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Water, Climate Change and Agriculture in MENA regions (Middle East and North Africa)

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Abstract

This article summarized Protracted conflicts in the Middle East and North Africa (MENA) region have left tens of millions of people in need of humanitarian and development assistance to have access to water. But the capacity of local water service providers (state-owned and private) to maintain adequate levels of services has decreased as conflicts and population movements across the region have continued, mainly towards urban areas. Other actors including United Nations agencies, international organisations, local NGOs and independent – often informal – water providers have played an important role in filling gaps in supply.
This study analyses all these actors' responses to continuing the supply of water during conflicts, focusing on factors of resilience building that particularly concern local service providers.

Key Words*:* Water, Climate Change, Agriculture; MENA regions

Eau, changement climatique et agriculture dans les régions MENA (Moyen-Orient et Afrique du Nord)

Résumé

Cet article résume Les conflits prolongés dans la région du Moyen-Orient et de l'Afrique du Nord (MENA) ont laissé des dizaines de millions de personnes ayant besoin d'aide humanitaire et de développement pour avoir accès à l'eau. Mais la capacité des fournisseurs locaux de services d'eau (étatiques et privés) à maintenir des niveaux de services adéquats a diminué à mesure que les conflits et les mouvements de population dans la région se sont poursuivis, principalement vers les zones urbaines. D'autres acteurs, notamment des agences des Nations Unies, des organisations internationales, des ONG locales et des fournisseurs d'eau indépendants – souvent informels – ont joué un rôle important pour combler les lacunes de l'approvisionnement.
Cette étude analyse toutes les réponses de ces acteurs au maintien de l'approvisionnement en eau pendant les conflits, en se concentrant sur les facteurs de renforcement de la résilience qui concernent particulièrement les prestataires de services locaux.

Mots clés : Eau, Changement Climatique, Agriculture ; Régions MENA.

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INTRODUCTION

MENA is an acronym for the Middle East and North Africa region, it is popularly used by academic, economic, social and international organizations. The MENA region is sometimes known as the Arab World or the Greater Middle East.

The term "Middle East" was coined in the 19th century to refer to the transcontinental area between southwest Asia and North Africa. It was Eurocentric and commonly used by the Western World. However, the composition of countries in the Middle East remains contentious even to date. To clear the ambiguity, the World Bank and the United Nations began using the term "Middle East and North Africa" to refer to the region spanning horizontally between Iran in the east to Morocco in the west. The second Bush administration coined the word "Greater Middle East" to refer to the entire Muslim-majority nations including Iran, Pakistan, and Turkey. While MENA is inclusive of Iran, it does not include Pakistan, Turkey, or Afghanistan. The boundaries of MENA is more geographic rather than social or religious.

There are 20 countries that are generally considered part of the MENA region. These are Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen. A further 16 countries are sometimes included depending on usage. These are Afghanistan, Armenia, Azerbaijan, Chad, Comoros, Cyprus, Djibouti, Eritrea, Ethiopia, Georgia, Mali, Mauritania, Niger, Somalia, Sudan, and Turkey. The population of the region is at least 381 million or 6% of the world's population. Egypt (94 million), Iran (80 million), and Algeria (40 million) are the most populous countries in the region.

Is Turkey a part of the MENA Region?

Turkey lies in between Europe and the Middle East. Much of the MENA region was once under the Ottoman Empire and therefore maintains close ties with Turkey. Modern Turkey is a popular destination for Arabs traveling for a holiday and investing in real estate. However, Turkey also has equally close relations with Europe and was at one point it was the capital of the Eastern Roman Empire. The country has a pending application to join the European Union, and if successful, it will be considered more of a European country rather than an Arab state. Turkey is considered part of the MENA region in the broader context, but it is occasionally omitted in most definitions.

For this book, the MENA region, comprising 21 countries, (Algeria, Bahrain, the Arab Republic of Egypt, the Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Palestine, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, the United Arab Emirates, and the Republic of Yemen). (Figure 1)

Figure 1. Overview of the Middle East and North Africa (MENA) region

The MENA region (Middle East and North Africa) is located between longitudes 13°W and 60° E and between latitudes15° N and 40° N covering a surface area of about 11.1 million square kilometers or about 8% of the area of the world. The MENA Region covers a surface area of about 14 106 km², partly in Africa and partly in west Asia. By virtue of its geographical location between the Tropics of Cancer and Capricorn, at latitudes 23°30' N and 23°30' S respectively, a substantial part of the region has a tropical climate. The region extends from the Atlantic Ocean in the west to the Persian Gulf in the east, and from the southern shore of the Mediterranean Sea in the north to southern Sudan and the Gulf of Aden in the south. The Red Sea penetrates the Arab Region from the southeast to the northwest, thereby separating the eastern part (Al-Mashreq Al Arabi) from both the central and western parts (Al Wasat and Al Maghreb Al Arabi respectively). One can also divide the Arab Region into the Arab Middle East subregion and the North African subregion. The Arab States located east of the Red Sea belong to West Asia. In this text we shall adopt the division of the Arab Region into three subregions: the western, middle and eastern. Although MENA countries share common identity-formation features — Islam as the main religion and Arabicas a common language— they differ in ethnicity, tradition, history and spoken dialects of Arabic. Economic development strategies also vary between the oil-producing states such as Kuwait and the United Arab Emirates, and the non-oil-producing countries such as Tunisia and Jordan.

The Maghreb sub-region (Northern African) extends from the Mediterranean climate zone to the arid zone. Rainfall occurs in the winter season, while the summer season is clear and dry. There are differences in the climate within the sub-region between the Maghreb countries. The Maghreb climate shows a drying and warmer gradient from north to south and a divided and dispersed hydrography with some average-size drivers only in Morocco. Egypt has an arid climate and a simple hydrography with very limited internal resources and only one river, the Nile, which enters the country from Sudan.

The sub-region of the Middle East as a complete desert climate that is very hot in the summer and relatively cold in the winter, with very scarce rainfall. Finally, the Mashreq region (countries like Iran, Iraq, Lebanon and Syria) has a milder and wetter climate compared to the Gulf Cooperation Council (GCC) countries.

The population of the region is large and continues to experience significant growth. Currently, the MENA region is home to about 386 million people — that is, 6.3 % of the world's population, with an average annual population growth rate of 1.7 % (World Bank data from 2011). The population more than doubled between 1970 and 2001. Currently, the population of MENA is growing by nearly 7 million people per year, second only to sub-Saharan Africa. Although the region's total fertility rate (average number of births per woman) declined from 7.0 births per woman in 1960 to above 3.0 births in 2006 and is expected to continue to fall, MENA's population is expected to nearly double in 50 years. About 60 % of the total population lives in urban areas, but this percentage is on the rise as people migrate to urban areas in search of better economic opportunities. This population growth has been accompanied by rapid and sometimes anarchic urbanization, with the appearance of large cities with infrastructure that is barely adequate to the needs of the population base, particularly in terms of hygiene and quality of life: drinking water, sewerage, urban waste and air quality.

The total surface area of the MENA region (21 countries) is 11.1 million km^2, accommodating a population of 381 million. This makes the region relatively scarcely populated, with a mere 34 inhabitants per km^2. The most important reason for the low population density is the arid conditions in the region (about 85 % of the area is desert) and the scarcity of water resources: the proportion of arable land out of the total land area is only 4.9 %

The MENA region has vast reserves of petroleum and natural gas (810.98 billion barrels, or 60 % of the world's oil reserves), and 45 % of the world's natural gas reserves (81,237.8 km^3), which make it a vital source of global economic stability.

The MENA region is the driest and most water scarce region in the world and this is increasingly affecting the economic and social development of most MENA countries. The region has about 0.7 % of the world's available freshwater resources. Today, the average per capita water availability in the region is slightly above the physical water scarcity limit, at about 1,076 m^3 per year (compared to the world average of about 8,500). In addition, the MENA region faces other major development challenges. These include a rapidly growing young population, high unemployment rates, and vulnerability to price shocks and climate change. The region also faces some political and security challenges, including extremism.

The Middle East and North Africa (MENA) region is vast, rapidly transforming and heterogeneous. Since 2011, the region has experienced an eruption of conflict in several Arab countries. What was termed the "Arab Spring" led to a series of wars and conflict in countries such as Syria, Iraq, Libya and Yemen. Domestic strife and foreign intervention have led to "failed states" across the region (Müller et al. 2016, Kinsman 2016). This report provides an analysis of underlying material risks and opportunities that contributed to the Arab uprisings. Two of the key issues that have been and will continue to face the MENA region are demographic change and economic factors. Despite the many shared features among MENA countries, there is comparatively little regional integration or policy coordination on joint demographic and economic policies in comparison with many other regions.

The region extends from the Atlantic Ocean in the west to the Persian Gulf in the east, and from the southern shore of the Mediterranean Sea in the north to southern Sudan and the Gulf of Aden in the south. The Red Sea penetrates the Arab Region from the southeast to the northwest, thereby separating the eastern part (Al-Mashreq Al Arabi) from both the central and western parts (Al Wasat and Al Maghreb Al Arabi respectively). One can also divide the Arab Region into the Arab Middle East subregion and the North African subregion. The Arab States located east of the Red Sea belong to West Asia. In this text we shall adopt the division of the Arab Region into three subregions: the western, middle and eastern. Table 1 includes the division of the Arab countries between these subregions together with some relevant data

The MENA region is a difficult environment for agriculture. Land and water are scarce, and both rain-fed and irrigated land in use suffer from ongoing degradation caused by wind and water erosion and unsustainable farming practices. In most countries, farms are quite small and hence subject to the challenges experienced by smallholders everywhere. Furthermore, the region is predicted to become hotter and drier in the future due to climate change.

The World Bank (2017b) report is a seminal work on MENA water policy. The report has drawn an accurate image of water scarcity in the region and spelled the required reforms both in the water sector and beyond it to avoid the failures and economic losses that would result from an unmanaged scarcity. Two recent World Bank (2017a, 2018a, b) reports presented an update of the state of water scarcity as well as the status of water security in the MENA region. They portrayed the existing challenges and chances to overcome the water security issues. The reports questioned the sustainability and efficiency of water resources management, the reliability and affordability of water services, and whether the water-related risks are appropriately recognized and mitigated.

