Food and Agriculture Organization of the United Nations

The State of Land and Water Resources for Food and Agriculture

in the Near East and North Africa region

The State of Land and Water Resources for Food and Agriculture

in the Near East and North Africa region

Food and Agriculture Organization of the United Nations
Cairo, 2022

Required citation:
FAO. 2022. *The State of Land and Water Resources for Food and Agriculture in the Near East and North Africa region – Synthesis report*. Cairo. https://doi.org/10.4060/cc0265en

ISBN 978-92-5-136288-4

Cover photographs: ©FAO

CONTENTS

Tables

Tables in Annex 2

Figures

Figures in Annex 1

Boxes

ACKNOWLEDGEMENTS

The preparation of the State of Land and Water Resources for Food and Agriculture (SOLAW) report has benefited from the support and input of a number of individuals and specialized institutions:

Conceptualization and overall supervision: Jean-Marc Faurès

Coordination: Jean-Marc Faurès and Theodora Fetsi

SOLAW preparation core group: Jean-Marc Faurès, Theodora Fetsi, Mohamed Al Hamdi, Abdel Hamied Hamid, Theresa Wong, Domitille Vallée, Mohamed Abdel Monem, Hichem Charieg and Mohamed Abdallah

Chapter authors:
Mohamed Abdel Monem, Dalia Abulfotuh, Mohamed Al Hamdi, Hichem Charieg, Lionel Dabbadie, Jean-Marc Faurès, Theodora Fetsi, Abdel Hamied Hamid, Jennifer Smolak, Domitille Vallée and Theresa Wong

Institutions and authors involved in preparation of the thematic reports:

- International Water Management Institute (IMWI) – Adham Badawy, Amgad Elmahdi and Homero Alejandro Paltan Lopez

- University of Bern, Centre for Development and Environment – Pandi Zdruli and Claudio Zucca

- United Nations Economic and Social Commission for Western Asia (ESCWA) – Julie Abou Arab, Maya Atie, Carol Chouchani-Cherfane, Daniel Griswold, Reem Nejdawi and Marlene Ann Tomaszkiewicz

- United Nations Human Settlement Programme (UN-Habitat) – Florence Egal, Ahmad Elatrash, Thomas Forster, Grace Githiri, Camilo Romero, Remy Sietchiping and Ombretta Tempra

Reviewers and resource persons: Guillaume Benoit, Christophe Besacier, Vera Boerger, Fatma Bouallegui, Aurelie Bres, Heba Fekry, Francois Guerquin, Nicole Harari, Cecilia Marocchino, Guido Santini, Stefan Schlingloff, Rima Mekdaschi-Studer, Makiko Taguchi and Feras Ziadat

Preparation of FAO statistics and maps: Mohamed Abdallah, Samar Abdelmageed, Nancy Chin and Patricia Mejias Moreno

Editor and Writer: Una Murray

Copy editor and proofreader: Clare Pedrick

Publishing arrangements and graphics design: Mariam Hassanien and Angham Abdelmageed

Administrative support: Heba Fahmy

FOREWORD

This is the first edition of the State of Land and Water Resources for Food and Agriculture (SOLAW) and fills an important thematic gap for the Near East and North African (NENA) countries. It is intended as a FAO regional Office for the Near East and North Africa (RNE) flagship publication, presenting objective and comprehensive information and analyses on the current state, trends and challenges facing two of the most important agricultural production factors: land and water.

The report focuses on the state of land and water in the Near East and North Africa (NENA) region, which includes Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, the United Arab Emirates (UAE) and Yemen, as well as West Bank and Gaza Strip. Some of the tables and figures refer to the Arab region, which includes all the NENA countries plus Comoros, Djibouti and Somalia, in which case reference to the Arab region is made explicitly. Land and water resources are central to agriculture and rural development, and are deeply and intrinsically linked to the NENA regional challenges of food insecurity and poverty, rapid urbanization trends and climate change adaptation and mitigation, as well as the degradation and depletion of natural resources, all of which affect the livelihoods of almost 420 million people in the region.

In the past 70 years, NENA's population has grown sixfold, compared with a threefold increase worldwide. Current projections indicate that NENA's population will reach more than 633 million by 2050, with almost three-quarters living in the region's cities. This translates into increased demand for food, with urban populations demanding diversified diets. Population growth, coupled with changing consumption patterns, exerts significant pressures on scarce land and water resources. NENA is one of the world's regions predicted to be most affected by climate change, which is already altering crop productivity and growth cycles. An increase in mean temperatures, floods and droughts affects smallholders the most, as well as poorer populations with low capacities to adapt and populations experiencing conflict. Land and water resources – the basis of our food production – are finite and are under severe stress in NENA. To address these challenges, future agricultural production will need to be transformative, becoming more productive and sustainable, focused on farming systems and crops that most efficiently use water resources. An increase in innovative approaches in response to the impacts of climate change is urgently required, and climate-smart practices must be scaled up and out.

The variety of situations that characterize NENA's agricultural landscapes is at the core of SOLAW, from irrigated and rainfed systems to drylands and rangelands, as well as forest-based systems and important agricultural subsystems and associated ecosystems (mountain agriculture, oases, inland fisheries and aquaculture, deltas and coastal areas, urban and peri-urban agriculture). The report shows that many areas in NENA are experiencing high population densities, putting water and land resources under increasing pressure and increasing the region's reliance on food imports and virtual water. The region has already reached the upper limits of production growth under the current resource constraints. The 'food systems at risk' are now drawing the attention of the NENA community as a focus for urgent and concerted remedial intervention, including through investments, not only on a regional scale but also locally, where the consequences of inaction on agricultural livelihoods are likely to be the greatest. There is a pressing need for appropriate policies, institutions and investments to respond to water scarcity and land degradation, and to ensure sustainable and productive food systems management, while assuring acceptable levels of economic development.

A major objective of this publication is therefore to build awareness on the status of land and water resources in NENA and highlight current opportunities and challenges. Over the years, the Food and Agriculture Organization of the United Nations (FAO) has established itself as a unique source for a variety of global data on land and water. These data have been fully exploited in the preparation of this report, presenting the most comprehensive and up-to-date regional overview on the availability of land and water resources, their use and management, as well as future trends and developments. The report takes into consideration major drivers of regional change, including demands driven by demographics, land degradation, water-use challenges, urbanization and accompanying changing consumption patterns, climate change impacts and declining public and private investments in agriculture. A stronger focus on the urban-rural interface is called for, using both modern technologies and nature-based solutions. Numerous examples of actions already under way in different NENA countries are illustrated for potential replication. Examples include wastewater reuse, bioeconomy and circular economy approaches, climate-smart agricultural approaches, digital monitoring of land and water resources, territorial but also decentralized planning approaches, and knowledge sharing at different levels. Since many issues are transboundary, the need for territorial planning and negotiating mechanisms is significant for NENA countries.

Given increasing competition for land and water resources, choices of options inevitably require stakeholders to evaluate trade-offs among a variety of ecosystem goods and services. The evidence and knowledge in this report should serve to mobilize political will, priority setting and policy-oriented remedial actions, at the highest decision-making levels.

Abdulhakim Elwaer

Assistant Director-General

ACRONYMS AND ABBREVIATIONS

ACCCP	Arab Centre for Climate Change Policies
AFED	Arab Forum for Environment and Development
ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
AFOLU	Agriculture, Forestry and Other Land Use
AOAD	Arab Organization for Agricultural Development
AOI	Agriculture Orientation Index
CAMRE	Council of Arab Ministers Responsible for the Environment
CES-MED	Cleaner Energy Saving Mediterranean Cities
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CO_2	carbon dioxide
CSA	climate-smart agriculture
ELD	Economics of Land Degradation Initiative
ENPI	European Neighbourhood and Partnership Instrument
EO	earth observation
ESCWA	United Nations Economic and Social Commission for Western Asia
FLW	food loss and waste
GCF	Green Climate Fund
GCC	Gulf Cooperation Council
GDP	gross domestic product
GEF	Global Environmental Facility

GeOC	Global Geo-Informatics Options by Context
GHS	greenhouse gas
ha	hectare
ICARDA	International Center for Agricultural Research in the Dry Areas
ICT	information and communication technology
IDMC	Internal Displacement Monitoring Centre
IDP	internally displaced person
IIA	integrated irrigation-aquaculture
IOM	International Organization for Migration
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Inter-governmental Panel on Climate Change
JMC	Joint Ministerial Council
LADA	Land Degradation Assessment in Drylands
LADA-WOCAT	The Land degradation Assessment in Drylands – World Overview of Conservation Approaches and Technologies
LAS	League of Arab States
LDC	least developed country
LDN	land degradation neutrality
LULUCF	Land Use, Land-Use Change and Forestry
m^3/inhab/yr	Cubic metres per inhabitant per year
mcm	million cubic metres
mm	millimetre
MODIS	Moderate Resolution Imaging Spectrometer
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
OPHI	Oxford Poverty and Human Development Initiative

OWL	other wooded land
NWFP	non-wood forest product
PPP	public-private partnership
RAS	recirculated aquaculture system
RCP	Representative Concentration Pathway
RICCAR	Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socioeconomic Vulnerability in the Arab region
RS	remote sensing
SDG	Sustainable Development Goal
SDS	sand and dust storm
SLM	sustainable land management
SLR	sea level rise
SLWM	sustainable land and water management
UNCCD	United Nations Convention to Combat Desertification
UNDESA	United Nations Department of Economic and Social Affairs
UNGA	United Nations General Assembly
UNHCR	United Nations High Commissioner for Refugees
WATSAN	water and sanitation
WFP	World Food Programme
WOCAT	World Overview of Conservation Approaches and Technologies

EXECUTIVE SUMMARY

This report covers Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, the United Arab Emirates and Yemen. These countries in the Near East and North African (NENA) region are diverse in terms of natural features, including topography, climate, soil, vegetation, and populations and culture. Yet the countries have one thing in common – they are all located in the most land- and water-scarce region of the world. This FAO report, which provides the latest land and water resource statistics for the region, outlines important challenges that NENA as a whole is facing in the lead up to 2030 and beyond.

This 'cradle of civilization', where agriculture began more than 12 000 years ago, has coped with diverse and complex challenges over the years. The report outlines some opportunities to address the current land and water challenges, presenting examples from within the region on which to build. Transformative change is required, in particular with regard to how land and water resources are valued, used and reused. Much depends on the political will of various actors and incentives for change processes that are put in place.

The report outlines how recent drivers of land and water resource use are primarily the result of a rapid population increase that has occurred in the past 70 years. High population growth and urbanization aggravate already fragile resources, impacting available land and water resources. The world population has increased three times since 1950, but the population in NENA has grown sixfold. In 2020, there were 418 million inhabitants in NENA and the figure is expected to continue to rise, reaching more than 633 million in 2050. At the same time, rural populations have declined. In 2018, people living in rural areas accounted for 40 percent of the total population, whereas in 1970 rural areas accounted for more than 60 percent. Two-thirds of the rural population are impoverished. Urban poverty is also notable, up to 20 percent in some cities.

Climate change projections do not provide a positive scenario for the NENA region, with higher temperatures and rainfall decrease generally predicted (although not in all areas), resulting in more drought and an increase in extreme events. Climate change vulnerability is high, with NENA ranked as the world's most arid region. Despite the impacts that climate is having on farming systems, climate change does not yet receive adequate attention.

Agriculture remains a significant pillar for economic development in many countries of the region, yet investment in agriculture within NENA countries is generally low. Although agriculture remains important, it only accounts for 13 percent of gross domestic product (GDP). Productivity is low relative to other sectors. NENA is the only region in the world where harvest area shrinkage is expected by 2050. NENA countries now rely increasingly on imports to meet their populations' needs. The NENA region was receiving about one-third of all international shipments of cereal, sheep meat and whole grains in 2019, and about one-fifth of all sugar, poultry meat, and skimmed milk imports. An over-reliance on food imports can also have political repercussions. The COVID-19 pandemic has had impacts on food security, exacerbating land and water inefficiencies. Food price increases were recorded in 2020, while in some countries such as Lebanon, Sudan and the Syrian Arab Republic, price rises exceeded 116 percent.

Key water and land degradation challenges

Water stress is a phenomenon experienced by all NENA countries, with some experiencing high and extremely high levels. Eight countries feature in the world's top ten highest levels of water stress. The global figure for a per capita share of renewable water resources is 5 732 m^3. Thirteen countries of the region have a per capita share of renewable water resources below 500 m^3 annually; seven countries fall below 100 m^3. Per capita freshwater availability has decreased by 78 percent in the past 50 years. This is much higher than the global figure of 59 percent. Nine NENA countries have suffered declines in per capita freshwater availability of more than 80 percent.

The region is therefore highly dependent on water resources from other regions, with 60 percent of all renewable water resources generated outside NENA boundaries. High dependency on transboundary groundwater aquifers in the region is also a challenge. A major change in water-use practice is required due to the severity of water scarcity and the further impacts of climate change on water availability, coupled with population growth.

Water-use efficiency is variable, with nearly half of NENA countries returning above world average figures. Agriculture is the major user of water, with irrigation accounting on average for 85 percent of water use. The NENA region has the highest percentage of cropland under irrigation, illustrating the strong dependency on water for agricultural production. Domestic water withdrawals account for only 10 percent. The region has seen additional pressure on limited water resources as a direct result of COVID-19-related hygiene measures.

Turning to the current state of land and soils, land degradation is a significant factor in NENA countries. The cost of land degradation in the region has been estimated at USD 9 billion per year, and has led to a reduction in the potential productivity of soil by about one-third in recent years. Degradation of rangelands in the Arab countries has been estimated at 3.3 percent of the land area, with some countries experiencing very high rates of rangeland degradation. Meanwhile, the region lost 12.8 percent of its forest cover and 16.9 percent of its area of other wooded lands (OWL) in the past 30 years. Almost two-thirds of NENA countries have less than 5 percent of their land under arable cultivation, with an overall range that extends from 0.25 percent in Oman to more than 25 percent in the Syrian Arab Republic, with considerable variation in arable land per capita. On average, arable land out of total land area in the region is less than half of the global average. Forest land cover is limited in the region, covering 2.47 percent of total land area in 2018, having declined by 13 percent in the past 30 years.

Soil salinity, water erosion and pollution are other challenges. Salt-affected soils in the NENA region cover 11.2 percent of its total land area. Secondary salinization due to irrigation affects land in some countries, with others facing major salinity challenges. In many countries, cities are encroaching on the best soils, with impacts on agricultural production and loss of fertile soils. Another issue is the inappropriate use of agrochemicals, which adversely affects soil fertility and water quality. In fact, 6 countries from the region are among the highest 20 countries in the world in terms of fertilizer consumption (kilograms per hectare of arable land). The NENA region is highly prone to sand and dust storms (SDS), which cause total GDP losses estimated at about USD 13 billion each year. Some countries are, however, acquiring land for agricultural use in other countries. Sudan is the most targeted country in NENA for such agricultural land deals. Many NENA countries still do not have sufficiently robust regulatory frameworks to govern land tenure and land-use rights.

