6).

The areas of each class were estimated and classified into 4 major groups, as follows:

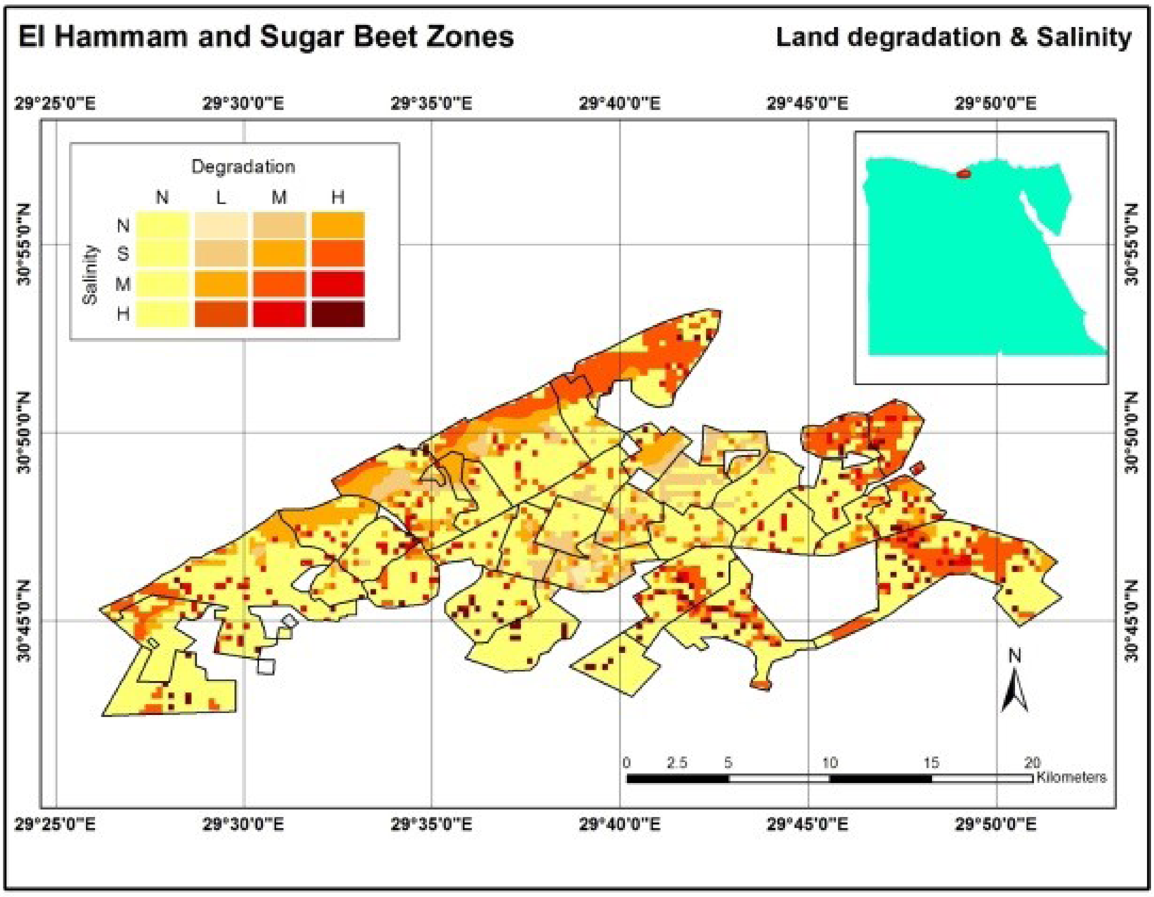
Group 1: No ADH , covering 47.5 % of the study area;
Group 2: Slight ADH, covering 49% of the study area;
Group 3: Moderate ADH, covering 3.2% of the study area; and
Group 4: Severe ADH, covering 0.27% of the study area.