The present paper presents an overview of the water resources for the following MENA countries. This introductory chapter gives a quantitative representation and description of current available water resources; water demand for industrial, domestic, and agricultural purposes; and water per capita decline over time.

The MENA region also faces growing challenges from environmental stresses, resulting from population pressures, urban growth, water scarcity and pollution, desertification and climate change, exacerbating water shortages. All MENA countries share environmental challenges in the following areas, which differ only in terms of magnitude and severity between the countries: water scarcity and quality; land degradation and desertification; urban and industrial pollution; inadequate capacities for waste management; coastal and marine environmental degradation; air pollution; climate change; and weak environmental institutions and legal frameworks.

The region experienced rapid economic growth between 2000 and 2010, then suffered a sharp economic slowdown post-2011, as a result of several economic and political factors. Prior to 2011, GDP per capita was growing steadily in the majority of the MENA countries, but the 2011 events in the region highlighted the limits of these forecasts, and MENA countries suffered a growth slowdown between 2011 and 2013. This growth slowdown has been accompanied by an increase in fiscal deficits. Large fuel (and food) subsidies have burdened governments' public finances. Governments have tapped into their foreign reserves, reducing fiscal space. Unemployment levels have remained high, and particularly high among women. Most unemployed people are educated, but they need connections *(wasta)* to get jobs because of widespread corruption in the public sector, and because of a weak private sector that is not sufficiently dynamic to generate jobs due to the constraints in the investment climate that hinder private sector growth. Most of the labor force is engaged in the informal sector, and their jobs provide no security. These are people who most likely live near the poverty line (Devarajan et al., 2014). After the profound social and political changes in 2011, the region is still fragile and suffers from (mainly youth) unemployment, poverty and regional disparities. Despite a wealth of oil resources and major improvements in health and education over the past few decades, this region's political, social and economic systems have not evolved in a way that effectively meets the changing needs of its rapidly growing young population. Nearly one in five people living in the MENA region is between the ages of 15 and 24, the age group defined as "young people". The transition from a period of high to low fertility, starting from the 1980s, has altered the age structure of the population, creating a "youth bulge" of 96 million people between the ages of 20 and 29 in 2010, and an estimated 104 million in 2030. As a result, the current huge increase in MENA's working age population has created a new policy challenge for MENA governments, which rarely have enough resources to accommodate the volume of people entering the labor market.

The Middle East and North Africa region, the most water-scarce populated region in the world, faces critical challenges for providing water to its ever-increasing population and protecting its agricultural economy, which demands colossal amounts of water for irrigation. The political turbulence in the region threatens efforts to build cooperation between the region's countries. Water-demand management is the only solution to the enormous water challenges the Middle East region faces, but implementation is uncertain.

As a largely arid region, the Middle East and North Africa (MENA) is particularly vulnerable to climate induced impacts on water resources, yet promoting adaptive governance strategies to deal with increased hydrological risk remains a low priority for political leaderships. It is increasingly clear that climate change will interact with other social, economic and political variables to exacerbate social and political vulnerabilities. In general, climate change acts as a "threat multiplier" for vulnerable countries and populations (Evans 2008a, b; UNDP 2007/2008). Yet climate im- pacts will not be equally distributed, and much will depend upon national resources and adaptive capacities. In this article, we delineate the expected impacts of climate change on water resources in the MENA and analyze the political, economic, and institutional drivers that have shaped governance responses.

Climate change coupled with demographic growth will profoundly affect the availability and quality of water resources in the MENA region (Conway and Hulme 1996; Suppan et al. 2008; Alpert et al. 2008; Sánchez et al. 2004; Milly et al. 2005; Gao and Giorgi 2008; Evans 2008a, b, 2009). Acceleration in the hydrological cycle will likely make droughts longer and rainfall events more variable and intense, raising probabilities of flooding and desertification. As we show, these impacts on the water sector, combined with deteriorating water quality, rising sea levels, and demographic growth, are already evident in much of the MENA. Over-extraction of groundwater aquifers and their contamination, salinization of agricultural land, and urban water shortages, we find, have sparked some policy reforms and adaptive measures, albeit under conditions of crisis management.

CURRENT SITUATION IN TERMS OF WATER RESOURCES AND WATER USE

The MENA region is naturally water scarce, yet water consumption is high. Currently, total water demand exceeds naturally available water supplies by almost 20 % (World Bank 2012). Rainfall is low and variable, evaporation rates are high and droughts are frequent, all contributing to low water resource reliability and availability. Most of the region is classified as arid or semi-arid (desert), receiving less than 250 millimetres of rainfall annually. In addition, MENA countries have to manage an unusual combination of low rainfall and high variability. The highest variability is found in the most arid countries, where average rainfall is so low that even modest rainfall can represent a huge variation on the mean, even though it might not pose a significant management challenge. Countries with this level of aridity concentrate on infrastructure that channels runoff when rainfall does occur, and dams that store water or encourage aquifer recharge. Countries that depend on water flowing in from other nations (Egypt and Syria among the countries analysed) may not have high levels of variability on their own territory but do experience the effects of variability in other territories. Variability is a particular challenge in those MENA countries that have just enough rainfall on average but where the patterns are irregular over time or space.

While the region has low water availability on average, the quantity of water available varies considerably among countries in the region (Table 1 and 2).

Table 1. Total renewable water resources in MENA region.

Source: AQUASTAT database, Food and Agriculture Organization of the United Nations (FAO)

	Produced internally (billion m^3/yr)			Total internally produced per capita	Total external renewable water resources	Total renewable water resources (billion m^3/yr)	Total renewable water resources per capita (m^3/inhab/yr)
	Surface water	Ground-water	Total	(m^3/inhab/yr)	(billion m^3/yr)		
Algeria	9.76	1.49	11.25	286.90	0.42	11.67	297.60
Egypt	0.50	1.30	1.80	21.94	56.50	58.30	710.50
Libya	0.20	0.60	0.70	112.90	0.00	0.70	112.90
Morocco	18.00	4.00	22.00	899.00	0.00	22.00	899.00
Tunisia	3.10	1.50	4.20	381.50	0.42	4.62	419.70
Jordan	0.49	0.45	0.68	93.76	0.26	0.94	128.80
Lebanon	4.10	3.20	4.80	995.40	-0.30	4.50	933.80
Syria	4.29	4.84	7.13	325.70	9.67	16.80	767.20

Table 2 Water resources in in MENA region

Renewable freshwater resources in MENA region

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Algeria	89	212 000	11 250	11 670	4	292	8 300
Bahrain	83	59	4	116	97	160	0
Egypt	51	51 070	1800	58 300	97	699	168 200
Iran	228	397 000	12 850	137 500	6.6	1 978	31 610 000
Iraq	216	94 680	35 200	75 610	53.45	2 625	139 700 000
Jordan	94	8 345	682	937	27.21	161	275 000
Kuwait	121	2 160	0	20	100	7.4	
Lebanon	823	8 559	4 800	4 503	0.79	1 159	225 650
Libya	56	98 530	700	700	0	112	389.89
Mauritania	92	94 350	400	11 400	96.49	3 826	900 000
Morocco	346	154 500	29 000	29 000	0	879	17 500
Oman	62	19 190	1 400	1 400	0	545	88 380
Palestine	409	2 313	766	766	0	333	0
Qatar	80	880	56	58	3.45	71	
Saudi Arabia	114	24 510	2400	2400	0	98	835 600
Sudan	250	489 800	4 000	37 800	96	996	21 230
Syria	252	46 670	7 132	16 797	72.29	882	19 654 000
Tunisia	207	33 870	4 195	4 615	9	419.7	2 677
United Arab Emirates	78	6 521	150	150	0	48.29	118 000
Yemen	167	8 817	2 100	2 100	0	100	462 500

(1) Precipitation (long-term average) (mm/yr)

(2) Precipitation (long-term average) (million m^3/yr)

(3) Internal renewable water resources (long-term average) (million m^3/yr)

(4) Total actual renewable water resources ((million m^3/yr)

(5) Dependency ratio (%)

(6) Total actual renewable water resources per inhabitant (m^3/yr)

(7) Total dam capacity (million m^3)

Figure 2 shows the available renewable water per capita in MENA countries for the years 1992–2014. The figure clearly shows that the available water per capita is dwindling over time for all MENA countries, reflecting an increased scarcity in the region. MENA countries are also characterized by high evapotranspiration rates, given the high temperatures most of the year. The common water sources for the MENA region are surface and groundwater in addition to non- conventional water such as desalination and recycled treated wastewater.

Food security, on the other hand, "exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life». These two definitions meet when water is put into an agricultural perspective. They are particularly important in regions with increasing water scarcity. The MENA region cannot currently and in the future meet its food production requirements due to increased water scarcity. As Figure 3 shows, all economies of the MENA region other than Turkey will face either water stress (below 1,700 cm/year/capita) or (absolute) water scarcity by 2050.

Water stress and water scarcity are not new to the MENA region: since the 1970s there have been several instances of insufficient water for food self-sufficiency (Allan 2002). However, while water and food insecurity can be mitigated through moderate food imports, the trend will only intensify. To date, the vast majority of MENA economies are almost entirely reliant on food imports for maintaining an adequate level of food and water security. The key import commodities are cereals and meat (UNESCWA 2017).

Water scarcity in the Middle East and North Africa (MENA) region can either be a destabilizing factor or a motive that binds communities together, according to a new joint report from the United Nation's Food and Agriculture Organization (FAO) and the World Bank, with the difference determined by the policies adopted to cope with the growing challenge. Protracted conflicts in the Middle East and North Africa have left tens of millions of people in need of humanitarian and development assistance to have access to water. But the capacity of local water service providers to maintain adequate levels of services has decreased as conflicts and population movements across the region have continued, mainly towards urban areas.