Following migration to cities, the complexities of the increasing urban population is a significant issue for NENA countries. Job creation is important for a growing youth population. Peri-urban and rural farmlands are under constant pressure from urbanization and degradation. Infrastructure development in cities is often at the expense of agricultural land, leading to land fragmentation.

As mentioned, NENA is one of the world's regions that is predicted to be worst affected by climate change. The region will experience an average mean temperature increase of 1.7 °C to 2.6 °C under Representative Concentration Pathway (RCP) 8.5,[1] with parts of the region seeing a rise of 4.8 °C by 2100 compared with the period 1985–2005. The highest increases in average mean temperature in the Arab region (more than 3 °C) are projected for non-coastal areas, including the Sahara Desert. A number of NENA countries are currently seeing the effects of climate change, with floods and droughts already having serious implications for agricultural yields. Droughts are expected to increase in frequency by 150 percent between 2020 and 2070, and flash floods will threaten coastal and low-lying agricultural areas such as the Nile Delta. Specific areas are particularly vulnerable to water stress, including all populated and arable lands. Crop yields are expected to decline due to a decrease in productivity accompanied by a shortage in the length of crop cycles. Continued changes in climate temperatures will have negative impacts on crop quantity and quality, which will affect food production.

The highest water-induced climate vulnerability areas, including in terms of adaptive capacity, are in the upper Nile Valley, the southwestern Arabian Peninsula, and the northern Horn of Africa. Rainfed farming systems are the most vulnerable farming system to climate change, which will threaten wheat, barley and other staple crops. Smallholders will be hardest hit by climate change, as well as populations living in the least developed countries (LDCs) and countries in conflict, due to low capacities to adapt, despite more moderate increases of temperature in some cases.

Populations across NENA have long played an integral, if not sometimes volatile role in the history of human civilization. Today, over one-quarter of NENA's 19 countries are affected by conflict. Hostilities and disputes have a massive impact on livelihoods, food security and natural resource degradation. Vital infrastructure is often damaged. Tension increases with regard to water resources (transboundary and national) and conflicts have direct adverse impacts on land use and management. As a result of conflict and environmental degradation, people flee their homelands. The NENA region hosts more than 40 million international migrants, of whom 14 million are intraregional migrants and more than 2 million are intraregional refugees. The Syrian Arab Republic currently has the highest number of internally displaced persons (IDPs) in the world. Not all countries host refugees and migrants on an equal scale – Saudi Arabia has the most migrants (3.4 million), while Jordan and Lebanon are among the top 10 countries in the world in terms of hosting refugees. Migrants, refugees and IDPs add pressure on the land in the areas where they settle, leading to land degradation and desertification.

Possible responses and existing initiatives under way

As well as highlighting the challenges, this report presents some positive initiatives from the region and a range of options available to help authorities respond to the issues of land and water resources. A more urgent response to land and water scarcity is required and there are some regional political processes and opportunities under way to collectively address some of the challenges.

First and foremost, acknowledging and responding to the value of water will help to increase water productivity, deter wastage and overexploitation of water resources and promote water reallocation. If the management of water storage and delivery infrastructure is improved,

[1] A Representative Concentration Pathway (RCP) is a greenhouse gas concentration trajectory adopted by the Inter-governmental Panel on Climate Change (IPCC). The fifth IPCC Assessment Report (2014) used four pathways for climate modelling. The pathways describe different climate futures, all of which are considered possible depending on the volume of greenhouse gases emitted in the years under consideration. The original pathways are now being considered with Shared Socioeconomic Pathways.

regional economic benefits could range from between USD 7 and 10 billion per year. The public sector must strengthen its role as either the central financing enabler and/or put in place legislation for public-private-partnerships such as incentives to construct, upgrade, operate and maintain irrigation infrastructure.

Adoption of a circular economy for water that considers water reuse, better water accounting, and more effective water allocation mechanisms is urgently needed and where it exists, should be scaled out. Indeed, more options to increase water storage in the region should be investigated, such as rainwater capture, wastewater treatment, better use of green water (rainwater stored as soil moisture), micro-water harvesting techniques and floodwater diversion (spate irrigation), stormwater management in cities, and artificial aquifer recharge via micro-catchment management. Switching to crops that consume less water and produce higher returns should be encouraged, along with solar renewable energy-powered pumps for irrigation. More and more free data sets and portals are becoming available to assist the mapping of water resources and assessment of consumption. Unmanned aerial vehicles, digital soil mapping surveys, digital agriculture technologies, internet of things, and mobile phone applications using remote sensing data combined with online analysis tools are some of the technology-based solutions that can continue to be scaled out. Expertise, cooperation and knowledge sharing on digital innovations and what works should be enhanced in the region.

Costs of virtual water – the volume of water that is needed to produce food – and water accounting must be transparently referred to in trading and national water budgets, so that the hidden flow of water in food or other commodities is considered. Integrated water resource management plans are required to minimize increased pressure on water at the level of watersheds. Regardless of the technology options adopted by a government or local authority, consultative processes and community participation, including a deliberate focus on women (as important water users) should be embedded in institutional planning and implementation.

The Arab Declaration on Climate Change has spurred a regional response and initiated coordinated studies or operational responses to water scarcity. Examples include the RICCAR regional Knowledge Hub, the Arab Centre for Climate Change Policies, and the 2019 Cairo Declaration emanating from the first joint meeting of ministers of water and ministers of agriculture.

Turning to the restoration of land and soil health for sustainable agriculture, international global processes are stimulating interest in agriculture, with an acknowledgement that integrated policies are needed to revive local economies, support natural resource regeneration and management and ensure food security. The UN Decade on Ecosystem Restoration (2021–2030) provides a focus for mainstreaming rehabilitation approaches in the NENA region, with an estimated 3.5 million km^2 of land potentially suitable for better sustainable land and water management (SLWM) practices (irrigated, rainfed and rangeland agro-ecosystems). It is important to note that 14 countries have set voluntary targets to achieve land degradation neutrality (LDN) by 2030. Sixteen NENA countries mention forest- and rangeland-related adaptation in their National Determined Contributions (NDCs), as measures to address climate change. Some countries have already set reforestation targets. FAO provides Guidelines for Sustainable Soil Management (VGSSM), which could prove highly useful for improved soil and water management. Digital innovations also offer valuable opportunities for the region, with remote sensing data helping to avoid, reduce and monitor soil health.

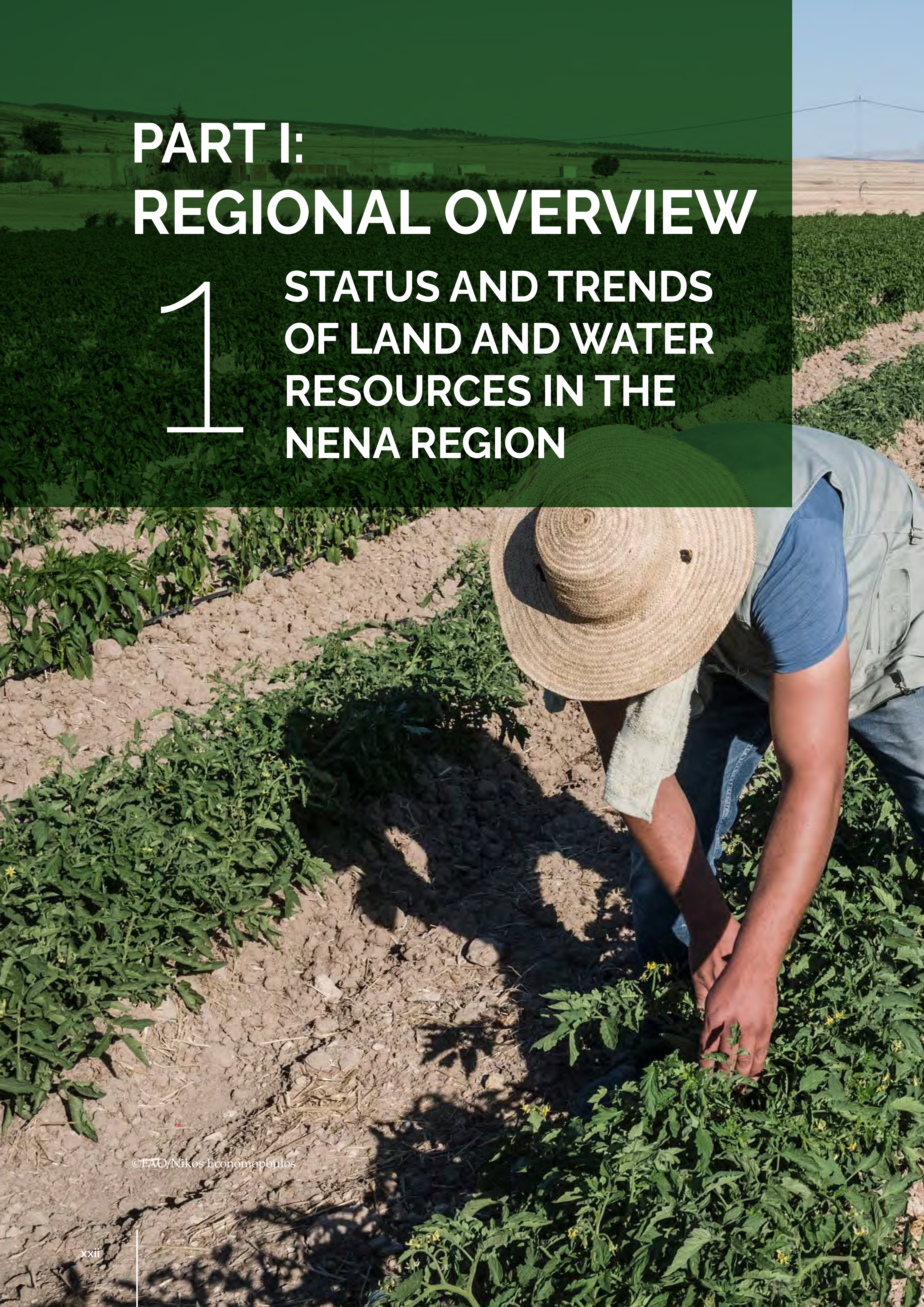
Agrifood systems will have to transform and adapt to climate change and natural resource scarcity. Climate-smart agricultural practices are being promoted by FAO and others in the region. The suite of CSA responses includes crop diversification, use of heat- and salt-tolerant crops, conservation agriculture with minimum tillage and crop rotation, adapted animal, fish and aquaculture varieties, and modification of sowing and planting time according to rainfall patterns. Bioeconomy concepts, including better use of waste, reducing food loss and waste, and wastewater recycling are major opportunities. The circular economy model aims to keep products, materials, equipment and infrastructure in use for longer periods.

Some of the countries' NDCs highlight that water, salinization and productivity losses are key adaptation priorities for the agriculture sector. Given that funding for water and sanitation, and Agriculture, Forestry, and Other Land Uses (AFOLU) sectors is five to seven times lower than for energy, transport, storage, industry and banking/finance, there are opportunities to use evidence from this report to channel climate finance flows towards addressing region-specific climate priorities in the agriculture, land and water sectors.

This report also calls for cities to reconnect with their rural territories, ensuring supply and demand for traditional and locally supplied fresh foods. In addition, urban and peri-urban agriculture can facilitate shorter supply chains. Indeed, there is strong scope for making use of digital technologies to facilitate better connections between smallholder farmers and cities – the COVID-19 pandemic has demonstrated how this is possible. Land and water management must be more effectively integrated within city watersheds. Green infrastructure and urban agriculture can be integrated in planning. Greener cities improve the quality of life and standard of living. Multiple environmental benefits may come about, such as flood control, reduction of stormwater runoff and soil sealing, as well as biodiversity protection. Otherwise, water availability, including both quality and quantity, will further deteriorate, severely affecting the resilience of urban communities. A functional multilevel governance system is required to address the significant challenges presented in this report, moving towards territorial governance.

PART I: REGIONAL OVERVIEW

1 STATUS AND TRENDS OF LAND AND WATER RESOURCES IN THE NENA REGION



©FAO/Nikos Economopoulos

KEY MESSAGES

- **The NENA region is dominated by deserts and a harsh environment.** The main characteristics are a high level of aridity and water stress, poor soils and limited arable land. Climate change projections predict higher temperatures and rainfall decrease, with more drought and extreme events. People living in coastal areas must prepare themselves for much more difficult futures than may be currently anticipated.
- **Water is the number one limiting factor for agriculture in the NENA region.** Understanding the sources of water withdrawals is key to understanding water stress in the region. Desalination is particularly important, given that about 50 percent of the world's desalination capacity is in the NENA region.
- **Freshwater availability per capita declined in NENA by 78 percent between 1962 and 2018.** This is much higher than the global figure of 59 percent. Nine NENA countries had reductions in freshwater availability per capita of over 80 percent, including all Gulf Cooperation Council (GCC) countries.[2]
- **Water stress levels are high in all NENA countries (except Mauritania).** Water stress ranges in NENA vary from 47 percent in Iraq to 3 850 percent in Kuwait. Values above 100 percent indicate overuse of water and/or a reliance on desalinated water. The world average of water stress is just over 18 percent (2018).
- **Water-use efficiency is variable in the region.** Almost half of NENA countries had levels of water-use efficiency greater than the world value in 2018. Good performance in water-use efficiency is generally found in the Mashreq and Gulf regions rather than the Maghreb. The NENA region has the highest percentage of cropland under irrigation in comparison with the global average, indicating a high dependency on water for agricultural production.
- **Land degradation is a significant feature of the region.** Soil salinity, water erosion and pollution are major challenges.
- **Arable land is scarce in NENA.** Under 5 percent of NENA's total land is arable, less than half of the global average. Twelve out of 19 NENA countries have less than 5 percent arable land. Arable land's share of total land in the region ranges from 0.25 percent to 25 percent. Arable land per capita is variable, with the lowest found in GCC countries (except Saudi Arabia).
- **Forestland cover is limited in the region.** Forests covered 2.47 percent of the total land area in the region in 2020 and OWL accounts for 2.36 percent. The NENA region experienced a loss of 12.5 percent in its forest cover and 16.9 of OWL between 1990 and 2020.
- **Aquaculture has emerged as an important sector in NENA.** Aquaculture doubled its production in ten years to reach 1.7 million tonnes and USD 2.3 billion worth in 2018. Aquaculture development has occurred with limited impact on land and water use, as good technologies are employed.