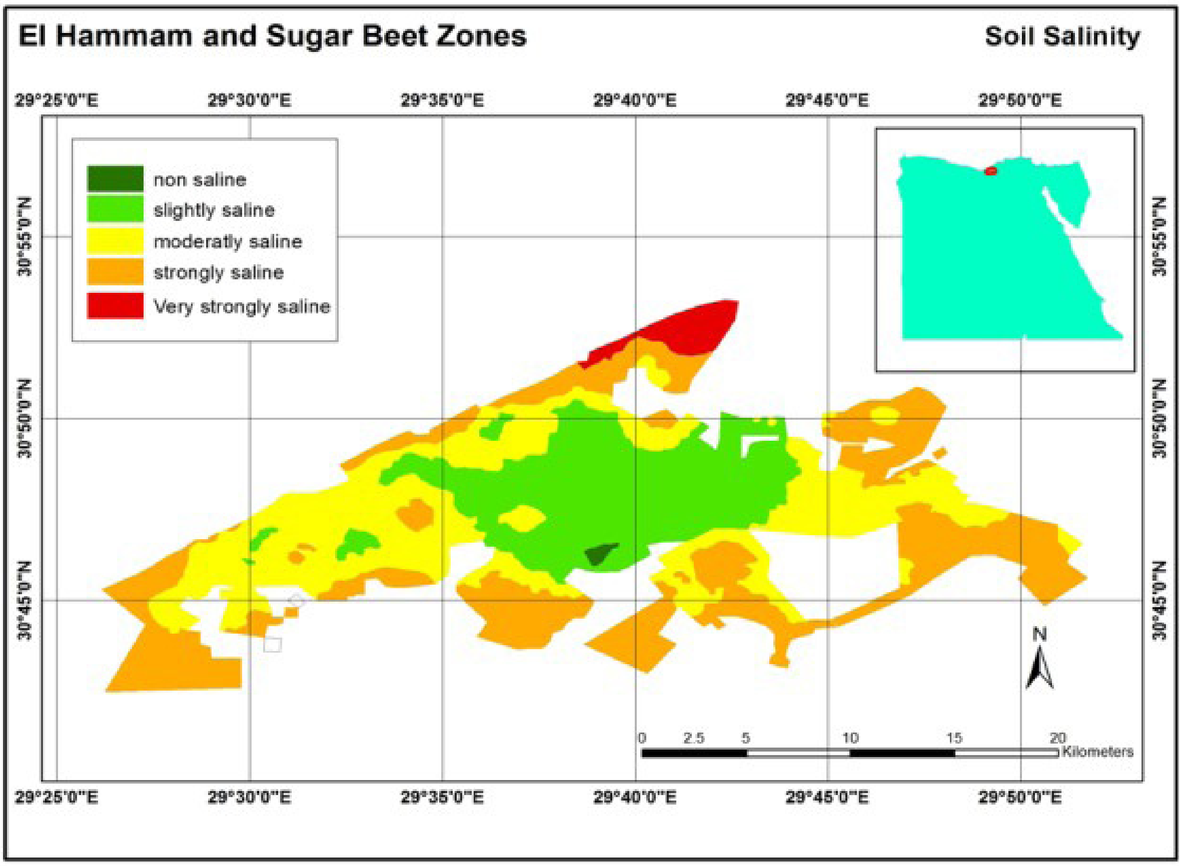
Case Study 3-Figure 6. Agricultural Drought Hazard Map

Land Degradation

Soil Land Degradation for the study area is shown in (Case Study 3-Figure 7) affected by salt accumulation and soil salinity increase. Soil Salinity increase in the study area is considered one of the major land degradation types that has affected land productivity. The results of salinity in year 1998 as illustrated in (Case Study 3-Figure 8) show that 23.7% of the total study area is non- to very slight-saline, slight saline covers 37.08% of the total study area, moderately saline covers 27.29% of the total study area and strongly saline represents 11.85% of the total studied area. Recent survey (2013) shows that salinity problem is increasing in its severity due to the accumulation of salts accompanied with rise in the mean temperature.



Case Study 3-Figure 7. Land Degradation Map



Case Study 3-Figure 8. Soil Salinity Map in 1998.

Community Population Stability

Since the beginning of the land distribution in 1989 up till 2014, the total population increased by 537%. The first increase took place during the first 10 years; the main reason was that the young graduates established their families and the number of children increased to 46% of the total community. While in the next 15 years many changes took place in the region, the total number of graduates had dropped down by 12%, and the total number of farmers dropped by 36.5%. The majority of dropped farmers were due to irrigation problems, inadequate agricultural services and reduction of land production in many cases due to land degradation (mainly due to high soil salinity in high lands and water logging in low lands) and the deterioration in the physical and social infrastructure and general standards of living.