Figure 2 Available renewable water per capita in MENA countries 1992–2014. (Source: World Bank 2018b. database, data for 2014)

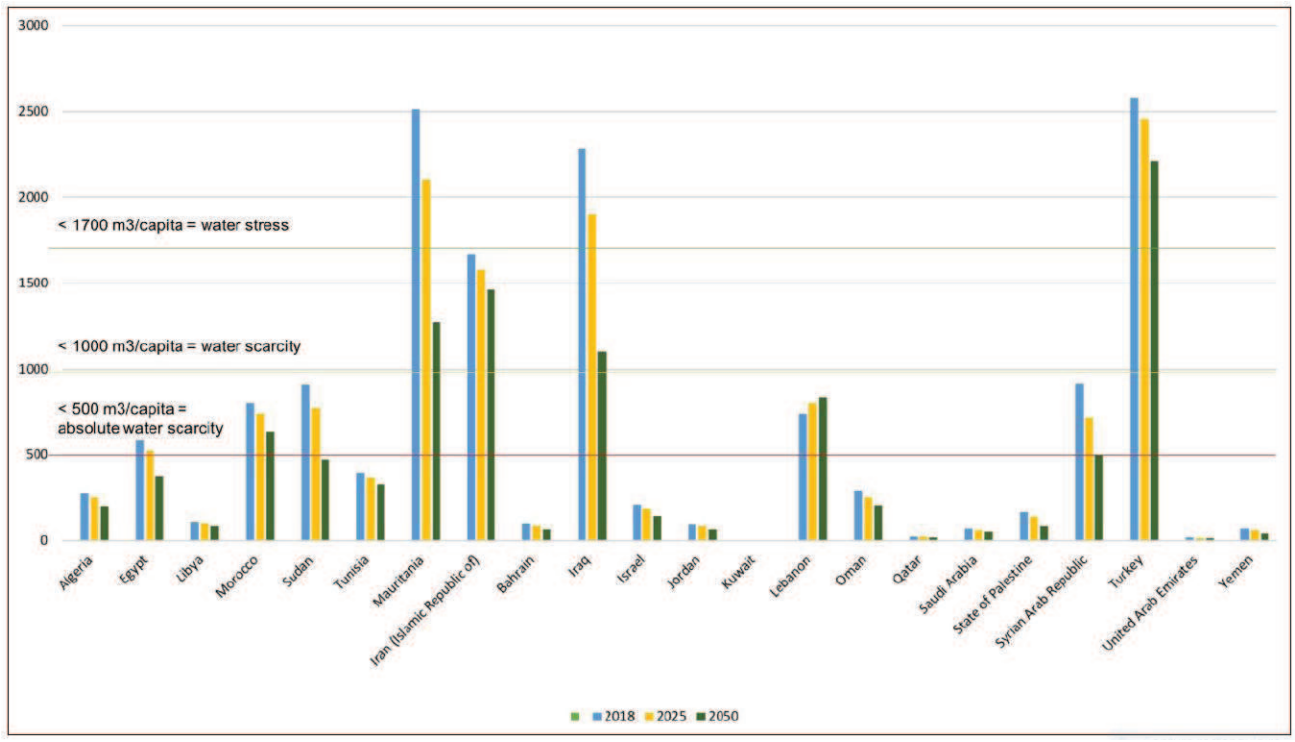
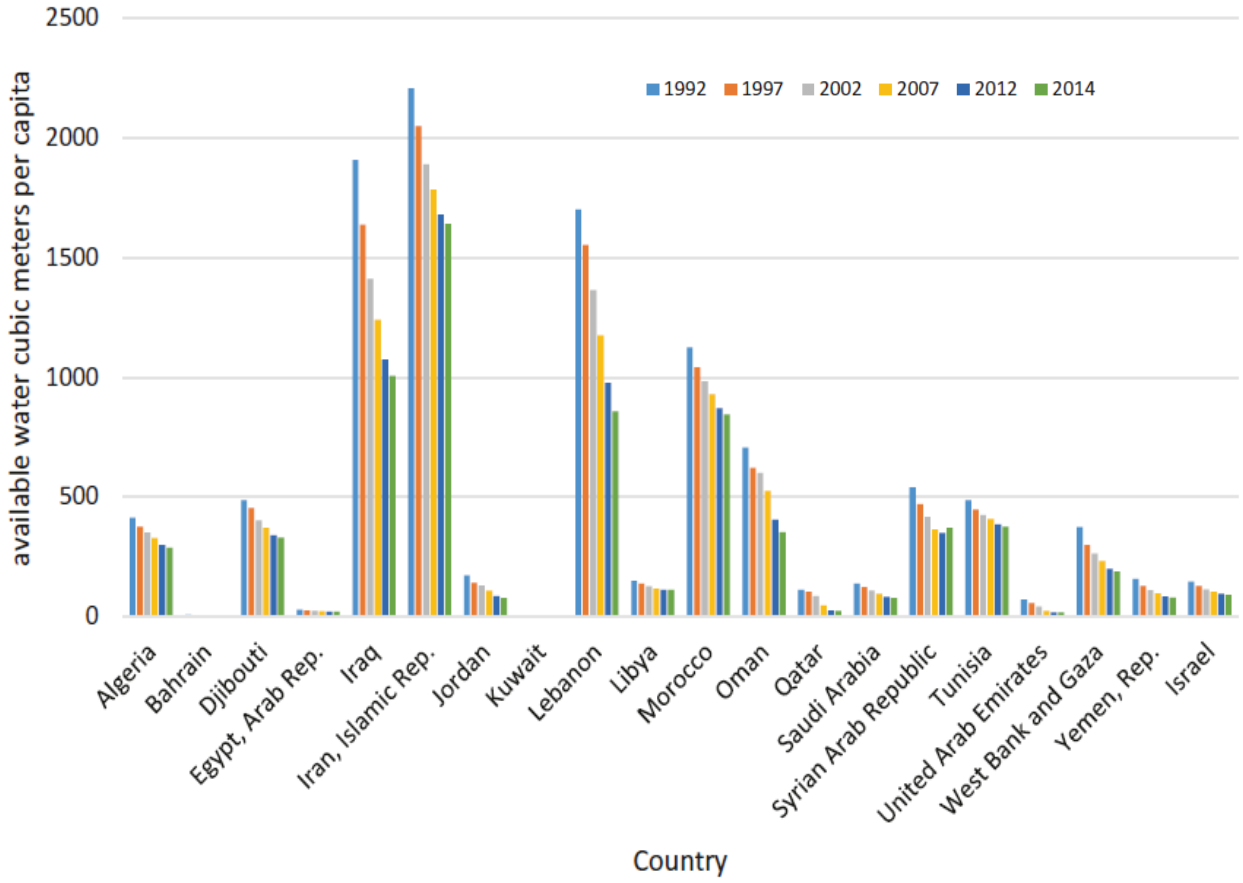


Figure 3 Water availability per capita, 2018, 2025 and 2050



Recently, the MENA Regions (Middle East and North Africa) has encountered various concerns in the sector of "water resource management" because of the rapid growth in the domestic, agricultural, and industrial activities. Feasible and practical strategies needed for sustainable management of the water shortage concerns in the MENA Regions (Middle East and North Africa) are suggested.

Figure 4 shows the distribution of surface water and groundwater resources. GCC countries, Djibouti, Libya, and Jordan have the lowest quantities of groundwater and surface freshwater. Egypt, Iraq, and Syria depend on transboundary water resources such as rivers originating from other regions and aquifers which are shared with other countries. Rivers are the main water source used for crop irrigation in Egypt and Iraq, which are threatened by the increasing level of water use by upstream countries.

Changes in water resources availability can be expected as consequences of climate change, population growth, economic development and environmental considerations. A two-stage modeling approach is used to explore the impact of these changes in the Middle East and North Africa (MENA) region. An advanced, physically based, distributed, hydrological model is applied to determine the internal and external renewable water resources for the current situation and under future changes. Subsequently, a water allocation model is used to combine the renewable water resources with sectoral water demands. Results show that total demand in the region will increase to 393 km^3 yr^{-1} in 2050, while total water shortage will grow to 199 km^3 yr^{-1} in 2050 for the average climate change projection, an increase of 157 km^3 yr^{-1}. This increase in shortage is the combined impact of an increase in water demand by 50% with a decrease in water supply by 12%. Uncertainty, based on the output of the nine GCMs applied, reveals that expected water shortage ranges from 85 km^3 yr-1 to 283 km^3 yr^{-1} in 2050. The analysis shows that 22% of the water shortage can be attributed to climate change and 78% to changes in socio-economic factors.

Figure 5 shows that Iran, Iraq, Lebanon, and Morocco have relatively the highest quantities of renewable water resources compared to other MENA countries, with water level of more than 800 cubic meter per capita per year. On the other extreme, Gulf Cooperation Countries (GCC), Jordan, Libya, and Yemen have the lowest level of available renewable water resources per capita and they highly depend on depleting groundwater and desalination.