[2] The Gulf Cooperation Council is a regional, intergovernmental political and economic union that consists of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

Introduction

The NENA region is the most land- and water-scarce region of the world, with 1.07 hectares (ha) of agricultural land per capita (0.16 ha of cropland per capita, against a global average of 0.20 ha per capita in 2018) and per capita water availability at 9 percent of the global average.[3] The agriculture sector is an important pillar of the economy in the region, contributing 14 percent of regional GDP (excluding the oil-rich countries) and providing employment to 38 percent of the economically active population. Between 75 and 85 percent of agricultural landholdings in the region are small-scale family farms, and these contribute more than 80 percent of the region's total agricultural production. But agricultural output is severely limited by water scarcity and climate change. Water scarcity is the primary limiting factor and the driver of the region's dependency on food imports, while climate change drives further land and water scarcity and degradation. In addition to the impacts of climate change, agricultural practices play a significant role in depleting and degrading the region's natural resources. In particular, the misuse of fertilizers and pesticides in areas of intensive agriculture has polluted both water and land, with persistent organic and chemical pollutants contaminating water, soil and the food chain (FAO, 2019c).

Due to the combined impacts of human use and climate change on the region's natural resources, the NENA region is likely to be the only region in the world where harvested area will actually shrink as a result of limitations imposed by water availability and soil degradation. Furthermore, population growth, and the ensuing growth of food demand, has consistently outpaced the growth of domestic food production, creating a widening gap between domestic production and demand, which is met through imports. The domestic production-consumption gap is particularly marked for cereals, which provide the bulk of calories in the region, but also for vegetable oils, sugar and meat (FAO, 2017a). The region is likely to remain dependent on food imports through 2050 (FAO, 2018b).

The NENA region includes Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen, as well as the West Bank and Gaza Strip. When tables and figures refer to the Arab region, this includes all the NENA countries, as well as Comoros, Djibouti and Somalia. Considering a combination of geographical and socioeconomic factors, this report has adopted the following country groupings (see Figure A1 in annex):

1. **Maghreb:** This subregion comprises Algeria, Libya, Morocco and Tunisia. These countries are located north of the Sahara Desert and most of their agricultural activity and population are concentrated along the coast. Their position on the southern side of the Mediterranean Sea provides them with market opportunities with Europe. Commercial agriculture in the subregion is modernizing rapidly, while the substantial smallholder sector remains less developed.

2. **Mashreq:** Egypt, Iraq, Jordan, Lebanon, Palestine and the Syrian Arab Republic make up this subregion. Its agriculture relies heavily on irrigation, and as in the Maghreb, it is divided into a dynamic commercial agriculture sector and a less developed smallholder sector.

3. **Least developed countries (LDCs):** Mauritania, Sudan and Yemen are the least developed countries of the region and have a range of institutional and infrastructural gaps. Agriculture represents a larger share of their GDP, and most of the population relies on agriculture for their livelihood.

4. **Gulf Cooperation Council (GCC) countries:** Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates make up the GCC. These countries have built their wealth on oil resources. Desert covers much of the land in the area, and agriculture plays a marginal role in the economy.

[3] Calculated based on data from FAOSTAT and AQUASTAT, 2021.

1.1 Land use and degradation

1.1.1 Land use

Figure 1.1 shows the land-use classes in all countries of the NENA region, as defined by FAO's World Programme for the Census of Agriculture (2015), which provides definitions for different ways that land is used for classification in agricultural censuses.

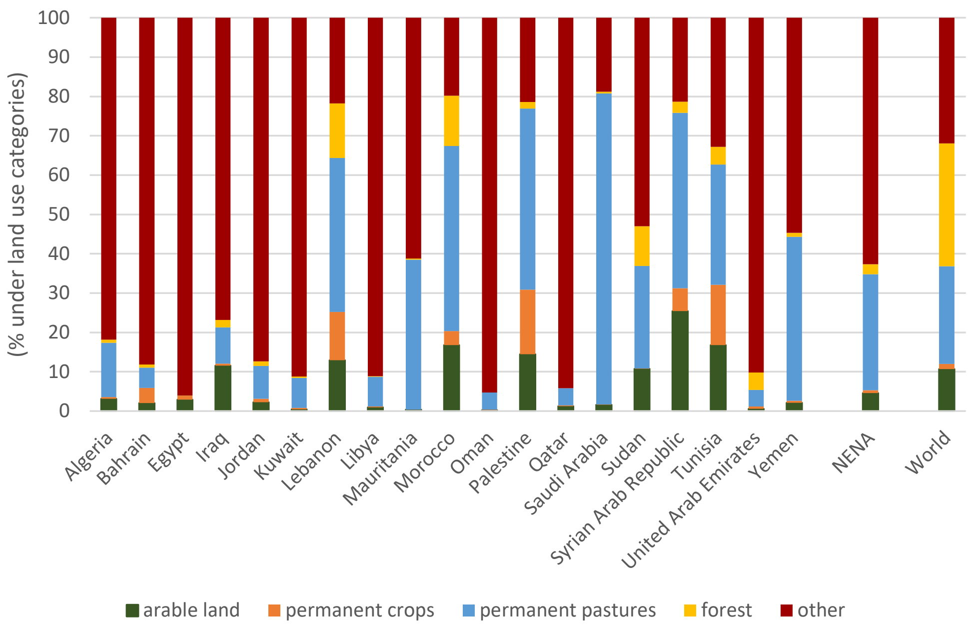
Arable land includes land under temporary crops, temporary meadows and pastures, and land that is temporarily fallow.

Land classified as cropland includes all the above, in addition to land under permanent crops (i.e. land cultivated with long-term crops that do not have to be replanted for several years, or land under trees and shrubs producing flowers, except for forest trees).

Agricultural land refers to cropland in addition to land under permanent meadows and pastures.

Another land-use class is forest and other wooded land, and based on specific height and canopy cover criteria, land can fall in either of these categories.

FIGURE 1.1 PERCENTAGE OF LAND UNDER DIFFERENT LAND-USE CATEGORIES



Source: Calculated using data from FAOSTAT, 2021.

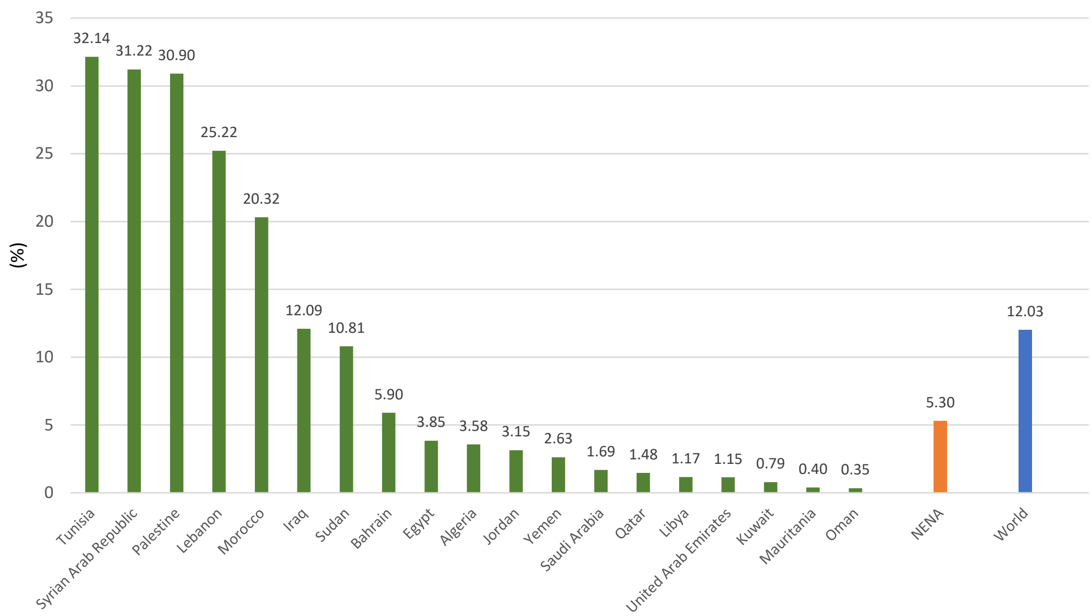
The section below discusses both arable land and cropland, with a short description of permanent crops in the NENA region.

Cropland

Cropland area differs greatly across the region, with Tunisia and the Syrian Arab Republic having the highest share of cropland area, and Oman, Mauritania and Kuwait having less than 1 percent of cropland area, in that order.[4] About 13 countries have shares below the world average of 12 percent (see Figure 1.2).

[4] As indicated, cropland includes arable land, as well as land under permanent crops (FAO, 2015).

FIGURE 1.2 SHARE OF CROPLAND IN PERCENTAGE OF TOTAL LAND AREA, 2018, NENA



Source: FAOSTAT, 2021.

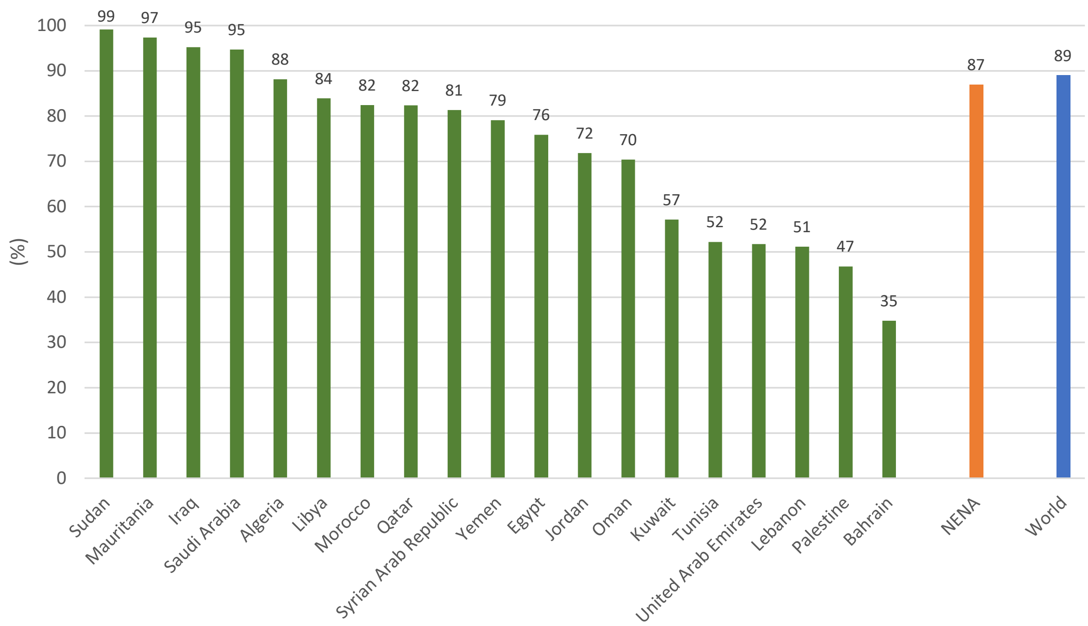
Arable land

Arable land constitutes about 87 percent of total cropland area in the region, compared with a world share of 89 percent in 2018. While 99 percent of the cropland area is arable in Sudan, only 35 percent is arable in Bahrain. Nine countries in the region have arable land at above 80 percent of their total cropland area (see Figure 1.3). Of NENA's 57.2 million ha of arable land, only 17 percent is highly productive (FAO, 2019c). The distribution of highly productive land also varies.

For example, Jordan has no highly productive land, whereas 14 percent of Sudan's land area is highly productive (ESCWA, 2017). Nevertheless, despite this major constraint, agriculture remains a vital socioeconomic sector in the region.

©FAO/Omar Sanadiki

FIGURE 1.3 SHARE OF ARABLE LAND OUT OF TOTAL CROPLAND AREA, 2018, NENA



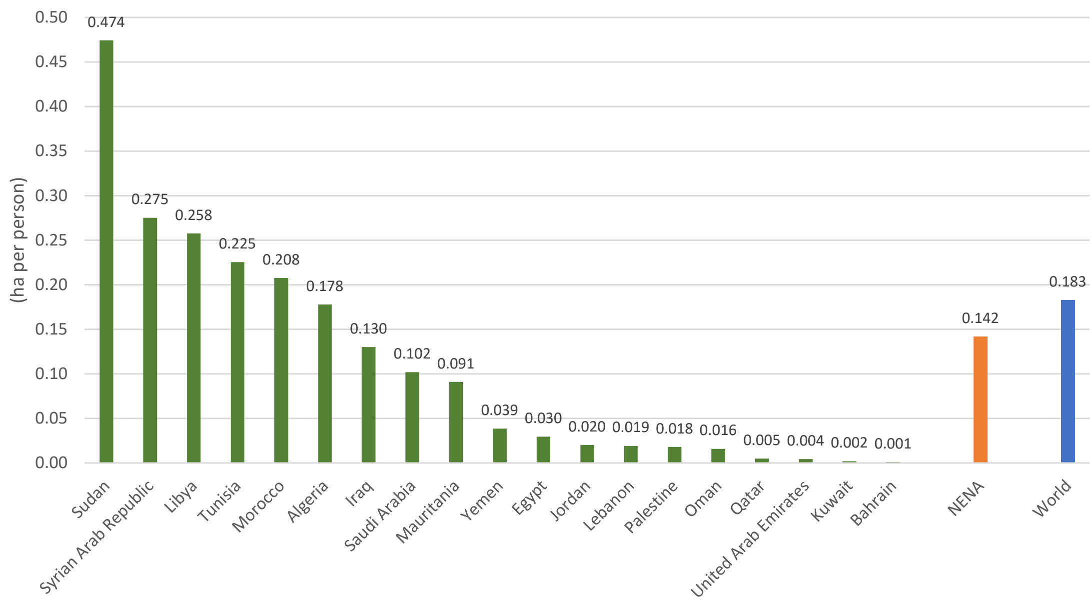
Source: FAOSTAT, 2021.

Per capita arable land

Arable land per capita varies greatly among the countries, with the highest percentage being held by Sudan, followed by the Syrian Arab Republic and the Maghreb countries. Apart from Saudi Arabia, the GCC countries present the lowest levels of arable land per capita in 2018, with Bahrain having only 0.001 ha per person (see Figure 1.4). During 1961–2018, the arable land per capita decreased in all countries, with the decline ranging from 42 percent in Kuwait to 93 percent in Jordan. Mashreq had the largest decrease of 77 percent, followed by GCC with a 71 percent decrease, and Maghreb with a 67 percent reduction (see Figure 1.5). Land fragmentation,[5] which is characteristic in the region, undermines productivity and access to markets, with implications for achieving sustainable rural livelihoods. Scarcity of land exacerbates the existing problem of stagnating productivity and low income of smallholder producers. Smallholders also lack the capacity to deal with financial, weather and climate turbulences in their production systems, which consequently affects their participation in markets.

[5] Where a number of spatially separate plots of land exist across an area.