After ten years of creating the new rural community in the Sugar Beet Zone, the percentage of stability could be considered the main index for identifying the extent of the success of agricultural development programs in the new agricultural communities. The higher the index reflects the success of the development programs and the lower the index reflects the failure of the agricultural policy or the pressures related to natural resources and poor agricultural management, and this rate depends on the reasons of attractions and expulsion in this area.

The most important factors that affect the stability in the study area are as follows:

Agricultural-Related Problems Including:

Water deficit and long irrigation intervals; Rainfall reduction due to drought; Rocky lands and areas infested with weeds; marketing problems resulting in the majority of the crops being sold at low prices; and the lack of effective financing mechanisms and agricultural cooperatives in most villages.

Social Services-Related Problems Including:

Poor drinking water services; lack of health services and education facilities. Transportation is also a major problem in the study area.

It turns out from the agricultural survey of both the Sugar Beet and El-Hammam Zones that the stability indicated by the settlement percentage is about 28%, and the lowest stability percentage reached about 17.8% at El-Hammam, and that the maximum is approximately 47%. Results also indicate that in general the stability in the different parts of the region and its villages is generally low. The stability figures reflect the level of socio-economic problems.

The low income from agricultural activities reflects problems related mainly to uncertainty of water availability. There is a window for potential economic opportunities by providing service and value-added activities to the agriculture products and/or in the field of animal production. There is urgency for studying water needs under climate change and drought in the region and studying the needs for changing crop patterns as well as the needs for improving infrastructure and services such as health, education, security transportation and communications.

In conclusion the study shows that farmers suffer in the area from both poor physical and socio-economic conditions. Poor quality and inadequate water availability in addition to soil salinity increase in the study area are considered the major land degradation that have affected land productivity. The current challenging conditions in the area accompanied with climate change risks and increasing agricultural production costs will definitely further negatively affect the region population stability.

RECOMMENDATIONS FOR BUILDING CLIMATE-RESILIENCE IN THE ARAB REGION (SOCIO-ECONOMIC AND POLICY INTERVENTIONS)

Disaster risk reduction needs to embrace three complementary and strategic goals, namely:

(1) Risk prevention and the pursuit of development pathways that minimize disaster risk generation;
(2) Risk reduction, i.e. actions to address existing accumulations of disaster risk; and
(3) Strengthened resilience, i.e. actions that enable nations and communities to absorb loss and damage, minimize impacts and bounce forward.

Long-term climate resilience development would require vibrant policies to assess social vulnerabilities and provide development responses that can reduce risks. The focus is on policies and actions that prioritize prevention of future risk accumulation and the exacerbating factors to underlying social tensions and challenges in the Arab region.

Therefore, facing these multiple challenges at the climate-poverty-development nexus, decision makers in the Arab region should increasingly focus on the root causes of poverty, inequality, and climate change. Development pathways should be shifted towards greater social and environmental sustainability, equity, resilience, and justice. Based on trends of climatic hazards in the Arab region, the existing institutional capacity, the on-going engagements in CCA and DRR, and the gaps identified in the previous sections of this report, the following is recommended:

- There is a need for political commitment including appropriate governmental entities and strong scientific institutions, for integrating drought risk issues into sustainable development and disaster risk reduction processes.
- Policy-makers should address the severe implications of climate variability, especially for the most vulnerable groups in the society, such as the most resource-poor, small-scale farmers and the poorer households. This needs must be considered and addressed explicitly while designing national development policies and strategies.
- Government should develop a contingency plan and mobilize financial resources for the potential permanent replacement of severely affected communities, mainly the most resource-poor, small-scale farmers and the poorer households.
- The scientific community should have a central and critical role in providing specialized scientific and technical input to assist governments and communities in drought risk reduction.
- A capacity building and knowledge development program should be designed and implemented to help build commitment, competent institutions, and informed population. The media should play an important role in improving the «disaster reduction consciousness» of the general population and disseminate early warnings.
- The sustainability of development and resilience of people, nations and the environment depends on sound risk management, which needs planning and investments that go beyond the reduction of existing risk and include the prevention of new risk accumulation.
- Adaptation along with mitigation measures will be essential to build up the resilience needed to cope with the changes ahead and to lessen the effects for the multitude whose lives will be radically altered.