Figure 4 Renewable volumes of groundwater and surface water in MENA. (Source: FAO AQUASTAT 2018, data for 2014)

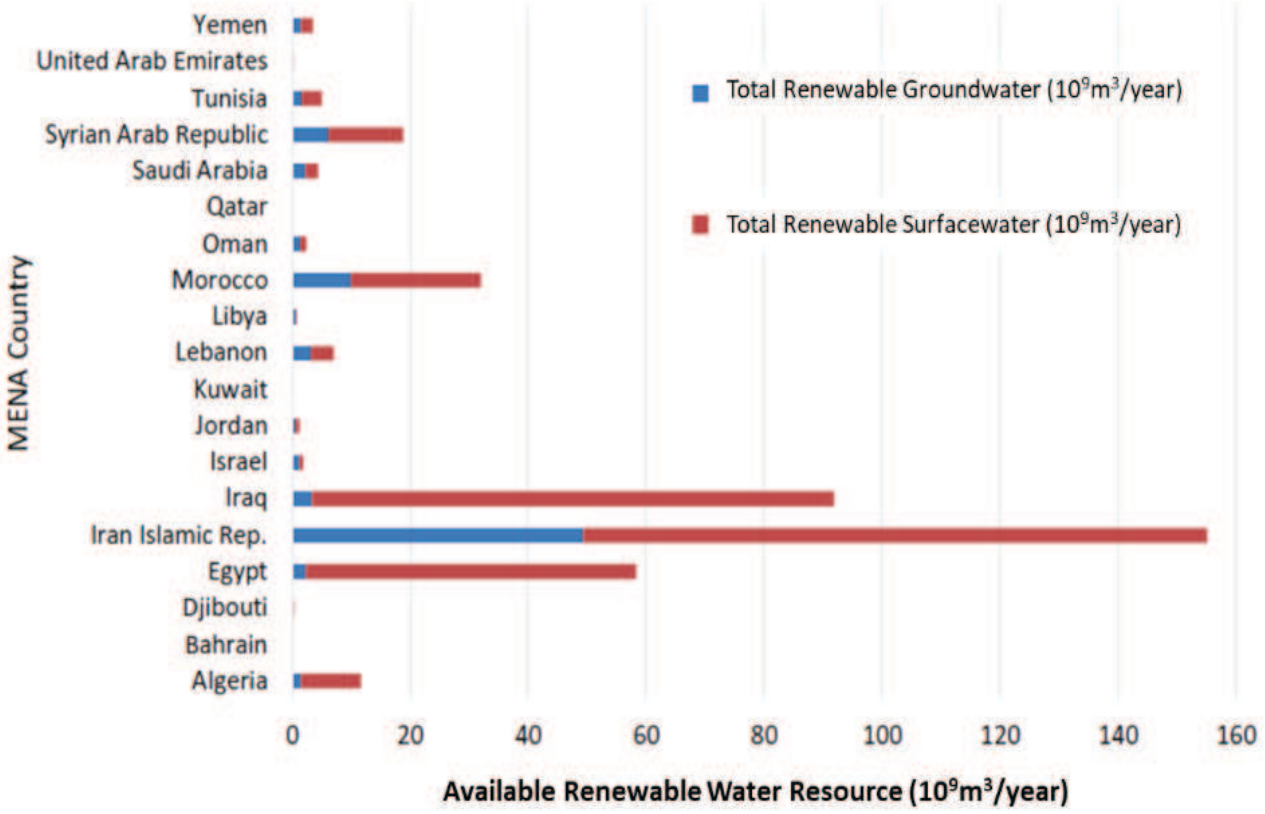
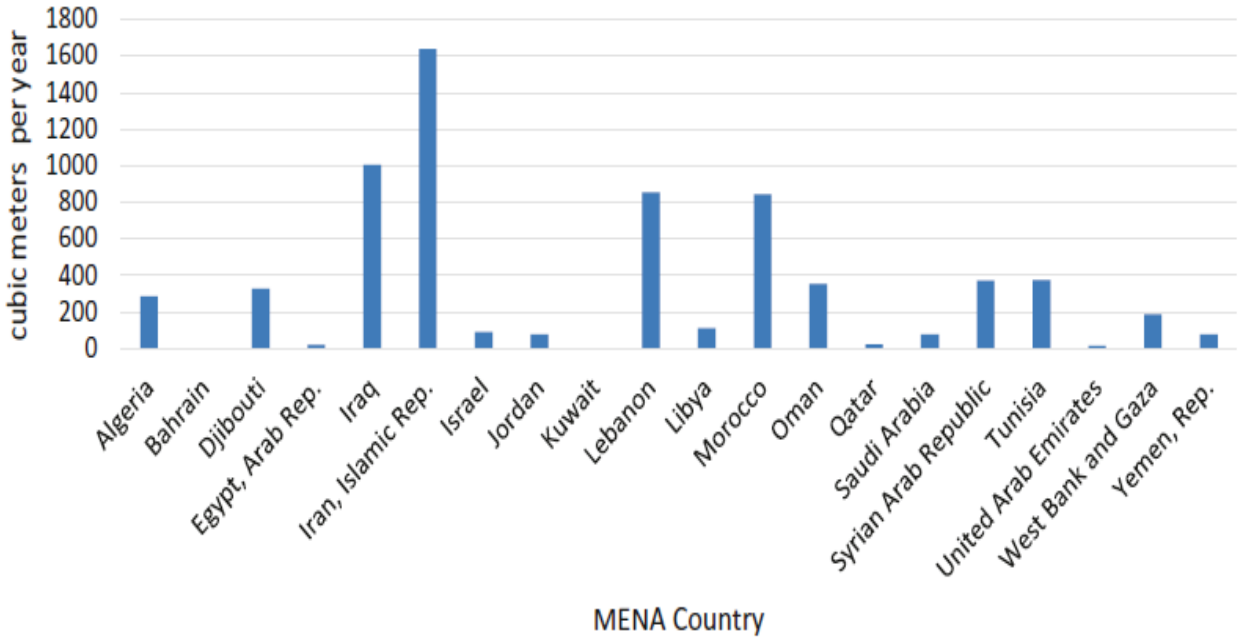


Figure 5 Renewable water per capita per year (m^3) for Mena Countries (Source: World Bank 2018b. database, data for 2014)



CLIMATE OF THE MIDDLE EAST AND NORTH AFRICA (MENA) REGIONS

The Middle East and North Africa region is experiencing a widening gap between freshwater supply and demand caused by population and economic growth and climate change. The region is diverse in its landscapes and climates, from the snowy peaks of the Atlas Mountains to the empty quarter of the Arabian Peninsula. The MENA region can be classified according to the aridity index, which is defined as the ratio between precipitation and ETref. On the basis of this index, the largest part of MENA can be classified as hyper-arid (<0.05) (World Bank, 2007). This hyper-arid area includes the inland in Northern Africa (Algeria, Libya, and Egypt). The coastal areas of Northern Africa, Iran, and the Western coastal region of the Middle East are defined as arid to semi-arid. Humid areas are found in the northern parts of Morocco, Algeria, Tunisia, Iraq, and Iran, and the western part of Syria and Lebanon.All the countries of the region are located on the coasts of the North Atlantic Ocean, the Mediterranean Sea, the Red Sea, the Gulf of Aden, the Persian Gulf, the Gulf of Oman and the Arabian Sea and, as such, there is no land-locked country in this region. The areas located along the Mediterranean coast lines display lower temperatures and more rainfall resulting in a more moderate climate when compared to the hot inland deserts.

Population densities in MENA are largest in semi-arid to humid regions, or where irrigation systems are present. Irrigation systems are mainly concentrated in the Nile Delta in Egypt, where it covers 60–80% of the surface area (World Bank, 2007), in the central part of Iraq, and scattered throughout Iran. Despite the presence of some humid regions and irrigation systems, the MENA region faces many challenges.

The countries of the Near East region have been grouped in three sub-regions based primarily on geographic and hydro-climatic similarities. These sub-regions are referred to as North Africa (Algeria, Egypt, Libyan Arab Jamahiriya, Mauritania, Morocco and Tunisia), Arabian Peninsula (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen), and Middle East (Islamic Republic of Iran, Iraq, Jordan, Lebanon and Syrian Arab Republic). Even though hot and dry weather prevails across the Near East region, there is a great variety in the physical geography of this vast area. The region is characterized by the presence of long coastal lines, vast deserts, rivers, and mountain ranges with resulting diverse hydro-climatic conditions. Some of the main transboundary rivers in the region originate outside of the Near East with their water flows generated from places like eastern Turkey (Tigris-Euphrates) and the Ethiopian highlands and great lakes of humid Africa (River Nile).

The largest challenge in the MENA region is that countries have to manage an unusual combination of a low annual precipitation that is at the same time highly variable. Three groups of countries can be identified:

(i) Countries that on average have adequate quantities of renewable water, but the within-country and within year variations are problematically large. These include Djibouti, Iran, Lebanon, Morocco, Tunisia, and the West Bank.
(ii) Countries with consistently low levels of renewable water resources. Therefore, these countries are highly dependent on non-renewable groundwater sources and supplies by desalination of sea water. These countries include Bahrain, Gaza, Jordan, Kuwait, Libya, Oman, Qatar, Saudi Arabia, the United Arab Emirates, and Yemen.
(iii) Countries that mainly dependent on the inflow of transboundary rivers such as the Nile, the Tigris, and the Euphrates. These countries include Syria, Iraq, and Egypt (World Bank, 2007).

In Figure 6, it is clear that in the majority of countries the annual precipitation sum for the current climate is low. Especially in Libya and Egypt the annual precipitation sum is very small (<25 mm). The wetter areas are the coastal areas of Morocco, Algeria, Tunisia, Lebanon, Syria, Iran, and Yemen. Decreases in precipitation are nearly seen in every country for the period 2020–2030, with the largest decreases found in southern Egypt, Morocco, the central and coastal areas of Algeria, Tunisia, central Libya, Syria, and in the central and eastern part of Iran. Decreases are in the range of 5–15% for most countries, with a decrease of more than 20% in southern Egypt. In several regions, also increases in precipitation are noticed. Increases are in the range of 0–20%. It should be noted that the annual precipitation sum in these regions is very low, meaning that an increase of, for example, 20% in southeast Libya means an annual increase of roughly 5 mm.