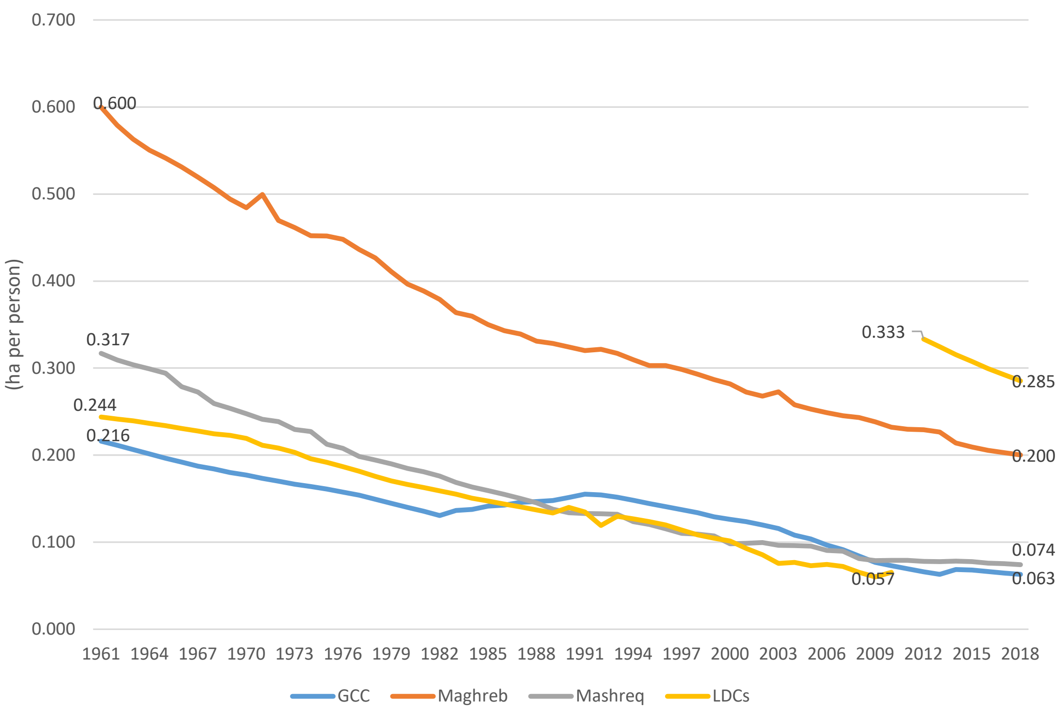
FIGURE 1.4 PER CAPITA ARABLE LAND IN 2018*



Source: Calculated using data from FAOSTAT, 2021.

*Per capita arable land is calculated by dividing the total arable land area by the total population in each country/region.

FIGURE 1.5 NENA SUBREGIONAL PER CAPITA ARABLE LAND, 1961–2018



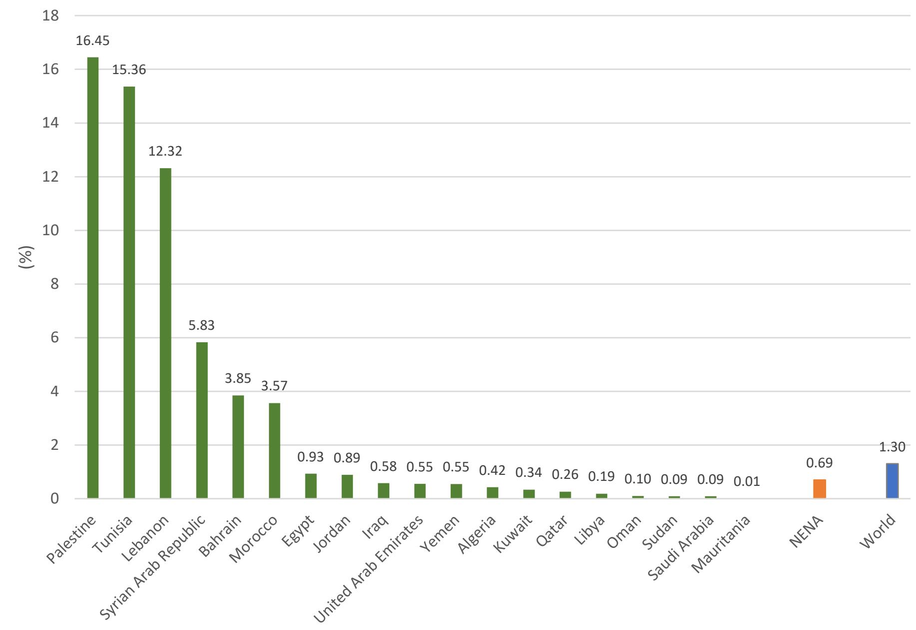
Source: Calculated using data from FAOSTAT, 2021.

*The level shift in the LDCs in 2012 was due to the inclusion of data for Sudan, not available prior to this date.

Land under permanent crops

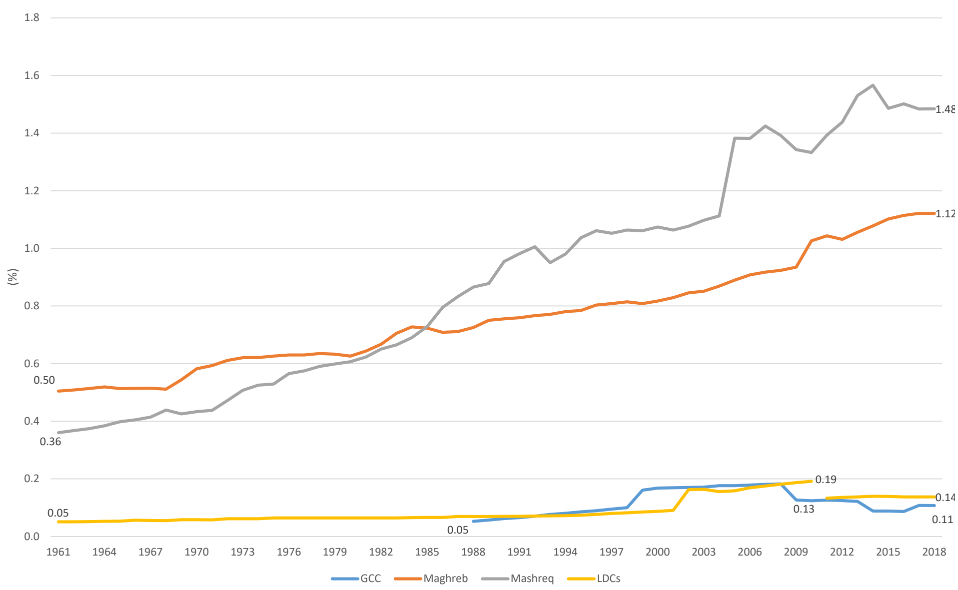
Land under permanent crops (olive trees, fruit trees, palm trees etc.) represents less than 1 percent of total land area in NENA (see Figure 1.6). The biggest share of land under permanent crops in total land area by country grouping is in Mashreq (1.5 percent in 2018), followed by Maghreb (1.1 percent in 2018); whereas LDCs and GCC countries have 0.14 and 0.11 percent respectively (see Figure 1.7).

FIGURE 1.6 LAND UNDER PERMANENT CROPS (SHARE OF TOTAL LAND AREA), NENA, 2018



Source: FAOSTAT, 2021.

FIGURE 1.7 NENA SUBREGIONAL LAND UNDER PERMANENT CROPS AS A PERCENTAGE OF TOTAL LAND AREA, 1961–2018



Source: FAOSTAT, 2021.

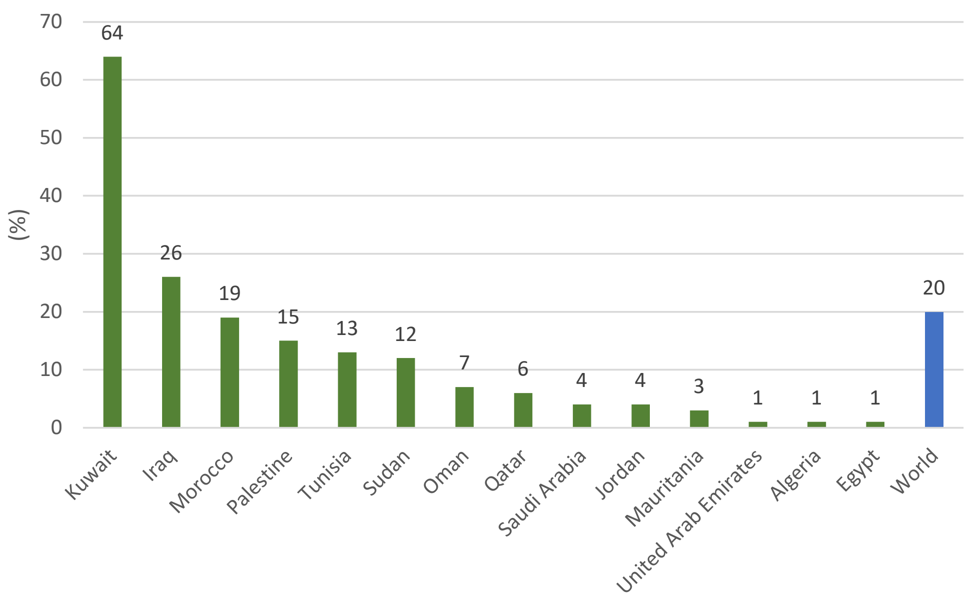
*The LDCs include Sudan since its creation in 2011.

1.1.2 Land degradation

The proportion of degraded land in total land area varies widely in NENA. The range is between 1 percent in Algeria, Egypt and United Arab Emirates and 64 percent in Kuwait, with 12 of the 14 countries in Figure 1.8. having percentages below the global average of 20 percent in 2015 (UNDESA, 2021). Some 22 million ha of the region's 30 million ha of rainfed cropland are degraded. The countries that presented the highest percentage of degraded land in 2015 were Kuwait and Iraq, with 64 and 26 percent respectively, which exceeded the world average of 20 percent (see Figure 1.8). Water erosion and unsuitable irrigation, land preparation and fertilization practices combine to lower soil fertility and increase salinization, alkalinity and contamination (FAO, 2019a). Soil salinity is a major challenge in several countries of the region due to unsustainable management and use of water with poor quality for irrigation (for example in Egypt, Iraq and Jordan). In addition, deforestation in NENA is high relative to the region's limited forest cover. The area of forests in the region decreased from 34.3 million ha in 1990 to 30.8 million ha in 2020, making a total loss of 4.5 million ha, which represents an average annual reduction of about 150 804 ha (or 0.4 percent/year). The area of OWL declined during the same period by 6 million ha, mainly driven by land-use changes in Sudan and Mauritania, which accounted for 96.6 percent of the total loss in OWL (FAO, 2020d). Most deforestation in the NENA region occurred during this period (1990–2020) in naturally regenerating forest, which accounts for 92.9 percent of forest area (28.3 million ha), as well as in OWL, which declined by 6 million ha (16.9 percent) (FAO, 2021a).

These challenges are further exacerbated by climate change, natural disasters, population growth and conflicts. A major concern is the occurrence of droughts, which are increasing in frequency, intensity and duration. The drought in the winter of 2015–2016 affected all North African countries, causing a significant reduction in grain production in Algeria, Morocco and Tunisia (FAO, 2018a).

FIGURE 1.8 PROPORTION OF LAND THAT IS DEGRADED OVER TOTAL LAND AREA (SDG 15.3.1), NENA, 2015



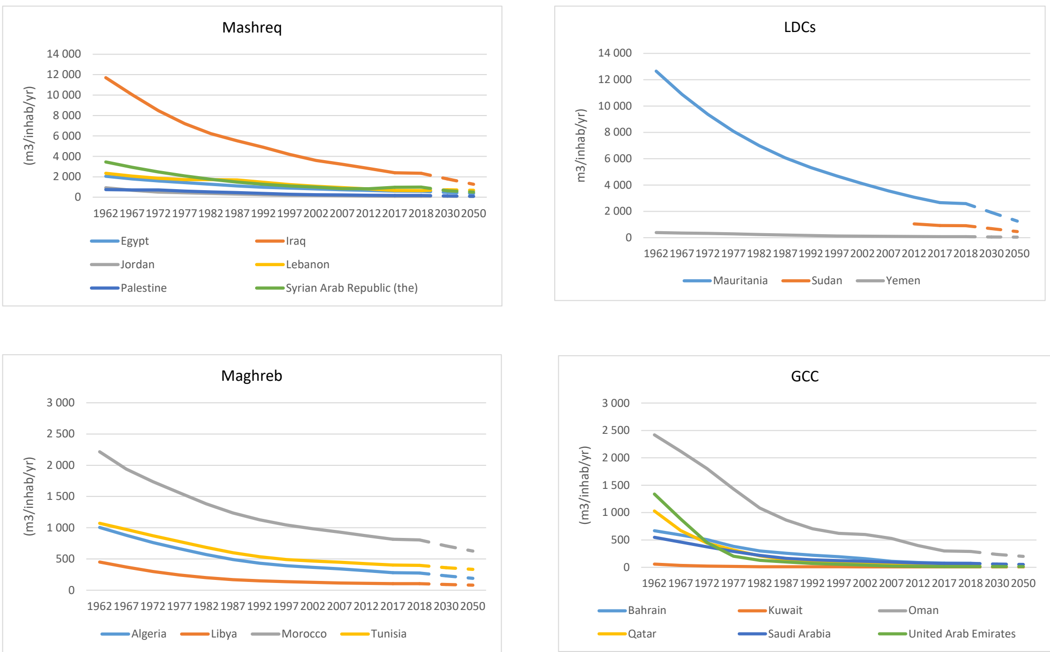
Source: UN Department of Economic and Social Affairs (UNDESA). 2021. *Global SDG Indicators Database.* [online]. [Cited 15 December 2021]. https://unstats.un.org/sdgs/indicators/database/

1.2 Water resources and use

1.2.1 Water resources

Water is the number one limiting factor for agriculture in the region and water crises have been rated by the *World Economic Forum 2015 Global Risks Report* as the highest risk factor (FAO, 2019b). Precipitation in most of the NENA region does not typically exceed 500 mm per year (Verner, 2012). In fact, apart from the Mediterranean zones in the north, yearly precipitation rarely exceeds 200 mm. Water scarcity derives from a combination of low availability of physical water resources and strong demand. Per capita freshwater availability dramatically declined for the period 1962–2018 in all NENA countries, with a percentage decrease ranging from 63 percent in Tunisia to nearly 100 percent in United Arab Emirates and Qatar. Nine NENA countries experienced reductions in per capita freshwater availability of more than 80 percent, including all the GCC countries (see Figure 1.9). In total, per capita freshwater availability decreased in NENA between 1962 and 2018 by 78 percent compared with a global reduction of 59 percent over the same period (see Figure 1.10). Currently, per capita freshwater availability in NENA is around one-tenth of the global average (Ward, 2016) but the rates are expected to decline further by 2050 as the population continues to grow. Apart from Iraq and Mauritania, all other 17 NENA countries have values below the water scarcity threshold of 1 000 m^3/year. The Syrian Arab Republic, Sudan, Morocco, Lebanon and Egypt are under stress water conditions (between 500 and 1 000 m^3/inhab/yr), while the situation is even more critical for almost two-thirds of NENA countries, which are under absolute water scarcity (<500 m^3/inhab/yr) (see Figure 1.11).