- Insurance programs, social protection measures, and disaster risk management may enhance long-term livelihood resilience among poor and marginalized people, if policies address poverty and multi-dimensional inequalities.
- More investment in research is needed to develop smart, climate-resistant agriculture. At the same time, economic diversification is essential to help vulnerable populations develop new revenues.
- The availability of open-source and open-access science-based risk information and knowledge is instrumental to cost-benefit analysis, transparent transactions, accountability and the development of partnerships with stakeholders.
- The increasing trans-boundary and global characteristics of risk drivers requires further cooperative efforts in their assessment and joint management.

REFERENCES

1. AbuZeid, K.; Wagdy, A.; Ibrahim, M.; CEDARE and Arab Water Council (2019). "3rd State of the Water Report for the Arab Region - 2015", Water Resources Management Program - CEDARE & Arab Water Council.

2. Aldakheel Y.; Al-Hussaini A. (2005) used of multi-temporal Landsat TM imagery to detect land cover/use changes in Al-Ahssa, Saudi Arabia. 6cientific Journal of King Faisal University (Basic and Applied Sciences) 6: 1426

3. Arab Water Council (AWC) and World Food Programme (WFP) held a regional consultation Workshop on 'Strengthening the Understanding of Social Vulnerability in the Arab region' in Cairo, Egypt, 25-27 September (2016).

4. Arab Water Council Regional Report: 'Strengthening the Understanding of Social Vulnerability in the Arab Region', (2017).

5. Donat, M.G., et al. "Changes in extreme temperature and precipitation in the Arab region: long-term trends and variability related to ENSO and NAO." International Journal of Climatology 34 (2014).

6. Duguy, B.; S. Paula; J.G. Pausas; J.A. Alloza; T. Gimeno and R.V. Vallejo, (2013). Effects of climate and extreme events on wildfire regime and their ecological impacts. In: Regional Assessment of Climate Change in the Mediterranean, Volume 3: Case Studies [Navarra, A. and L. Tubiana (eds.)]. Advances in Global Change Research Series: Vol. 52, Springer, Dordrecht, Netherlands, pp. 101-134.

7. Erian W, B Katlan, N Assad and. S Ibrahim (2014). "Effects of Drought and Land Degradation on Crop Losses in Africa and Arab Region with Special Case Study on: drought and conflict in Syria", Background paper prepared for the (2015) Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR

8. Erian W, B Katlan, N Assad and. S Ibrahim (2014). "Effects of Drought and Land Degradation on Crop Losses in Africa and Arab Region with Special Case Study on: drought and conflict in Syria", Background paper prepared for the (2015) Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR

9. Erian W., B Katlan, B. oul. dbedy, H. Awad, E. Zaghtity and S Ibrahim, (2012). "Agriculture Drought in Africa Mediterranean and Middle East, Background paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

10. Erian W.; Fares, F. S.; Udelhoven, T. and Katlan, B. (2006). «Coupling Long-Term "NDVI" for Monitoring Drought in Syrian Rangelands.» The Arab J. for Arid Environments – ACSAD, 1(0): 77 – 87. Erian W. F. (2000). The use of Geo-Statistical Analysis for Assessing Soil Qualities Impact on the Stability of EL Hammam Area, Egypt. Alex. J. Agric. Res. 45 (2): 13 – 37.

11. FAO (2011). "The State of Forests in the Amazon Basin, Congo Basin and Southeast". A report prepared by the Food and Agriculture Organization of the United Nations (FAO) or the International Tropical Timber Organization (ITTO) concerning for the Summit of the Three Rainforest Basins, Brazzaville, Republic of Congo.

12. FAO (2014). -Executive Brief Syria Crisis, http://www.fao.org/fileadmin/user_upload/emergencies/do3/Syria-Crisis-Executive-Brief-03-04-14.pdf

13. FAO and ITPS. (2015). Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy

14. http://maps.elie.ucl.ac.be/CCI/viewer/

15. Information is calculated by the LAS/AWR-AGIR from (Arino et al 2008 and The European Space Agency 2010), http://www.esa.int/images/globcover_poster 2010_H.jpg).