For 2040 through 2050 we see a larger decrease in precipitation for the majority of countries than for 2020 through 2030. Especially in Morocco, the central and northern part of Algeria, Tunisia, Syria, the southern and central part of Saudi Arabia, the northern part of Iraq, and in Iran, precipitation has decreased with respect to the current climate and 2020–2030. (Terink et al., 2013)

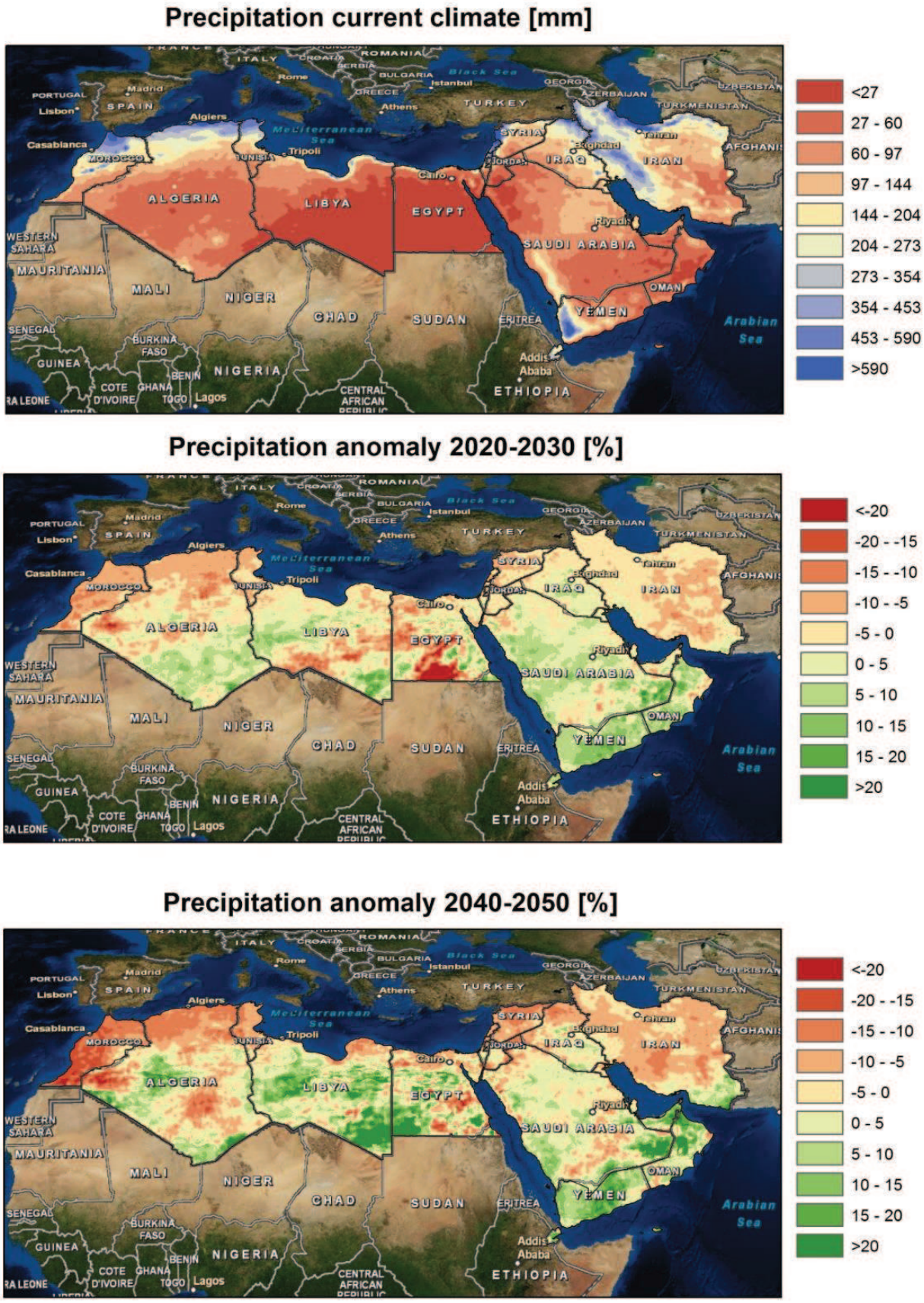


Figure 6. Spatial patterns of precipitation projections. Top: Average annual precipitation sum of the current climate. Middle: Precipitation anomalies of 2020–2030 with respect to the current climate. Bottom: Precipitation anomalies of 2040–2050 with respect to the current climate. (Walter et al., 2011).

If we consider the temperature projections (Figure 7) then it is clear that the MENA region is characterized by high average annual temperatures. Very high temperatures are found in the southwestern part of Algeria, the western and eastern part of Saudi Arabia, in Yemen, in Oman, and in the southern part of Iran. Temperature projections for 2020-2030 indicate a rise in temperature throughout all countries. The smallest increases in temperature (<0.15 °C) are found in North Libya, North Egypt, Israel, Lebanon, Jordan, and West Syria. The largest temperature increases (>0.65 °C) are found in the northern part of Morocco and Algeria, South Algeria, the southern part of Saudi Arabia and Iran, and in the central and northern part of Yemen and Oman.

Temperature projections for 2040-2050 indicate an even larger increase in temperature throughout the MENA region. An increase of more than 1.7 °C is not an exception. These findings are higher than the global average (Figure 7). The smaller temperature increases are found in the same regions as in the period 2020-2030. Large temperature increases (>1.5 °C) are found in the northern part of Morocco and Algeria, central and South Algeria, the central and southern part of Saudi Arabia, and in the northern part of Iraq, Iran and Yemen.

Much of the land area in the Near East region is covered by deserts. The Sahara Desert stretches from the Red Sea in the east to the Atlantic Ocean in the west, representing more than 90% of the landmass of Northern Africa. The Rub Al Khali Desert, known also as the Empty Quarter, covers an area 1,000 km long and 500 km wide in the South of the Arabian Peninsula. There is also the Nefud Desert in the northern part of the Arabian Peninsula. Other main deserts in the region include the Dasht-e Kavir and Dasht-e Lut deserts which cover large parts of east central and north sections, respectively, of the Islamic Republic of Iran. The Near East region has many internal mountains as well as several mountain ranges rising to various elevations. These include Tebetsy Mountain in Libyia with the highest peak of 3,000 meters. The Atlas Mountains range in North Africa which stretches across much of Morocco, northern Algeria and part of Tunisia has its peak in Morocco at an elevation of 4,165 meters. The Zagros mountain chain in the Islamic Republic of Iran reaches 4,432 meters at its peak. Other mountain ranges in the region include those in Lebanon and Yemen with highest elevations at just over 3,000 and 3,268 meters, respectively.

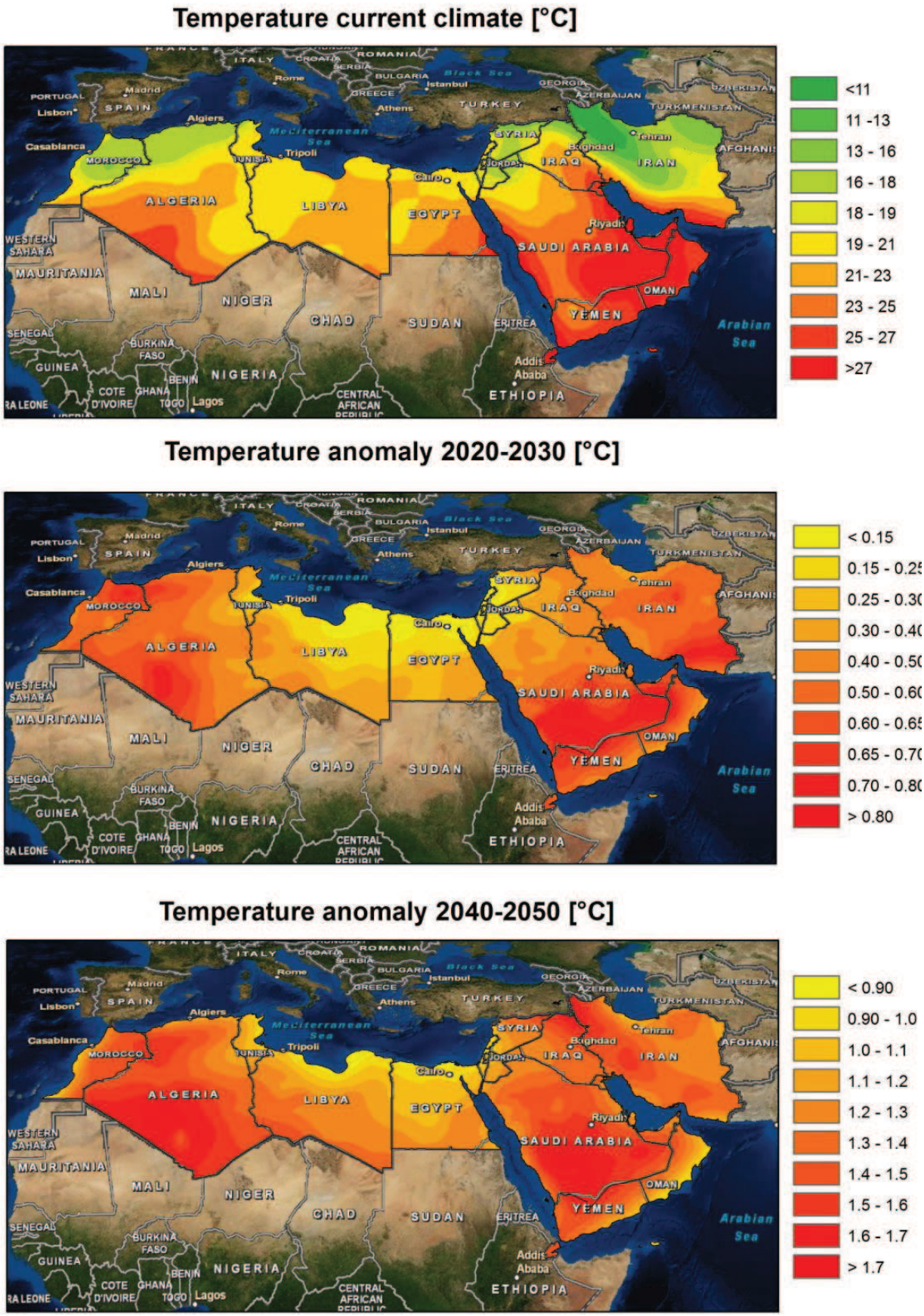


Figure 7. Spatial patterns of temperature projections. Top: Average yearly temperature of the current climate. Middle: Temperature anomalies of 2020-2030 with respect to the current climate. Bottom: Temperature anomalies of 2040-2050 with respect to the current climate. (Walter et al., 2011).