FIGURE 1.9 TOTAL RENEWABLE WATER RESOURCES PER CAPITA, NENA COUNTRIES, 1962–2050*

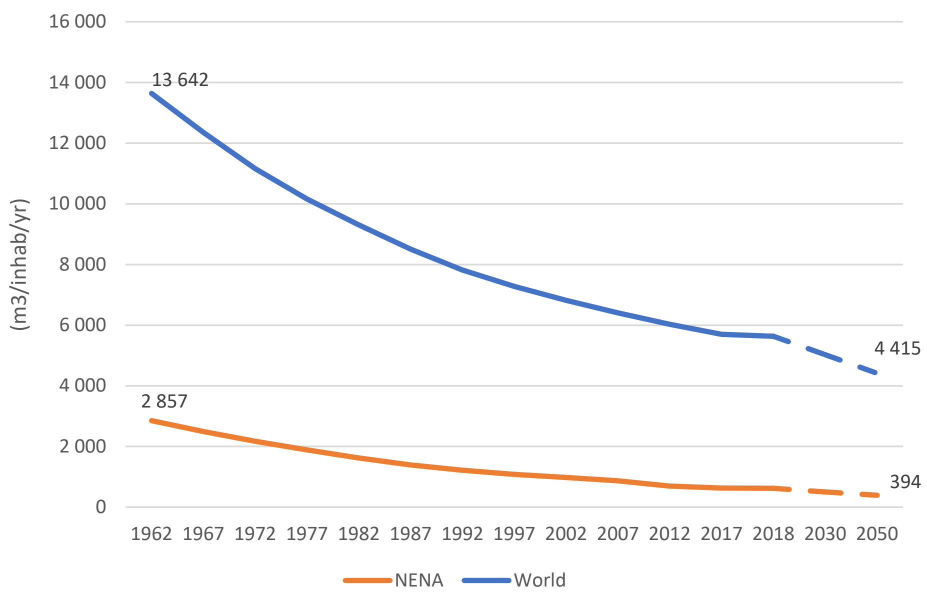


Source: AQUASTAT and UN Department of Economic and Social Affairs (UNDESA). 2021. *Global SDG Indicators Database.* [online]. [Cited 15 December 2021]. https://unstats.un.org/sdgs/indicators/database/

*Projections for 2030 and 2050 assume constant water availability and are based on the UN Population Division median (50 percent) prediction interval variant for the population probabilistic projections; the LDCs include Sudan data starting from 2012.

Note: Total renewable water resources per capita is calculated as [total renewable water resources (10^9 m3/yr) *1 000 000]/[Total population (1 000 inhab)].

FIGURE 1.10 TOTAL RENEWABLE WATER RESOURCES PER CAPITA, NENA AND WORLD, 1962–2050*

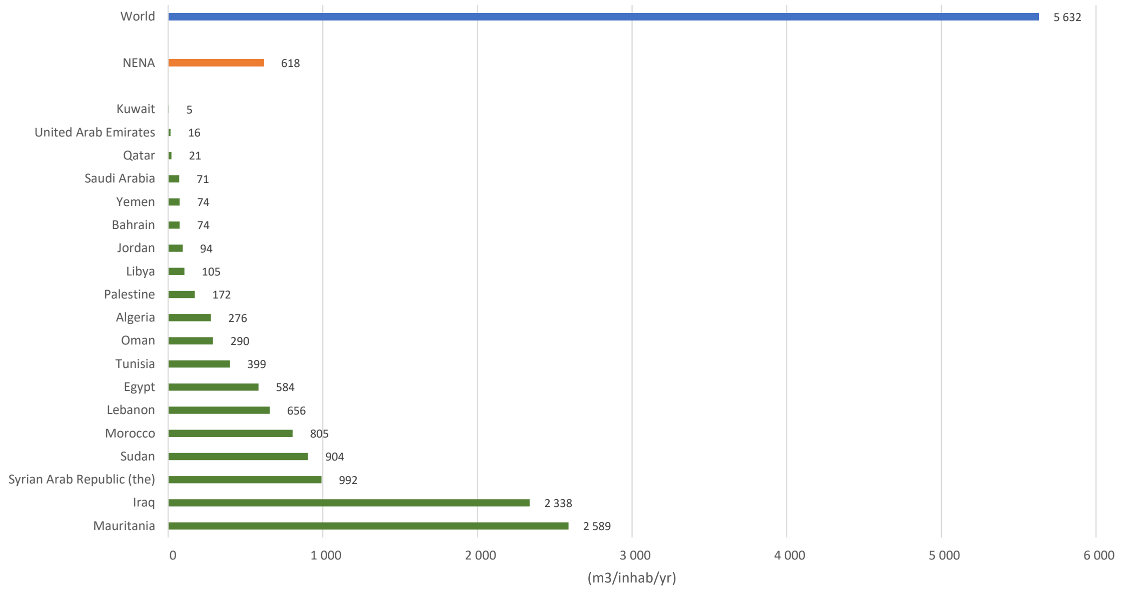


Source: AQUASTAT and UN Department of Economic and Social Affairs (UNDESA). 2021. *Global SDG Indicators Database.* [online]. [Cited 15 December 2021]. https://unstats.un.org/sdgs/indicators/database/

*Projections for 2030 and 2050 assume constant water availability and are based on the UN Population Division median (50 percent) prediction interval variant for the population probabilistic projections; the LDCs include Sudan data starting from 2012.

Note: Total renewable water resources per capita is calculated as [total renewable water resources (10^9 m3/yr) *1 000 000]/[Total population (1 000 inhab)].

FIGURE 1.11 TOTAL RENEWABLE WATER RESOURCES PER CAPITA IN NENA IN 2018*



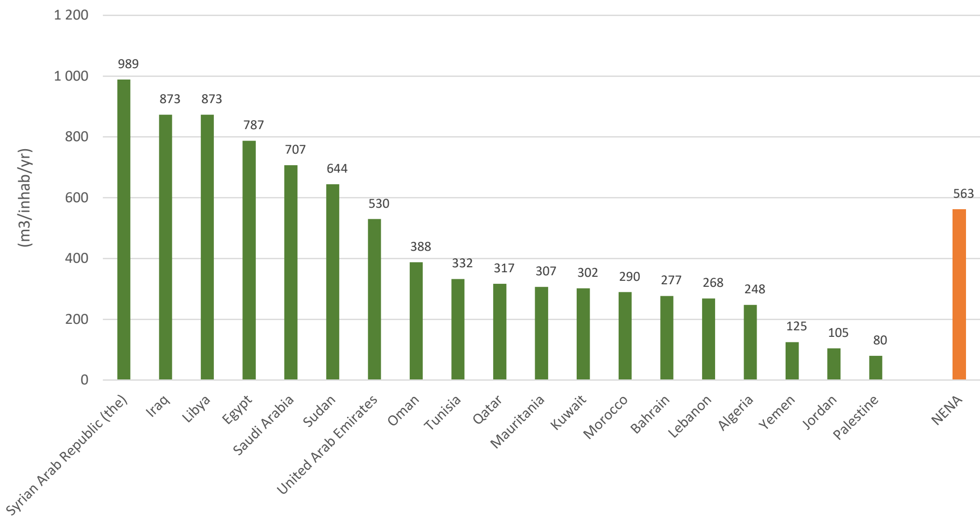
(m³/inhab/yr)

Source: AQUASTAT and UN Department of Economic and Social Affairs (UNDESA). 2021. *Global SDG Indicators Database.* [online]. [Cited 15 December 2021]. https://unstats.un.org/sdgs/indicators/database/

*Total renewable water resources per capita is calculated as [total renewable water resources (10^9 m³/yr) *1 000 000]/[Total population (1 000 inhabitant)] m³/inhab/yr.

Most of the exploitable water is already withdrawn and the region's rivers and aquifers are seriously depleted (FAO, 2011a). The countries with the highest water withdrawal per capita are the Syrian Arab Republic, Iraq, Libya and Egypt, with a rate of more than 700 m³/inhab/yr (see Figure 1.12). In addition to excessive extraction and competition, the governance of water resources impacts the availability of freshwater in the region. Freshwater management falls under multiple mandates, hence across many government agencies, impeding coordinated and integrated policies. About 60 percent of surface water is transboundary, but there are no legal and functional agreements on sharing the water (FAO, 2019b). In addition, the region has the lowest water tariffs in the world, with heavily subsidized water use – all contributing to lowering water productivity to half of the world average (OECD-FAO, 2018; World Bank, 2018). Countries require a more coherent vision regarding water use, allocation and sharing.

FIGURE 1.12 TOTAL WATER WITHDRAWAL PER CAPITA, NENA, 2018*



Source: AQUASTAT.

*Total water withdrawal per capita for NENA is calculated as [total water withdrawal in relevant countries (10^9 m³/yr)*1 000 000]/ [Total population in relevant countries (1 000 inhab)].

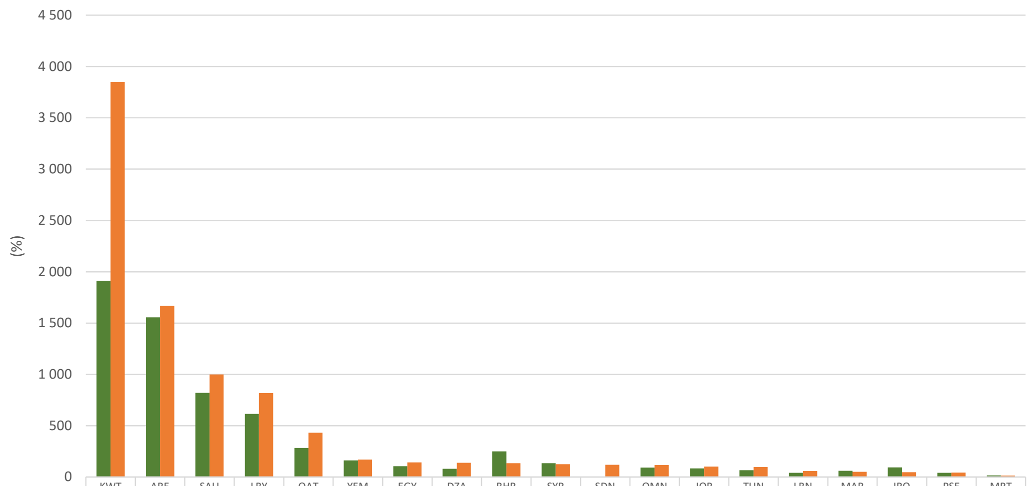
1.2.2 Water stress

Most of the NENA region countries are characterized by high and extremely high levels of water stress.[6] Indeed, more than 60 percent of the regional population and 70 percent of their economic activities are in areas that are characterized by high and very high levels of water stress (World Bank, 2017a). These estimates are about two to three times greater than global averages (Veolia Water, 2011) of 18.4 percent. Aside from Mauritania, in 2018 water stress levels were high in all NENA countries, ranging from 42.7 percent in Palestine to 3 850.5 percent in Kuwait (see Figure 1.13). Levels are also particularly high in United Arab Emirates, Saudi Arabia and Libya at 1 667.3, 1 000 and 817.1 percent respectively. Apart from Morocco, the Maghreb subregion is experiencing an increasing trend in water stress. Libya had the highest level of water stress in 2018 – more than six times higher than other Maghreb countries. The Mashreq subregion has the lowest stress levels within

[6] Water Stress is a measure of the ratio of water withdrawals to renewable surface water supply. It should be noted that its metric does not account for the contribution of nonconventional water supplies or groundwater resources that may have been developed to relieve water stress.

the NENA subregions. Nevertheless, the trend among Mashreq countries is quite variable, with only Iraq having a constantly decreasing level during the period 2000–2018. In the LDCs, water stress levels remained almost unchanged between 2000 and 2018, although Mauritania experienced a small decline in water stress (about 3 percentage points), while Yemen increased its water stress level by around 9 percentage points (see Figure 1.13).

FIGURE 1.13 LEVEL OF WATER STRESS, NENA, 2000 AND 2018



	KWT	ARE	SAU	LBY	QAT	YEM	EGY	DZA	BHR	SYR	SDN	OMN	JOR	TUN	LBN	MAR	IRQ	PSE	MRT
2000	1 912	1 556	820	615	283	161	104	79	249	134		92	83	66	41	61	93	40	16
2018	3 851	1 667	1 000	817	431	170	141	138	134	124	119	117	100	96	59	51	47	43	13

Source: AQUASTAT and FAO. *Sustainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

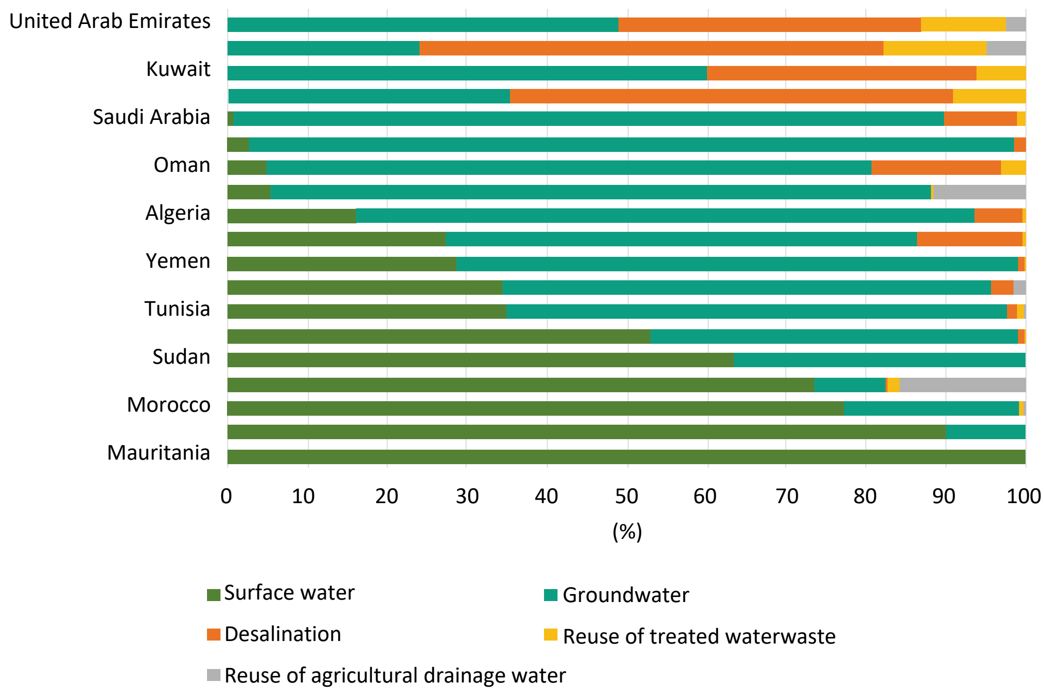
Note: Data of Sudan are not available for 2000.