16. IPCC, (2014): Climate Change (2014): Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

17. Kaijser, A. and A. Kronsell, (2013). Climate change through the lens of intersectionality. Environmental Politics, 1-17, doi:10.1080/09644016.2013.835203.

18. Kattana, H. , (2011). Agriculture Production Indicators In North Eastern Part of Syria. WB, MAAR and A3AD Workshop on: Reducing Vulnerability to climate change in Agricultural Systems in Syria, March 23-24, El-Hassakeh governorate, Syria.

19. Latham J, R Cumani, Il Rosati and M Bloise (2014), Global Land Cover SHARE (GLC-SHARE), database Beta-Release Ver 1.0 –FAO

20. Modified from the parts written by W. Erian, in the study: M Allam, W Erian and S Razik. (2014). "Study on Displacement Resulting from Natural Disasters and Climate Change Sugar Beet and El Hammam Zones, Nubaria Province, Egypt" RAED and NRC

21. Nashawatii, H. (2011). Climate Change: impacts and adaptation in Syria, , during WB, MAAR and A3AD workshop: Reducing Vulnerability to Climate Change in Agricultural Systems: Building Response Strategies, 23-24., Hassakeh Governorate, Syria.

22. Nightingale, A., (2011). Bounding difference: Intersectionality and the material production of gender, caste, class and environment in Nepal. Geoforum, 42(2), 153-162.

23. Nkonya, Ephraim, (Ed); Mirzabaev, Alisher, ed.; and von Braun, Joachim, ed. (2016). Economics of land degradation and improvement- A global assessment for sustainable development. Cham, Switzerland: Springer International Publishing

24. Seneviratne, S.I.; Nicholls, I.; Easterling, D.; Goodess, C.M.; Kanae, S.; Kossin, J.; Luo, Y.; Marengo, J.; McInnes, K.; Rahimi, M.; Reichstein, M.; Sorteberg, A.; Vera, C. and Zhang, X. (2012). "Changes in Climate Extremes and their Impacts on the Natural Physical Environment." Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Edited by C. Field, V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K.L. Ebi, M. D. Mastrandrea, K. J. Mach, K.-G. Plattner, S. K. Allen, M. Tignor, and P. M. Midgley, Cambridge University Press: Cambridge, UK, and New York.

25. T. Friedman, ‘The Scary Hidden Stressor’, The New York Times, 2 March (2013); C.E. Werrel and F. Femia (eds.), The Arab Spring and Climate Change, Center for American Progress, Stimson, The Center for Climate and Security (2013); F. Femia and C.E. Werrel, ‘Climate Change Before and After the Arab Awakening: The Cases of Syria and Libya’, in Werrel and Femia, The Arab Spring and Climate Change, pp.23–38; S. Mohtadi, ‘Climate Change and the Syrian Uprising’, Bulletin of the Atomic Scientists, 16 Aug. (2012).

26. The (2018) Crop and Food Security Assessment Mission(CFSAM), conducted jointly by the UN Food and Agriculture Organization (FAO) and the World Food Programme (WFP).

27. Varley, Ann (1994). The Exceptional and Every day. Vulnerability in the International Decade for Disaster Reduction, Disasters, Development, and Environment. New York: John Wiley & Sons.

28. Verner, Dorte, ed. (2012). Adaptation to a Changing Climate in the Arab Countries. Washington, DC: World Bank. DOI: 10.1596/978-0-8213-9458-8. License: Creative Commons Attribution CC BY 3.0.

29. World Bank, (2012). ”Adaptation to a Changing Climate in the Arab Countries MNA”, Flagship Report, Sustainable Development Department, Middle East and North Africa Region, Report N° 64635 – MNA.

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THE ARAB GEOGRAPHICAL INFORMATION ROOM

League of Arab States - Arab Water Council

المجلس العربي للمياه

Arab Water Council

WFP

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Geographical Information Towards Building Risk Resilience in the Arab Region

(Water, Food and Social Vulnerability Nexus)