Walter et al (2011) consider the anomalies for 2020-2030, then we notice a slight increase in annual reference evapotranspiration. This increase is in the range 0-1% for the largest part of the countries. Despite the lowest values of annual reference evapotranspiration found in the coastal areas, these areas are exposed to the largest (up to more than 9%) increase in annual reference evapotranspiration. In some countries, like for example in Algeria, Libya, Egypt and Jordan, we see a small decrease in annual reference evapotranspiration. This is caused by the range between the maximum and minimum temperature for the selected random year,

For 2040-2050 there is an increase in annual reference evapotranspiration in all countries, except for some small regions in Morocco, Libya, and Egypt. Again, these decreases are very small. The highest increases are again found in the coastal regions, with increases of more than 9%.

The MENA region is home to some of the poorest and most malnourished people in the world. An estimated 70% of the poverty is found in rural areas although only about 43% of the total population (over one billion) lives there. Cereals provide the largest component of the human diet in the region, while livestock production, often the major income earning activity in marginal areas, is increasingly dependent on supplementary feeding of grain.

The region already has the highest level of imports of food grain globally. Demand will rise while regional production will be increasingly affected by water scarcity. In order to assess the scope and impacts of water scarcity and droughts in the MENA region, we should give an in-depth assessment of the current situation with regards to water scarcity and droughts, and consists of data collection of information at river basin or local level, and we should give also give an inventory of measures taken by MENA countries to manage water scarcity and droughts in proactive and reactive ways.

The last climate variable of interest is the reference evapotranspiration (Figure 8). A clear pattern of annual reference evapotranspiration is observable for the current climate. The coastal areas have the smallest annual reference evapotranspiration, while moving inland the reference evapotranspiration becomes higher. The largest annual reference evapotranspiration values (>2200 mm) are found in South-West Algeria, South Egypt, Djibouti, the southeastern part of Saudi Arabia, the southern part of Iraq and Iran, North-East Yemen, and West Oman.

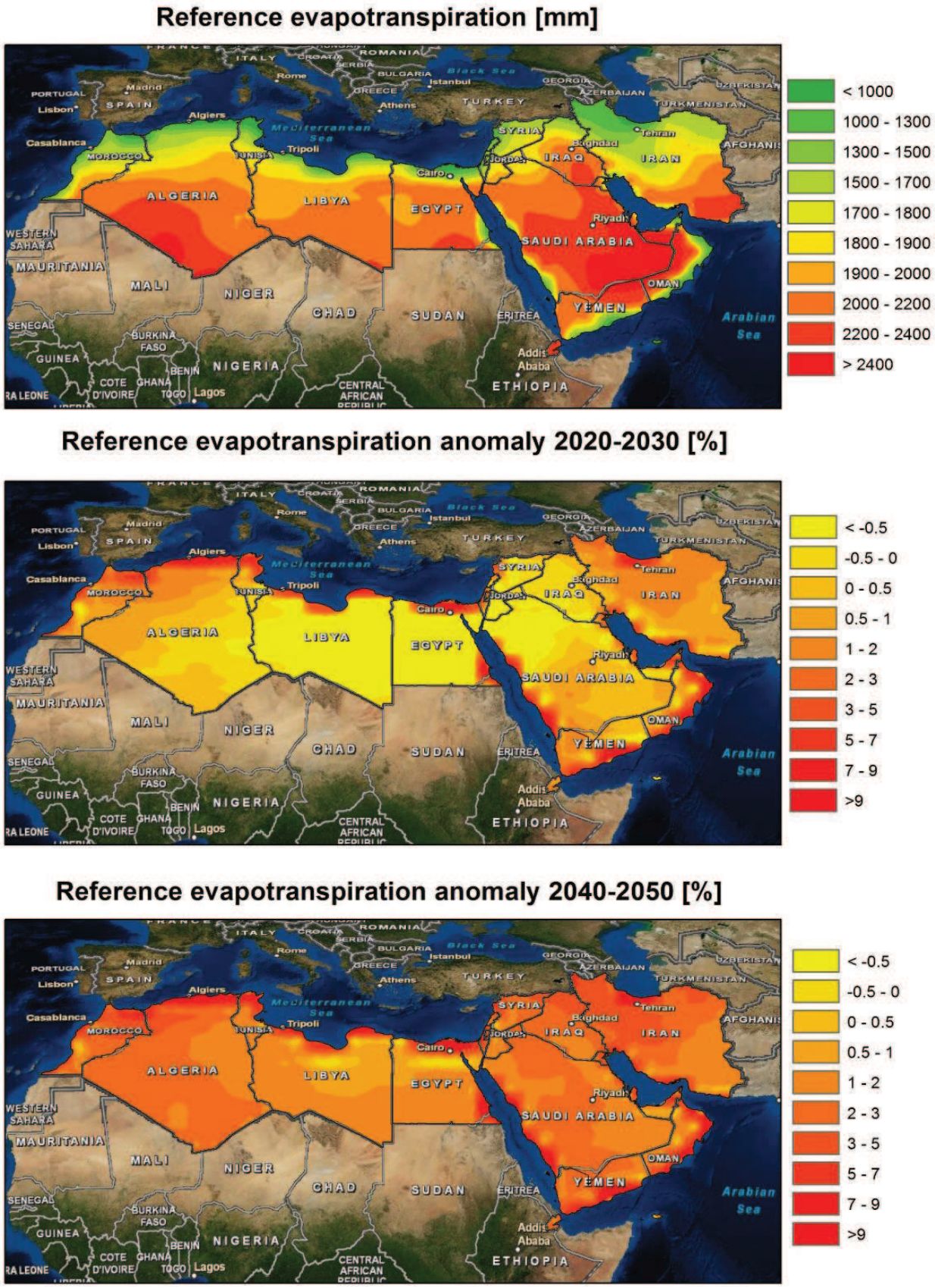


Figure 8. Spatial patterns of reference evapotranspiration projections. Top: Average yearly reference evapotranspiration sum of the current climate. Middle: Reference evapotranspiration anomalies of 2020-2030 with respect to the current climate. Bottom: Reference evapotranspiration anomalies of 2040-2050 with respect to the current climate. (Walter et al., 2011)

Food security situation

Households are food secure when they have year-round access to the amount and variety of safe foods their members need to lead active and healthy lives. Changes in food security, then, are driven mainly by events or conditions that affect families' ability to access safe food. Chief among these are incomes, the working of food markets to ensure food availability, and state public services to ensure food safety. The largest disrupter of these three factors in the region is conflict, which divides the region into two distinct subregions from the point of view of food security – conflict and non-conflict countries.

The Prevalence of Undernourishment (PoU) estimates the share of the population of a country facing absolute food deprivation. It is defined as the probability that a randomly selected individual from the reference population is found to consume less than his or her calorie requirement for an active and healthy life. (FAO, 2017c). Table 4.1 shows the prevalence of undernourishment in conflict and non-conflict countries in the MENA region.

As a rule of thumb, countries with a PoU of less than 5% are considered to be relatively food secure. As highlighted in Table 4.1, the non-conflict countries of the region are, in fact, relatively food secure. According to the PoU, in 2014-2016, the conflict countries of the MENA region were less food secure than the average level for least developed countries (LDCs). Whereas 28.2% of the population of the MENA conflict countries faced absolute food deprivation, only 24.4% of the population of the LDCs faced such insecurity (FAO, 2017c). Though the high level of food insecurity in the conflict countries accords with expectations, care should be taken in interpreting these data for the prevalence of undernourishment. The PoU is a good indicator of hunger during periods when the income or consumption distribution is relatively constant, but it is not a good indicator of hunger when sharp changes in the distribution of food occur. The PoU likely underestimates the actual prevalence of undernourishment during times of conflict, because the inequality in food consumption parameters used to calculate it are derived from national household survey data, which are usually not available or accurate during times of conflict (FAO, 2017c). Setting aside these caveats for the moment, the level of measured PoU in the conflict countries has been over three times the level in the rest of the MENA countries since 1999-2001, and has been rising gradually vis-à-vis the other countries in the region since 2003 (Table 3). This pattern in the evolution of the PoU in the conflict countries is consistent with it being partially driven by conflict, but it is also clear that they had relatively high levels of food insecurity even before conflict arose.

Table 3. Prevalence of undernourishment in conflict and non-conflict regions in MENA, 1999-2001 to 2014-16

	1999-2001	2001-2003	2003-2005	2005-2007	2007-2009	2009-2011	2011-2013	2013-2015	2014-2016
All MENA	9.7	9.8	10.0	10.0	9.6	8.9	8.4	8.4	8.8
Non-conflict countries	6.3	6.4	6.5	6.3	6.0	5.5	5.0	4.7	4.7
Conflict countries	29.0	28.4	28.9	29.1	28.5	26.6	25.3	26.1	28.2
Of which:									
--Yemen	29.9	30.7	30.9	28.9	27.1	25.7	24.6	25.2	28.8
--Iraq	28.3	26.6	27.4	29.3	29.6	27.2	25.9	26.7	27.8
--Sudan							25.9	25.7	25.6

Note: Undernourishment data exist for only three of the five conflict countries, and the aggregate is constructed from these data. Source: FAO (2017c).

The Middle East has experienced many environmental concerns lately. Water resources are becoming increasingly scarce, especially for the millions there who already lack access to sanitary water. Some of these countries, including Yemen, the United Arab Emirates, Saudi Arabia, and Iraq, are facing unique problems that require global, immediate attention. Beside their neighboring location, one shared factor of all these countries is their lack of water resources and poor water management.

The Middle East has some of the largest oil reserves in the world, which produces most of the area's wealth. Even so, the region's climate and environment make living harsh. The Middle East requires water resources and suitable land for agriculture. Much of the land that is available for producing food is destroyed by increasing desertification.