1.2.3 Sources of water withdrawals

Understanding the sources of water withdrawals is key to understanding water stress in the region. Overall, a combination of groundwater, surface water and, to a lesser extent, desalination dominates water withdrawal practices across the region (see Figure 1.14). Water sources are diverse within the region. Apart from Morocco, generally, Maghreb and Gulf countries use more groundwater and other sources compared with surface water, with percentages of groundwater use ranging from about 24 to 96 percent. The situation in Mashreq countries is more mixed, with half the subregion depending more on groundwater and half more on surface water. Additionally, Jordan, Lebanon and the Syrian Arab Republic in the Mashreq grouping use more groundwater compared with surface water, with percentages ranging from about 59 percent in Jordan to 80 percent in the Syrian Arab Republic, while Egypt, Iraq and Palestine depend more on surface water, with percentages ranging from 53 percent in Palestine to 90 percent in Iraq. Surface water overabstraction is believed to account for the fact that about one-tenth of surface water consumption in Mashreq and in the Nile region is unsustainable, or maintained at the expense of environmental flows (World Bank, 2017a). Indeed, in countries such as Egypt, Iraq and the Syrian Arab Republic, overabstraction is believed to have already altered the flow regimes of key riverine systems (Shamout, 2015; Al-Mudaffar Fawzi *et al.*, 2016).

As a result of limited surface water resources, the NENA region relies significantly on the use of groundwater resources (FAO, 2010b). The already important groundwater abstraction rates increased almost uniformly across the region between 1990 and 2010, especially in the Arabian Peninsula. For example, in the North-Western Sahara Aquifer – which spans three countries (Algeria, Libya and Tunisia) – water abstractions increased critically, from 0.6 to 2.5 m³/year (Steenbergen *et al.*, 2010). In the Tigris and Euphrates basin, more than 60 percent of water storage losses were linked to groundwater depletion (Voss *et al.*, 2013; Joodaki *et al.*, 2014).

FIGURE 1.14 WATER WITHDRAWALS BY SOURCE PER TOTAL WATER WITHDRAWAL, NENA, 2015 AND 2017



Source: AQUASTAT and AbuZeid, K. & Wagdy, A. 2019. 3rd *State of the Water Report for the Arab region.*
*Data for Jordan, Lebanon, Qatar and Tunisia are for 2017; data for the rest of NENA countries are for 2019.

Desalination is particularly important given that about 50 percent of the world's desalination capacity is in the NENA region (Wold Bank, 2017a; Borgomeo *et al.*, 2020). Yet these practices are mainly found in high-income countries in the Gulf, which have been able to afford investment in desalination technologies. For example, in Bahrain, Kuwait and Qatar, desalination may account for more than 60 percent of water withdrawals. Significantly, about 45 percent of the wastewater generated in the NENA region is treated. This is a relatively high share compared with other developing global regions (where the average figure is 28 percent for low-middle-income countries).[7] However, subregional characteristics should also be considered. While in countries such as Kuwait or United Arab Emirates, more than 90 percent of domestic and industrial wastewater flow is safely treated, in others, such as Algeria, Iraq, Lebanon and Libya, this proportion falls to about 15 percent (UN Water, 2021). Thus, effective practices in terms of wastewater are possible in the region and could become widespread if further encouraged and incentivized.

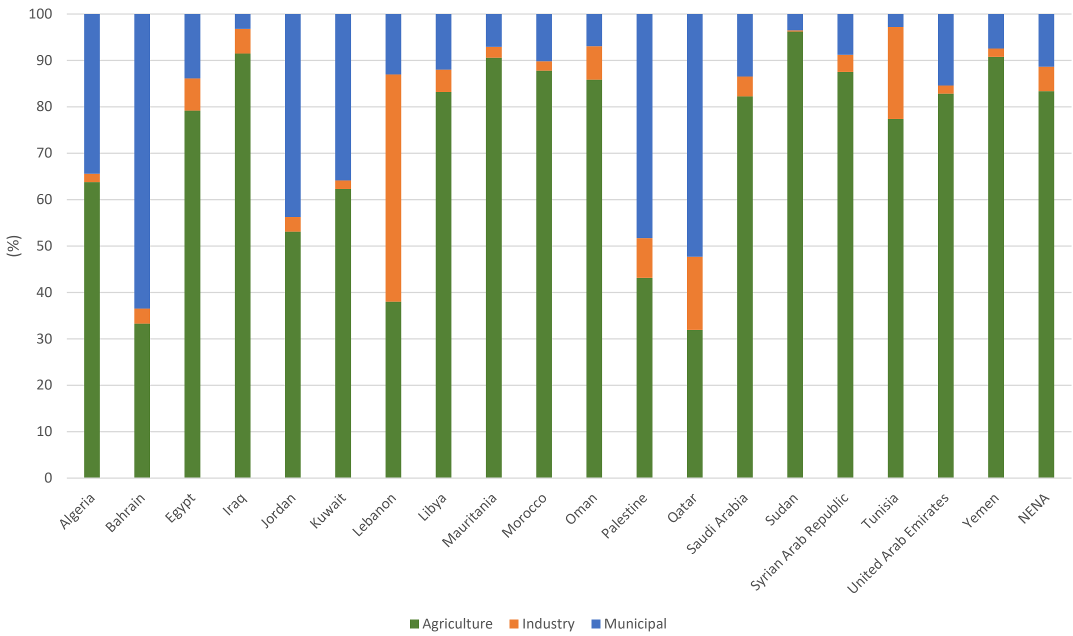
[7] On average, high-income countries treat about 73 percent of their wastewater. The figure drops to 54 percent in upper-middle-income countries and to 28 percent in low-middle-income countries. Globally, about 80 percent of wastewater is released without adequate treatment (cited in FAO, 2020c).

1.2.4 Water use by sector

Agriculture accounts for 85 percent of freshwater withdrawals in the region, far above the global average of 70 percent. In Sudan and Yemen, this figure reaches more than 90 percent (see Figure 1.15) (World Bank, 2021). The agriculture sector faces growing competition due to demands from other economic sectors, as well as population growth, changing food habits and environmental services. Areas surrounding the major river systems such as the Nile and the Tigris-Euphrates are hotspots of agricultural water withdrawals (World Bank, 2017a). Freshwater withdrawal figures potentially change if groundwater, which is essential for the agriculture sector, is also considered. However, since groundwater resources are not well monitored and regulated, it is difficult to accurately measure their role in the sector.

Regional industrial water use in NENA (at about 5 percent) is about one-quarter of the global average (about 20 percent). In Lebanon, Qatar and Tunisia, the industrial share approximates (or exceeds, in the case of Lebanon) global averages. Domestic water withdrawals account for about 10 percent of total withdrawals. In Bahrain and Qatar, this figure surpasses 50 percent; and in Algeria, Bahrain, Jordan, Kuwait, Palestine, Qatar and United Arab Emirates the share exceeds 15 percent. So, while agriculture is indeed the dominant source of water withdrawals, these figures also show that agriculture would face water competition if policies were oriented towards increased domestic and industrial water supply.

FIGURE 1.15 WATER WITHDRAWALS BY SECTOR IN NENA COUNTRIES, 2017

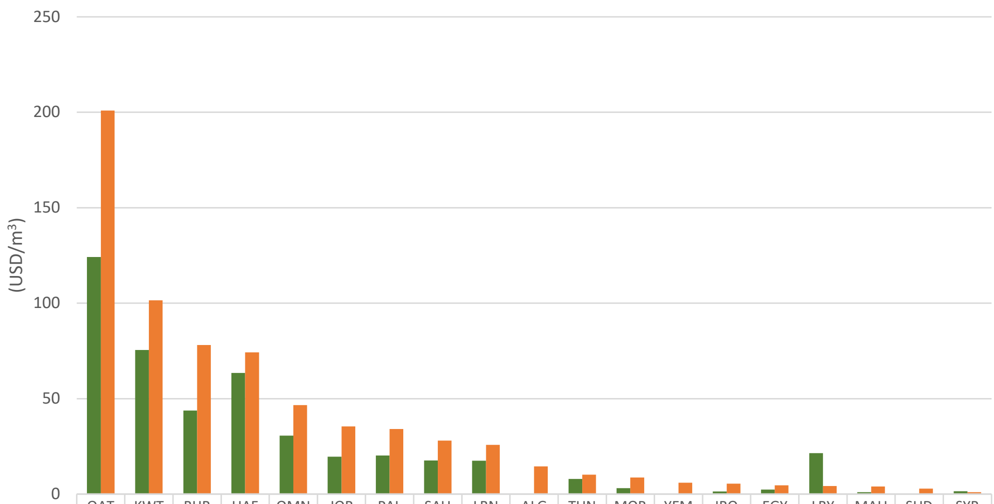


Source: AQUASTAT, 2021.

1.2.5 Water-use efficiency

Water-use efficiency, also called water productivity, is the value of a product or service divided by the volume of water diverted from its source to produce it, and is expressed in USD/m³. Almost half of the NENA countries with available data had levels of water-use efficiency greater than the world value of USD 19/m³ in 2018. Water-use efficiency depends on a country's capacity to make the best use of scarce resources. Countries in conflict experienced the greatest decreases in water-use efficiency between 2000 and 2018 (80 percent in Libya and 33 percent in the Syrian Arab Republic). A strong performance in water-use efficiency has been seen in the Mashreq and GCC countries relative to the Maghreb countries. Exceptions were Morocco, where water-use efficiency increased by 185 percent during 2000–2018 and the Syrian Arab Republic, which saw a decrease of 33 percent (see Figure 1.16).

FIGURE 1.16 WATER-USE EFFICIENCY, NENA, 2000 AND 2018



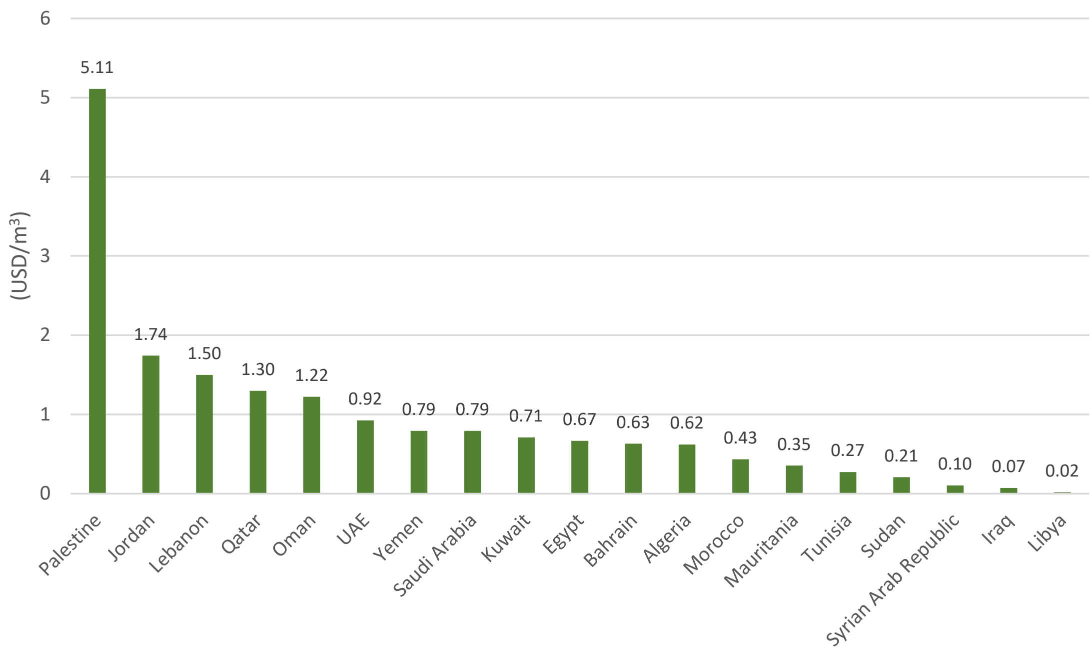
	QAT	KWT	BHR	UAE	OMN	JOR	PAL	SAU	LBN	ALG	TUN	MOR	YEM	IRQ	EGY	LBY	MAU	SUD	SYR
2000	124.2	75.5	43.8	63.5	30.6	19.6	20.2	17.6	17.5		8.0	3.1		1.4	2.4	21.5	1.0		1.5
2018	200.8	101.6	78.1	74.2	46.6	35.4	34.1	28.1	25.8	14.5	10.2	8.7	6.0	5.4	4.6	4.3	3.9	2.8	1.0

Source: AQUASTAT and FAO. *Sustainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

Note: Data of Algeria, Sudan and Yemen are not available for 2000.

Agriculture water-use efficiency, which measures the agricultural value added per unit of water used for the agriculture sector, was below the world average (USD 0.60/m³) in 2018 in seven NENA countries, including Iraq, Libya, Mauritania, Morocco, Sudan, the Syrian Arab Republic and Tunisia (see Figure 1.17). Palestine's high value is due to the fact that the total harvested irrigated crop area reported there is greater than in other countries, and water withdrawals in agriculture are much lower. In addition, drip irrigation systems are mostly used, reflecting efforts towards ensuring best water productivity. There are many opportunities and strong potential for enhancing agricultural water-use efficiency in the region.

FIGURE 1.17 IRRIGATED AGRICULTURE WATER-USE EFFICIENCY (USD/M³), NENA, 2018[8]



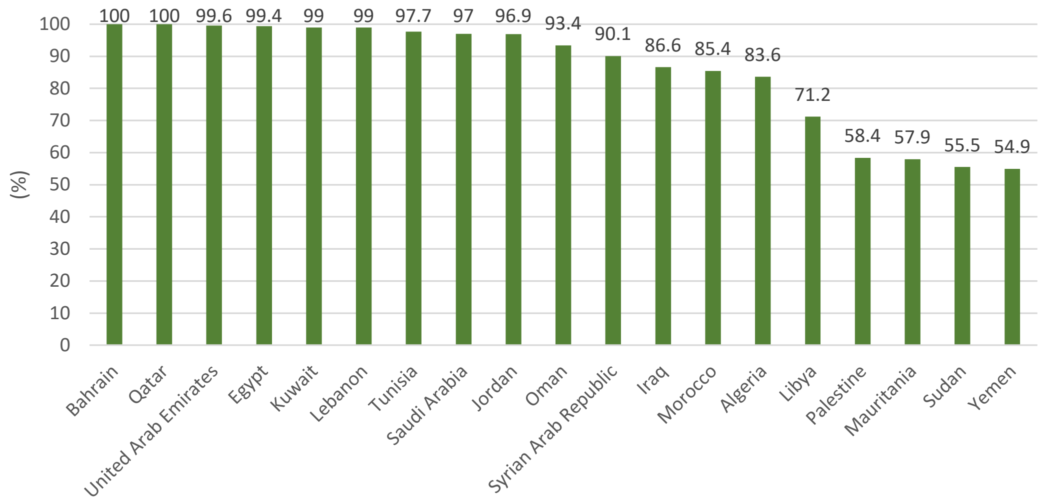
Source: AQUASTAT, 2021.

1.2.6 Water quality

Water quality poses an additional challenge to water resources in the region. Apart from the Nile, all major water bodies in the region are believed to have important loads of nutrients and pollution, as well as high potential for eutrophication (Garnier *et al.*, 2010; Seitzinger *et al.*, 2010). While point-source discharges of nutrients are believed to play a major role, the constant stress of surface and groundwater resources often also results in poor levels of water quality (Jasechko *et al.*, 2017). For example, overabstraction may lead to higher concentrations of contaminants, as well as more saltwater intrusions into streams and aquifers. Countries lacking safe access to drinking water are Palestine, Mauritania, Sudan and Yemen, with less than 60 percent of the population having access to improved drinking water sources, while GCC countries rank first in the list, with over 93 percent (see Figure 1.18).

[8] This indicator is provided by AQUASTAT and measures agricultural value added per unit of water used for the agriculture sector, expressed in USD/m³, with agriculture including livestock, aquaculture and irrigated crops. It is calculated as Irrigated Agriculture Water Use Efficiency] = ([Agriculture, value added to GDP]/[GDP Deflator (2015)]*100)*[% of agricultural GVA produced by irrigated agriculture]/100)/[Agricultural water withdrawal])/10 000 000.

FIGURE 1.18 PERCENTAGE OF POPULATION WITH ACCESS TO SAFE DRINKING WATER, NENA, 2017



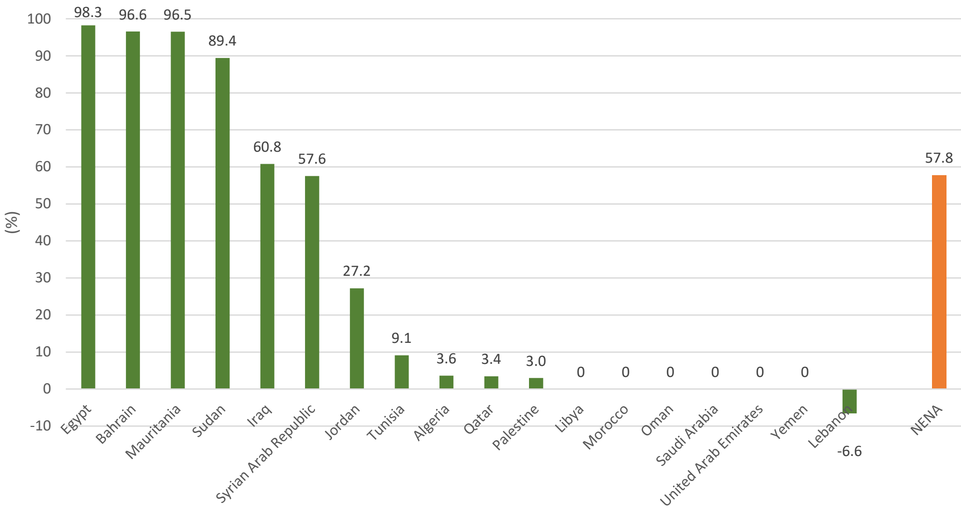
Source: AQUASTAT, 2021.

1.2.7 Transboundary water resources

Transboundary water resources shape the region's water availability. Half of Mashreq countries (Egypt, Iraq and the Syrian Arab Republic), as well as Mauritania and Sudan are highly dependent on water resources generated in upstream countries, with more than 50 percent of their total renewable water resources coming from external sources (see Figure 1.19). Importantly, about 60 percent of total surface water in the region is shared across national borders and all countries share at least one aquifer. As such, the three main river systems of the region, the Nile, Tigris-Euphrates and the Jordan-Yarmouk, are shared with countries that in some cases are also outside the NENA region. Other shared rivers include the Shat Al Arab, the Orontes between Iraq and Kuwait, and the Nahr el Kabir between Lebanon and the Syrian Arab Republic. Transboundary water flows are more critical for countries such as Egypt, Iraq and the Syrian Arab Republic, which almost totally depend on other countries for surface water resources (FAO, 2010b).

Transboundary water systems are also relevant for groundwater resources. Indeed, several of the largest groundwater systems in the NENA region are transboundary. These include the Nubian Sandstone (Egypt, Libya and Sudan), North Western Sahara (Algeria, Libyan Arab Jamahiriya and Tunisia), and Disi Aquifer (Jordan and Saudi Arabia) (FAO, 2010b) (see Figure A5 in Annex). Other minor groundwater systems also have significant repercussions on country-level water budgets. For instance, Bahrain and Kuwait have up to 97 percent dependence on groundwater flows from Saudi Arabia. As such, local-level water scarcity conditions may be attenuated or accentuated by decisions made upstream outside national borders.

FIGURE 1.19 EXTERNAL RENEWABLE WATER RESOURCES AS % OF TOTAL RENEWABLE WATER RESOURCES, NENA, 2018[9]



Source: AQUASTAT, 2021.

The region's poor water endowment, linked with a growing population, is preventing it from producing sufficient food to feed its people. The growing gap between food supply and demand is compensated by increasing levels of food imports, and therefore by a growing dependency on international food markets. 'Virtual water' is often considered as an element of a region's water balance. The NENA region imports virtual water from all over the world and it is the largest global food importer (Antonelli *et al.*, 2017; World Bank, 2017a; OECD-FAO, 2018). The United States of America, Brazil and Argentina are the major virtual water exporters to the region. Altogether, the Americas account for almost half of the NENA region's virtual water imports. Water imports to the region increased by about 150 percent in just 25 years (between 1986 and 2010) (Antonelli and Tamea, 2015; Antonelli *et al.*, 2017). As the dependency on imports does not appear likely to change readily in the coming years, it has become an acute discussion point for decision-makers in the region.

1.3 Main Agricultural systems in the NENA region

The above sections have portrayed a region dominated by deserts and a harsh environment, whose main characteristics are a generally high level of aridity and water stress, poor soils and limited arable land. Within this general context, a series of agricultural systems have developed over time, adapting to the biophysical conditions, and responding to market demands. Understanding the region's land and water challenges and how to address them requires a grasp of the agricultural systems that they support. Based on similar previous exercises (Dixon *et al.*, 2001 & 2019; FAO, 2011d; Lewis *et al.*, 2018), this report considers five major agricultural systems and four subsystems. Their main features are described below, along with key issues associated with their management. Table 1.1 provides a synopsis of the main agricultural systems discussed in this publication, together with relevant subsystems.

[9] External renewable water resources as percentage of total renewable water resources is calculated by dividing the total external renewable water resources for each country or region by its total renewable water resources.

TABLE 1.1 MAIN AGRICULTURAL SYSTEMS AND RELEVANT SUBSYSTEMS IN THE NENA REGION

Agricultural systems	Length of growing period	Main production	Distribution of rural population (%)	Rural population density (persons/ km²)	Distribution of area excluding desert (km²)	Main issues
Major agricultural systems						
Irrigated	Year-round	Wheat, fruits, vegetable, sugar cane sugar beet, fodder	32.6	170	8.9	Access to water, pollution, misuse of inputs
Rainfed	>150 days	Cereals (wheat), olive, fruit trees	21	45	21.7	Droughts, temperature increase
Dryland	90–150 days	Cereals (barley, millet), beans, livestock: goats, sheep	15.7	35	20.8	Droughts, access to markets, finance and inputs
Pastoral	30–90 days	Livestock: sheep, goats, camels	20.5	25	38.2	Access to basic services, heatwaves
Forest-based	>150 days		10.1	45	10.3	Deforestation, land degradation
Relevant subsystems						
Oases	< 30 days	Dates, vegetables				Overuse of water, access to markets and diversification of income
Mountains		Vegetables, fruit trees, legumes, cereals, livestock				Low investments, small size of plots, water scarcity, high production costs, lower productivity, access to markets

Agricultural systems	Length of growing period	Main production	Distribution of rural population (%)	Rural population density (persons/ km²)	Distribution of area excluding desert (km²)	Main issues
Urban/ peri-urban agriculture		Vegetables, fruits, dairy products				Urban encroachment, land tenure, access to quality water
Fisheries and aquaculture		Fish				Competition for land and water
Deltas and coastal areas		Rice, vegetables, cereals				Seawater intrusion, urban encroachment on arable land

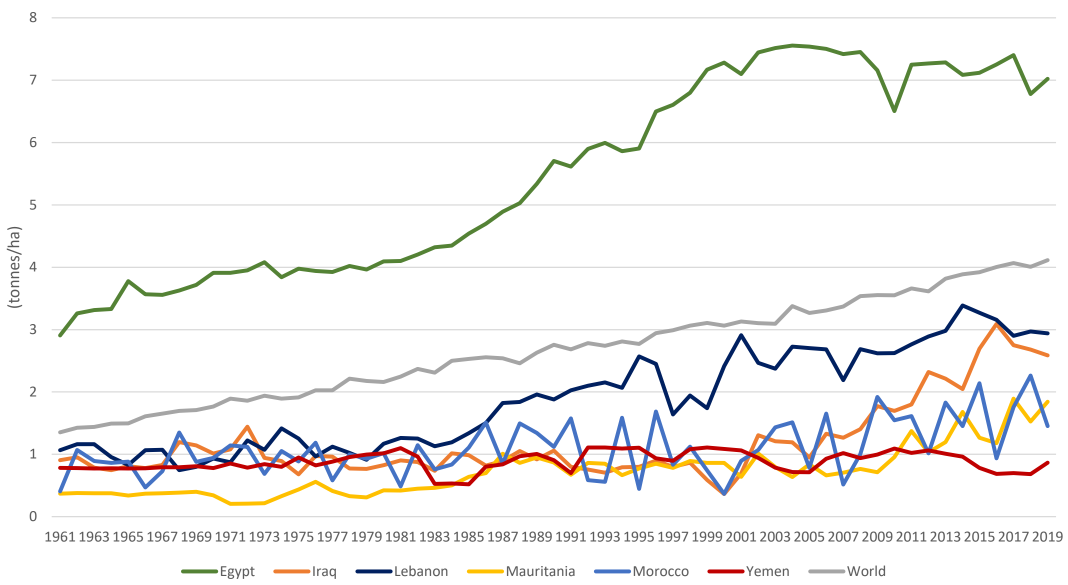
Source: Adapted from Dixon *et al.* (2001, 2019), FAO 2011d & Lewis *et al.*, 2018

Agricultural production in the NENA region is dominated by rainfed systems. Cereals, mostly grown under rainfed production, cover about 60 percent of the harvested land in the region and contribute to about 15 percent of the value of agricultural production (Nin-Pratt *et al.*, 2017; OECD-FAO, 2018). Cereal yields in the region reveal large discrepancies, with Egypt and GCC countries showing yields higher than the world average, and the other countries lagging behind, with yields far below their potential (see Figure 1.20 and Figure A7 in Annex). Horticultural products such as citrus, fruits, vegetables, tree nuts and others, which have higher economic values, occupy less than 20 percent of NENA's harvested land (idem) and contribute to 40 percent of the value of agricultural production. Table A6 in the Annex provides the value of the main crops for each country of the region.

In more than three-quarters of the region's countries, less than 5 percent of the land is arable, and about 75 percent of the regional croplands are estimated to be degraded (Nin-Pratt *et al.*, 2017; OECD-FAO, 2018). Erosion and desertification pose a significant threat to agriculture. Climate change is expected to further exacerbate the situation, with serious implications for the different agricultural systems.


©FAO/Nikos Economopoulos

FIGURE 1.20 CEREAL YIELDS IN SELECTED NENA COUNTRIES AND IN THE WORLD (TONNE/HA)



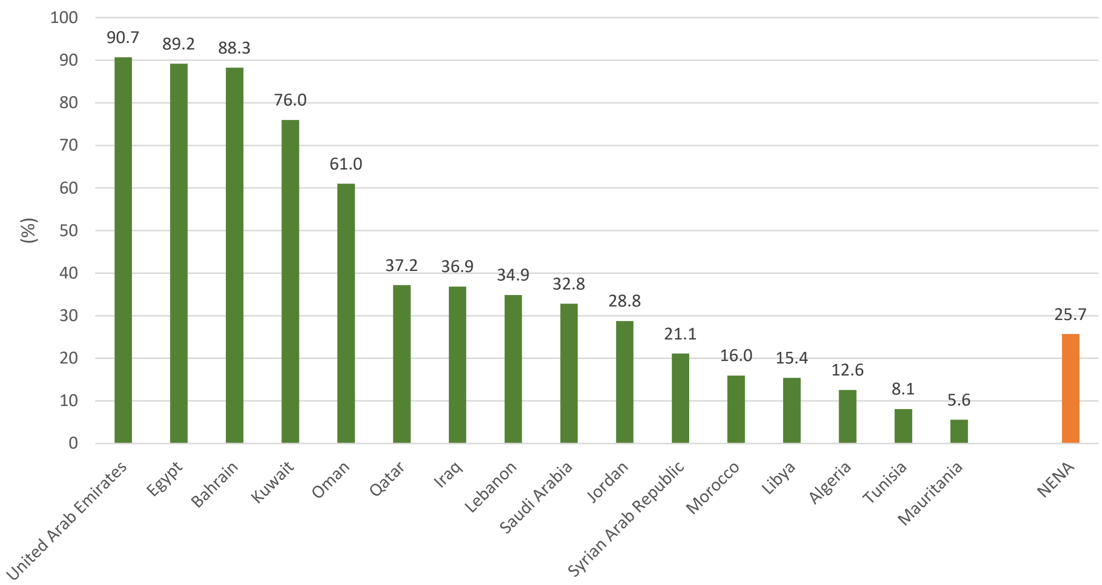
Source: FAOSTAT, 2021.