Desertification is a sweeping environmental problem, with vast effects in countries such as Syria, Jordan, Iraq, and Iran. Universal causes for a spread of arid environment are unsustainable agriculture practices and overgrazing. Agriculture uses 85 percent of water in this region. It is common to misuse land by heavy irrigation in the Middle East. In the area droughts are more frequent, and contribute to the changing landscape. The overuse of water in agriculture is affecting the countries' already undersized water resources.

Jordan, located in the Syrian Desert, and Yemen, on the southern tip of the Arabian Peninsula, both endure severe water scarcity in the Middle East. For example, Jordan's average freshwater withdrawal is less than 10 % of Portugal's average, despite being the same size. The cost of water in Jordan increased 30 % in ten years, due to a quick shortage of groundwater. Yemen has one of the highest worldwide rates of malnutrition; over 30 % of its population does not meet their food needs. In recent years, Yemen has not been able to produce enough food to sustain its populations. Water scarcity has damaged the standard of living for inhabitants of the Middle East.

Desalination plants are an overuse of water resources in the Middle East. Seventy % of desalination plants in the world are located in this area, found mostly in Saudi Arabia, the United Arab Emirates, Kuwait, and Bahrain. While the plants produce water needed for the arid region, they can manufacture problems for health and the environment. The seawater used most in desalination plants has high amounts of boron and bromide, and the process can also remove essential minerals like calcium. Also, the concentrated salt is often dumped back into oceans where the increased salinity affects the ocean's environment. The plants harm local wildlife and add pollutants to the region's climate. In addition, desalination is the most energy-costing water resource. The Pacific Institute explains that the high use of energy results in raised energy prices and higher prices on water produced, hurting the consumer. The water produced can be beneficial towards substituting any lack of freshwater, but these areas have tendencies towards overuse of their natural resources. Concerns with the large amount of desalination plants in the Middle East focus on the improper dependency they will cause, instead of encouraging alternate forms of water and energy and conserving freshwater.

The Middle East has numerous struggles with its current water resources, and the region needs more than one solution to generate an optimistic environmental position for the future.

Conflict and food security in the MENA Region

At the end of 2017, over 30 million people in this region were in need of assistance to satisfy their basic food needs. Among those, the food security situation was most critical in countries with lingering or escalating conflicts: Yemen, Syrian Arab Republic, Iraq and Sudan. In Yemen, according to the latest assessment carried out in March 2017, about 17 million people, corresponding to 60% of the total population, required food assistance. In the Syrian Arab Republic, some 6.5 million are estimated to be food insecure, and an additional 4 million at risk of food insecurity as they are using asset depletion strategies to meet their consumption needs. In Iraq and Sudan, about 3 million are food insecure. Smaller figures are reported for Libya and Mauritania, about 0.4 million each.

Residents in conflict zones often have to resort to food coping strategies to cover the severe food shortages they are facing. Households tend to reduce the number of meals and restrict the consumption of adults to prioritise children. If the crisis lingers, households deplete their assets and are no longer able to draw on stocks or other reserves. They resort to child labour, which often includes the withdrawal of children from school to carry out agricultural activities in order to cope.

Economic activity, including agricultural production, suffers in a conflict environment and further impairs livelihoods. While agricultural production is often one of the most resilient activities in an economy, those continuing to farm are often confronted with high production costs, lack of inputs and damaged or destroyed infrastructure. Agricultural activities, particularly those related to irrigated crops, suffer when fuel prices are high, with consequent increases in the share of rain fed crops, which in turn bear lower yields.

Fertilisers are often subject to international sanctions. Farmers tend to plant seeds saved from the previous harvests, further constraining yields. Many rural households tend to rely on casual labour opportunities as their main source of income. In many conflict-affected areas, hired agricultural labour tends to be replaced by family labour in order to cope with the increased costs of production. While agricultural production improves household and local food availability, limited infrastructure including cold chain and transportation links often prevents deliveries to urban markets. Consequently, prices of local products tend to be low in producing regions, and high in the urban markets, despite availability.

The impact of lower agricultural production on world agricultural markets may be small, but has been dramatic in the affected countries. Before the conflict, Syria – one of the larger producers – produced on average about 4 Mt of wheat, but reached only 1.8 Mt in 2017. In Yemen, total domestic cereal production covers less than 20% of the total utilisation (food, feed and other uses). The country is largely dependent on imports from the international markets to satisfy its domestic consumption requirement for wheat, the main staple. The share of domestic wheat production in total food utilisation in the last ten years is between 5% to 10%, depending on the domestic harvest. While conflict did not substantially increase the country's dependence on imports, conflict-related decrease in production deteriorated livelihoods of farmers and pushed many to food insecurity.

The unpredictability of conflict threatens food security and local livelihoods but also livelihoods in the host countries. In addition to the millions who have fled countries due to the conflict, many are on the move internally, many multiple times. Internally displaced people and their host communities are often the most vulnerable to food insecurity. In Syria, about two in five people are on the move inside the country. In Iraq, in the first half of 2017, close to 1 million people were internally displaced, mostly due to the military operations in Mosul, in addition to the 3 million people already displaced by November 2016. As of early February 2018, over 5.5 million refugees were registered in the region covering Egypt, Iraq, Jordan, Lebanon and Turkey. In addition, a large share of the population lives abroad without seeking refugee registration.

When food production is limited by insufficient water resources, the consequences are of high geopolitical relevance. In the MENA region, water and food insecurity tend to lead to a greater rural exodus and therefore higher levels of urbanization. Cities grow much faster in the MENA region than in other world regions, a trend that will intensify if rural livelihoods are threatened due to water scarcity. The future of the MENA region will thus be played out in urban areas requiring substantial domestic and international policy shifts to strategically address specific challenges. These challenges include industrializing economies to obtain

sufficient foreign exchange to act as a strong player in global agricultural trade. MENA economies could follow the example of the Mercosur countries to strategically cooperate to achieve improved trading terms.

The Syrian conflict can be taken as an example of what happens if high migration to cities due to environmental problems is inadequately addressed. Syria was affected by a severe drought between 2006 and 2010, which led to a decrease in the contribution of agriculture to national gross domestic product (GDP) from 25 to 17 %. This resulted in high urban migration, and farmers being unable to find sufficient job opportunities (Kelley et al. 2015). The rest is history, with climate change and associated water problems as one of the drivers of the Syrian conflict. The social question of agriculture is not exclusive to Syria. Across the MENA region, farmers are living precarious livelihoods. Only those farmers who have off-farm income or access to land enjoying relatively high precipitation levels or irrigation water live in moderate poverty. Thus, the social dimension of agriculture is a crucial issue for governments to address if the lessons from Syria are to be taken seriously.

Water stress or water scarcity does not mean that food production is precluded. Rather, agriculture has to be reformed in a way that livelihoods can be protected and water resources used in the most efficient manner. Agricultural sectors in the MENA region will have to move to high-value crop production with high-resource efficiency methods and higher water productivity. This requires a shift to integrated water management concepts. For example, lessons can be drawn from the water-energy-food nexus (WEF nexus) to reuse wastewater for food production or desalinated water through the use of renewable energy to grow cash crops. Australia's Sun Drop Farms show, in an arid context, how to grow vegetables using desalinated water through solar energy to cater for the domestic market (Margolis 2012). Researchers at the University of Wageningen have gone further by developing metropolitan food clusters and agroparks where food is grown in urban and peri-urban areas using highly efficient technologies such as hydroponics and precision agriculture to produce more food per drop of water (Buijs et al. 2010). This is especially promising if the life span of water is expanded by utilizing treated wastewater for food production. Another key resource in rainfall-prone areas of the MENA region is the so-called green water – water stored in the soil profile generated from rainfall (Assi et al. 2018). This water has very low opportunity costs as it cannot be pumped or diverted to be used as irrigation water. It is an essential part of any food security strategies in the MENA region.

Resource use efficiency is not only a technological question. Grafton et al. (2018) showed that higher irrigation efficiency rarely reduces water consumption if public authorities fail to introduce water quotas to strictly allocate water resources among farmers. This means that, before investments in technology are made, a policy shift is called for, to introduce strict water policies. At present, illegal wells are widespread across the MENA region, which may lead to a tragedy of the common's situation in which self-interest of farmers negatively affects common goods such as water resources.

The European Union can play a very important role in mitigating the effects of water scarcity in the MENA region. There are several ways in which it can act as a friendly external power to support the transition of agricultural economies to low-resource and high-tech economies. First, the EU could give firm support to governments with better advice on institution-building to regulate water use in the agricultural sector. Second, the EU can provide technology transfer from its agricultural research organizations as well as targeted investment in wastewater treatment facilities and high-tech

farming facilities to support MENA economies in their transition from traditional agriculture to high-tech, low-resource input agriculture. Third, MENA economies will be unlikely to grow sufficient cereals for domestic and regional food security. Thus, the region will further have to import cereals from around the world. This can be facilitated by establishing an agricultural customs union between the EU and MENA economies to provide producers of high-value crops in the MENA region with access to the European market. Similarly, MENA importers can be provided with tariff-free access to European cereals and other staple foods to support food and nutrition security in the MENA region. Therefore, the key arena for mitigating water and food management in the MENA region will have to come from policymakers both regionally and internationally

IMPACT OF CONFLICTS: WATER SERVICES UNDER STRESS

What is water Scarcity?

Different terms exist to refer to the lack of water or water shortages experienced at different scales (eg household, community, city, country or region), and over different timescales (eg temporary due to conflict or long-term due to climate change). In this report, 'water scarcity' refers to the yearly amount of renewable freshwater per capita (in m^3) within a country territory. Different levels have been identified: 1,700m^3/capita/year being regarded as 'water stressed', 1,000 m^3 as 'high scarcity', and 500 m^3 'extreme scarcity'.

However, it can be easy to misinterpret these terms outside a given geographic and socio-economic setting. Water is never scarce in absolute terms, but it is perceived as scarce under specific allocative and institutional circumstances (Ioris, 2012). In fact, nearly all major cities produce a sufficient volume of potable water to meet more than satisfactory human health and sanitation needs. Water scarcity goes beyond a sole physical insufficiency of resources: it is also a product of uneven social distribution and unsustainable management practices (Swyngedouw, 2006).

Scarcity of water actually results from a combination of physical, institutional and technical factors:

• *Physical scarcity* in availability of freshwater of acceptable quality with respect to aggregated demand, in the simple case of physical water shortage.
• *Scarcity* in access to water services, because of the failure of institutions in place to ensure a reliable supply of water to users, or to the inability of households to afford a connection/the costs of water.
• *Scarcity* due to the lack of adequate infrastructure (irrespective of the level of water resources) due to financial constraints.
In the last two cases, countries may be unable to capture and distribute resources due to limited financial resources, to a lack of institutional willingness or to a lack of capacity to maintain and manage them appropriately.
Water itself has been the cause of many tensions and inequalities in the region. Disputes over transboundary sources have arisen between countries where one side or the other has been accused of taking 'more than their fair share' by their neighbours. Important inequalities within countries have also created tensions, where wealthy users have enjoyed the cleanest and cheapest water, whilst the poor have often lived in polluted areas where water is often both more expensive and of poor quality (Devlin, 2014; Tropp and Jägerskog, 2006).

Water scarcity and climate change

MENA has been one of the most arid regions of the planet for several thousand years (Greenwood, 2014). Today, the region is home to about 6 per cent of the world's population but has access to less than 2 per cent of the world's renewable freshwater resource (Moustakbal, 2009). It includes 14 of the countries that will be the most 'water-stressed' in the world by 2040 and nine of them are identified as 'extremely water scarce'.

MENA is considered as the most water-scarce region in the world (Maddocks et al. 2015). While in 2014 Lebanon had an amount of total renewable freshwater resources per capita of 770m^3 per year, Jordan had only between 120 and 200m^3 of renewable water resources per person per year (FAO, 2014; Mercy Corps 2014).

This is approximately a fortieth of the global average and a ninth of the MENA average (ie 7,000–8,900 and 1,150m^3/capita/year respectively) (Badran, 2016). Most MENA countries have been facing major institutional challenges to address the physical scarcity they face. Many have relied on modern technologies to supply water, for example through desalination. Added to these, conflicts have led to 'water crises' (ie insufficient access to potable and domestic water for a given period caused by development and/or humanitarian issues). Government policies can play a greater role than so-called natural events in the creation of water scarcity (FAO, 2007; Mercy Corps, 2014; Stewart, 2013).

More recent extreme weather events associated with climate change have led to a further decline in the availability of water resources. Particularly in the Upper Jordan River Basin, mean annual temperatures could increase by up to 4.5 degrees Celsius and there could be a 25 per cent decrease in mean annual precipitation by the end of the century. Increased aridity suggests an increase in the number of countries in the region being below the level of absolute scarcity. With currently less than an averaged 200 m^3 of renewable freshwater available per capita per year, Jordan is already one of the most water-scarce countries in the world (Greenwood, 2014).

Agriculture has historically played an important role in the economic development of the region and countries' reliance on water has increased, particularly for largescale irrigation. Water has also been used for the production of energy through the construction of dams. For example, Iraq has one of the largest dams of the region in Mosul, which has a water storage capacity of 11.1km^3 and produces energy for 1.7 million people (Al-Ansari and Knutsson, 2011). Such dependency has started to pose problems as needs for food, energy and water have continuously increased with the growing population's demand, which in turn has also made countries more vulnerable during times of droughts (Farid et al., 2016).

Virtual water imports to make up for freshwater deficits (eg by importing food grown with water elsewhere) have not always been possible for lower-income countries with weak purchasing power (ICRC, 2015).

About 170 million of the region's 300 million people (nearly 57 per cent) reside in urban areas (UN-Habitat, 2016). Except in Egypt, Syria and Yemen, all MENA countries have experienced significant urbanisation over the past 30 years (Madbouly, 2009). The entire country of Lebanon is itself considered as urban (UN-Habitat, 2011). According to UN projections, 280 million people out of 430 million in MENA (65 per cent) could be urban by 2020 (World Bank, 2008). Rapid urbanisation in MENA, like many other regions in the world, is accompanied by inadequate social and infrastructure development to respond to everyone's needs, thereby putting existing services at risk.

By the beginning of the twenty-first century, diminishing renewable groundwater resources and population growth pushed countries to develop projects extracting water from new sources. For example, the Disi project in Jordan was developed to extract fossil water from a large aquifer and supply Jordanians with domestic water until 2022. The aquifer's total supply capacity has now been reached, leaving the country's population in need of new water resources. In Gaza, the Palestinian Water Authority (PWA) has initiated the construction of two desalination plants. While these interventions relieve water-supply systems stretched to the maximum, they remain insufficient to meet the needs of the population or to enable the recharge of the strained aquifer on which it relies (EIB, 2016).

Post-2011 revolts and further instabilities

A wave of conflicts started in 2011 in several MENA countries and continue to engulf the region in violence. Wars have physically affected societies through casualties and infrastructure destruction. As the conflicts have continued a range of further social issues have emerged across the entire region. They have caused multiple political and economic instabilities affecting societies and putting barriers to service providers meeting populations' basic needs. In the water sector, such instabilities have increased the strain on utilities' abilities to cope, eventually leading to declines in levels of service, and leaving populations in need of humanitarian assistance.

The Syrian war is one of the bloodiest conflicts of the century. Since 2011, attacks have even targeted civilians, humanitarian actors and the facilities necessary for basic service provision. Damage to pumping stations and other water infrastructure has been particularly severe in rural Damascus, Idlib, Homs and al-Raqqa. Six years of continuous conflicts have deepened insecurity, reduced availability of services and led to steady economic decline.

Water itself has been used as a 'weapon of war' (DuBois King, 2015). Its use for political negotiations in besieged areas such as Eastern Aleppo led to the loss of control of the network by utilities, and therefore exposed entire populations relying on it. Before the crisis, 96 per cent of the population in Syria had access to water from the main network. In the cities of Aleppo and Homs, coverage was reaching 100 per cent. Today, about 70 per cent of the population in Syria lacks access to sufficient domestic water, and to adequate drinking water (OCHA, 2015).

Another case is that of the Iraqi civil war. Since 2014, it has plunged the country into chaos. Conflicts in Iraq have restricted access to many areas leading to major challenges supplying populations with basic services. Similar to Syria, the strategic weaponisation of water has led to the destruction of water infrastructure, population centres and industrial facilities. During the battle for Mosul that started at the end of 2016, almost 650,000 people were left without access to water from the network for six weeks following an attack on pipelines. This population was therefore forced to find alternative sources of water, often from poor-quality sources. UNICEF estimates that 10 million people are currently being affected by the war in Iraq, of which 4.7 million are children. Despite a high incidence of population displacement (currently 3 million individuals), many have returned to their homes where public service provision is limited or completely nonexistent (UNICEF, 2016; 2017).

A problem of cumulative impacts

As argued by ICRC (2015), 'even without recent droughts and ongoing conflicts, many Middle Eastern states would be struggling to meet the basic water needs of growing urban populations. Aligning with this statement, we argue that the accumulation of various issues and the range of unsustainable management practices in MENA are to be considered as having contributed to current problems.

Current impacts must be analysed through the way they have affected water-supply mechanisms, here referred to as systems. Systems require inputs in order to function. Therefore, water provision systems are disrupted when one or several inputs (ie resources) are missing or under pressure. Building on ICRC (2015), inputs are categorised here as essential human, physical and economic resources:

- Human resources refer to people and associated operations and planning processes (eg utilities' staff, small-scale entrepreneurs, contractors).
- Physical resources include hardware and consumables (eg water, electricity, infrastructure, equipment, water treatment material).
- Economic resources relate to the financial input used to invest in staff, material and any other sub-systems (eg capital).

Continuous or persistent deterioration of water-supply mechanisms expose populations to health risks. Extreme cases of cumulative impacts have resulted in disease outbreaks. These can be caused by factors ranging from repeated attacks on treatment plants to the need for a population to rely on water resources of which the quality is not monitored, or which lack protection and are polluted by fecal pathogens. Yemen has suffered from multiple cholera outbreaks since the start of the conflicts.

Many people without access to water have become reliant on wells they have dug themselves and from which they extract polluted water. The multitude of impacts, their interconnectedness, and accumulation over time give complex challenges to utilities. Responses often occur as a direct reaction to visible impacts, rather than in addressing root causes of the issues.

Since 2011, conflicts have left an estimated 50.25 million people in need of humanitarian water, sanitation and hygiene (WASH) assistance in the entire MENA region.

The wave of protracted wars in the region and resulting political and economic crises have physically affected entire societies. They have also caused the displacement of between 22 and 24 million people, corresponding to nearly one third of the total number of displaced people in the world. The conflict in Syria alone has led to 6.5 million IDPs and 4.8 million fleeing as refugees to neighboring countries, whose water systems were already fragile. In Jordan and Lebanon, more than 80 per cent of Syrian refugees have settled in urban areas.

'Resilience' refers to the ability of a system to anticipate, absorb, accommodate or recover from shocks and stresses. Water supply will better resist the threats posed by conflicts and further impacts if utilities have stronger resilience capacities.

In the water sector, resilient systems are characterized by flexibility, resourcefulness and responsiveness, redundancy (in systems' design or with the availability of spare resources), modularity (self-organization) and safe failure (minimum damage). Furthermore, we argue that working towards sustainability and equity goals will help build stronger resilience.

As per sustainable objectives, protecting a system against damage to social, environmental and economic components is a pre-requisite for resilience. Supplying everyone equitably with water services also helps build a stronger service system.

In order to build short and long-term resilience, utilities need to break patterns of growing vulnerability. As such, they need to take into account pre-existing issues, and to consider future development. Their capacities will be reinforced with more efficient resource management and with enhanced relationships with the communities that they serve. In this study, we aim to demonstrate that humanitarian and development interventions are more sustainable and equitable when they are coordinated with local actors, and when they are able to adopt a supporting role as opposed to a substitution role.

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