1.3.1 Irrigated systems

The low annual rainfall in most of the region has forced farmers to rely on irrigation to secure their production. Dating back more than 8 000 years, irrigation first developed in the Nile Valley and in Mesopotamia, transforming desert areas into productive land. Egypt and GCC countries rely almost exclusively on irrigation for their food production, and the percentage of cropland that is irrigated is higher in NENA than in any other region of the world. In other parts of the region, such as in the Maghreb countries, Sudan, Lebanon and parts of Iraq, more favourable rainfall conditions allow for rainfed production, but irrigation remains an important feature of agricultural policies. Most countries have developed irrigation infrastructure to the extreme, making use of all available water (see Figure 1.21). In the future, very little additional irrigation will be possible and future investments in irrigation will have to concentrate on improving water productivity – in other words, producing more with less water. It is also likely that water that is available for agriculture will be progressively reduced in most countries due to increasing demand for water from cities and industries.

©FAO

FIGURE 1.21 AREA ACTUALLY IRRIGATED AS A PERCENTAGE OF CROPLAND, NENA, 2017*



Source: Calculated using data from AQUASTAT and FAOSTAT, 2021.

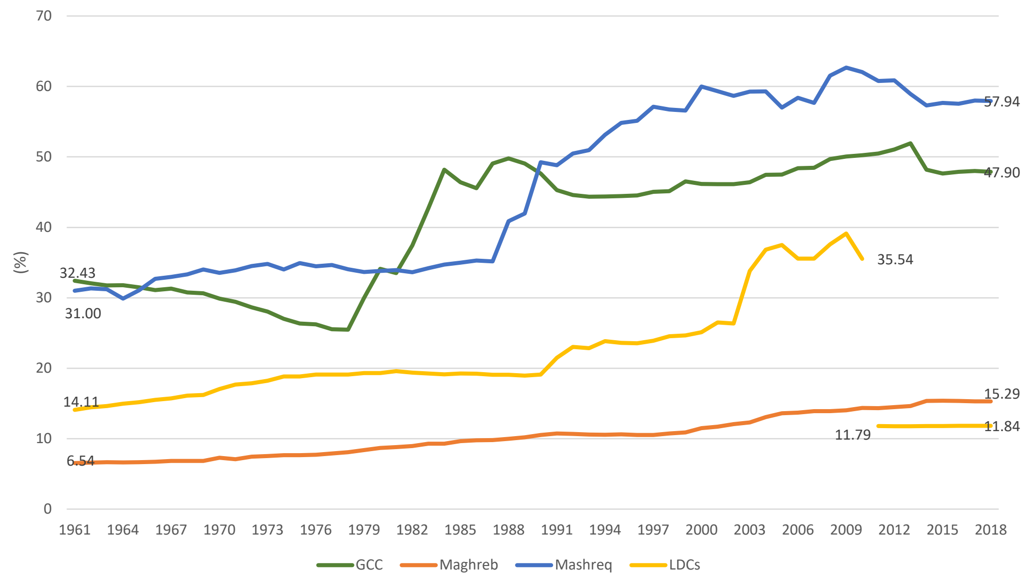
*NENA average is missing data for Palestine, Sudan and Yemen.

Despite the large percentages of areas irrigated compared with the availability of arable land and permanent crops in most of the individual GCC countries, the subregional figures show that Mashreq has a higher percentage (43.4 percent) of irrigation compared with the GCC (35.1 percent). This is because the GCC countries with high shares of irrigated cropland represent a small share of the total cropland, while those with lower levels of irrigation comprise most of the total cropland in the subregion.

A similar pattern is seen in the area equipped for irrigation as a percentage of arable land and permanent crops, with GCC countries having the highest percentages (exceeding 100 percent), whereas Maghreb countries and LDCs rank at the bottom of the list. Conversely, the area equipped for irrigation as a percentage of arable land and permanent crops in NENA is 26.1 percent, higher than the world average of 21.6 percent.[10] Between 1961 and 2018, all NENA subregions except the countries under the LDC grouping had increased rates, with the largest percentage point change recorded in Mashreq (27 percent), followed by the GCC (15.5 percent), and Maghreb (8.8 percent) (see Figure 1.22).

[10] Because this percentage is calculated from arable and permanent crops, it exceeds 100 percent in some countries such as the GCC nations, and irrigated area can cover other land uses.

FIGURE 1.22 NENA SUBREGIONAL PERCENTAGE OF ARABLE AND PERMANENT CROPLAND EQUIPPED FOR IRRIGATION, 1961–2018*[11]



Source: FAOSTAT, 2021.

*The level shift in the line for LDCs in 2011 was due to the inclusion of Sudan's data, which were not previously available.

1.3.2 Rainfed systems

Rainfed systems are concentrated in areas of relatively favourable precipitation that allow for good production in normal years. Rainfed systems can be found in the Maghreb countries along the coast, in Lebanon, part of the Syrian Arab Republic and Iraq, in Sudan and in small areas of Saudi Arabia and Yemen. The dependency of rainfed systems on precipitation during the growing season renders them vulnerable to climate change, which in turns impacts the livelihoods of smallholders. High temperatures and uneven distribution of rainfall are the main factors impacting rainfed agriculture, although many adopted farming practices aim to appropriately prepare the soil for water storage. As agroclimatic conditions are changing, soil moisture levels are affected, and degradation processes caused by wind and water are more acute when acting synergistically with inappropriate techniques.

Productivity is especially low in rainfed smallholder systems that grow cereals and horticultural crops as a diversification strategy, to ensure minimum income and provide for direct consumption. Lack of investment and innovation in productivity and sustainability limits the capacity of smallholder farmers to specialize and apply improved farming practices, resulting in consistently low yields of both their horticultural and cereal crops. The latter can be verified by figures for the NENA subregions, ranging from just 0.60 tonnes per ha (t/ha) in LDCs to 5.71 t/ha in GCC, which is higher than the world average. Between 2010 and 2016, the region's wheat yield averaged 2.2 t/ha and the oilseed yield averaged 0.9 t/ha – both considerably lower than the global average of 3.2 t/ha for both crops (OECD-FAO, 2018).

1.3.3 Drylands

Dryland systems are production arrangements that occur in semi-arid areas that have water limitations and receive very low annual rainfall. Dryland systems cover 4 percent of the region's land area, with an agricultural population of 14 percent of total population

[11] All averages computed are simple unweighted averages.

(FAO, 2002b). Drylands are in the northern part of the Maghreb subregion, mainly inland and often in proximity to rangelands. However, in some cases such as in Morocco, drylands are also located near the coastal zone. Dryland systems are also typical in Sudan, Yemen, West Bank and Gaza Strip, northern Iraq and the Syrian Arab Republic, and the southern part of Lebanon. Cereals such as wheat and barley for fodder dominate production in the region. However, in Jordan a more diversified production pattern includes vegetables and fruits, such as tomatoes, cucumbers, bananas, melons and citrus (Lewis *et al.*, 2018). Crops are alternated and land remains fallow for one or two years to restore soil moisture and prepare it for the next cultivation. Sheep and goats are also integrated in this production system.

1.3.4 Rangelands

Rangelands are used for grazing and as a feed resource, providing valuable services on which rural households depend, contributing to the resilience of rural livelihoods. Rangelands occupy vast areas of the NENA region, exceeding 50 percent of total land area in several countries (NEFRC, 2017). With the exception of Egypt and the small Gulf countries, which are predominantly desert, most NENA countries have substantial areas for livestock production and pastoral activity (see Figure 1.1). Livestock production in Algeria, Tunisia and Morocco constitute 48, 30 and 26 percent of agricultural GDP, respectively (Dutilly-Diane, 2006). Moreover, a study showed that the total economic value of the direct use value of rangelands as fodder in Tunisia was about TND 200 million (USD 125 million) (NEFRC, 2017).

Rangelands are also a reservoir for agrobiodiversity. However, they face major challenges such as climate change, urbanization, inappropriate management practices and increased competition with other land uses, leading to their degradation. The fact that rangelands are considered as wastelands that can be converted to other uses when needed has direct implications for rangeland degradation and is contributing to placing these resources under mounting anthropogenic pressures (NEFRC, 2017). In addition, rangelands are subject to land fragmentation and overgrazing, both of which contribute to habitat loss and a further decline in their carrying capacity. Average vegetation cover as a percentage of land area in the region decreased from 3.7 percent in 1990 to 2.8 percent in 2013, while livestock numbers increased during the same period by 25 percent (NEFRC, 2017) due to increased demand for animal products.

Improving the management of rangelands has many benefits for environmental restoration. As carbon sequestration in degraded rangelands decreases, implementing restoration activities and good agricultural practices can increase carbon stock. These include manure management, rehabilitation with appropriate species, and controlled livestock grazing. It has been estimated that through rangeland restoration and desertification programmes in Central-West Asia and North Africa, soil carbon sequestration can range between 1.735 and 4.337 Tg Carbon over a period of 50 years (FAO, 2011a).

1.3.5 Forest-based systems

Forests offer several ecosystem services including soil carbon storage, soil conservation, watershed protection, sand dune stabilization and desertification control. Trees acting as windbreaks protect soils from wind erosion and can contribute to higher yields. In addition, tree roots stabilize soils, especially on slopes, and prevent soil washing into the waterways. In a region characterized by water scarcity, the role of forests in protecting water supplies and ensuring water quality is crucial. Estimates of the value of watershed protection in Algeria, Tunisia and Morocco, using Saharan Acacias is about EUR 20/ha (USD 22.5/ha), while it can climb to EUR 38/ha (USD 43/ha) if areas are covered with Mediterranean forest types (FAO, 2010c). Despite their importance, the limited forests in the region are under continuous pressure from human-induced activities such as land-use change and deforestation, as well as climate change. Between 1990 and 2020, NENA forest cover declined from 35.3 million ha to 30.8 million ha. Table A4 in the Annex presents data on the declining forest area as a proportion of total land area in NENA. Table A9 in the Annex indicates that the area of OWL as a proportion of total land area in NENA was 4.8 percent in 2020, down from 5.7 percent in 1990. Other woodlands also decreased from 35.4 million ha to 29.4 million ha over the same period (see Figure 1.23) (FAO, 2021b). Four NENA countries, Mauritania, Sudan, Egypt and Oman had net decreases ranging from -0.89 percent to -3.71 percent in their forest areas between 2010 and 2020 (see Figure 1.24). Countries that have witnessed continuous loss in the area of OWL throughout the past three decades are Sudan, Mauritania, Morocco and Tunisia (FAO, 2020d). However, the loss in Sudan and Mauritania alone accounted for 96.6 percent of that in the region (FAO, 2021b).

On the positive side, the area of planted forests in the NENA region increased steadily between 1990 and 2020, from 1.5 million ha to 2.2 million ha (FAO, 2021b). According to the *Global Forest Resources Assessment* (FAO, 2020a), the Maghreb countries had the highest planted forest area in 2020, with Morocco having 635 000 ha, followed in ascending order by Algeria, Libya, Tunisia, the Syrian Arab Republic and Sudan. Nonetheless, that increase does not compensate for the loss of 10.5 million ha of forests and OWL (FAO, 2020d). This loss has a significant impact on the region's biodiversity – forests and OWL host a wide range of the region's fauna and flora species. FAO indicates (2020d) that five countries (Algeria, Mauritania, Morocco, Sudan and Tunisia) have developed management plans to guide the sustainable utilization of their forest resources. Collectively, these make up a total area of 9.2 million ha under sustainable forestry management. Strengthening and upscaling these efforts is urgently required.

Another positive development is that the area of forests designated for biodiversity conservation increased by 58.4 percent between 1990 and 2020 (FAO, 2020d). Non-wood forest products (NWFPs) showed significant importance in the region. FAO (2021) estimated the value of NWFPs in 2015 at USD 347.4 million (4.5 percent of the global total). NENA's forest area represents 1 percent of the global total.

According to the *Global Forest Resources Assessment* (FAO, 2020a), three NENA countries: Kuwait, Tunisia and Bahrain are among the top 10 countries in terms of the proportion of total forest area designated primarily for soil and water protection. This percentage ranges from 86 percent in the case of Bahrain to 100 percent in that of Kuwait (FAO, 2020a). Countries such as Morocco, Algeria, Tunisia, the Syrian Arab Republic and Jordan have planted trees through integrated watershed management programmes to control landslide and erosion (FAO, 2011a).

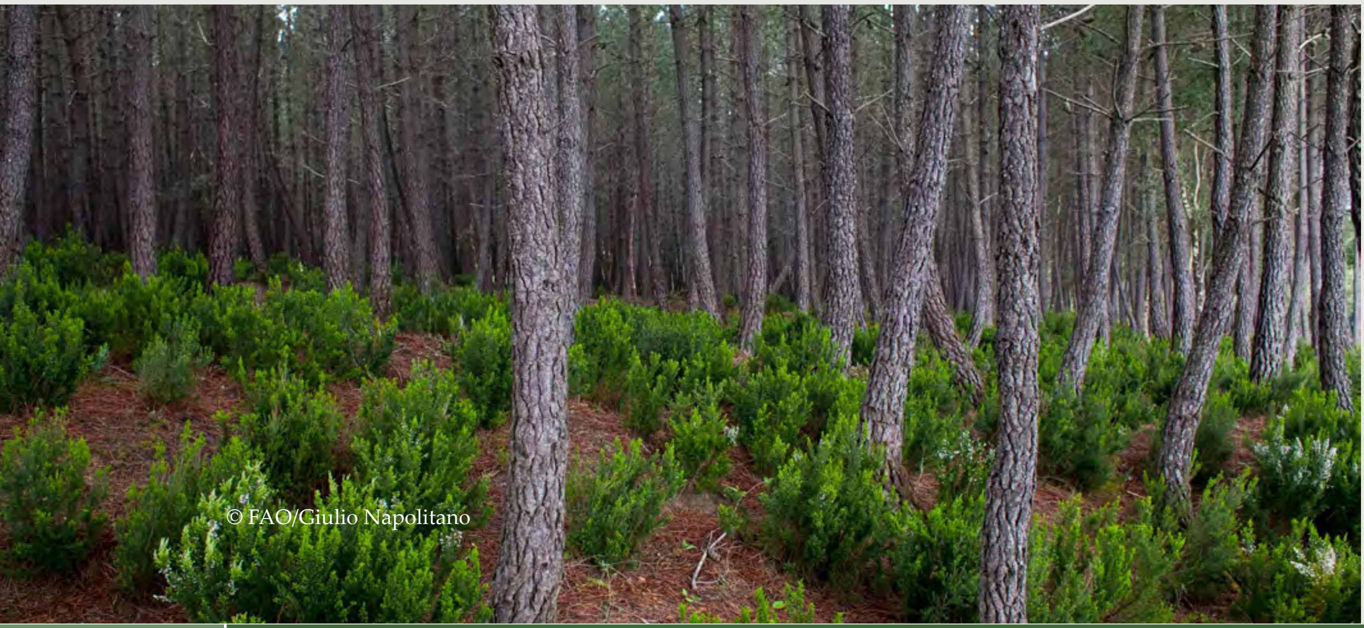
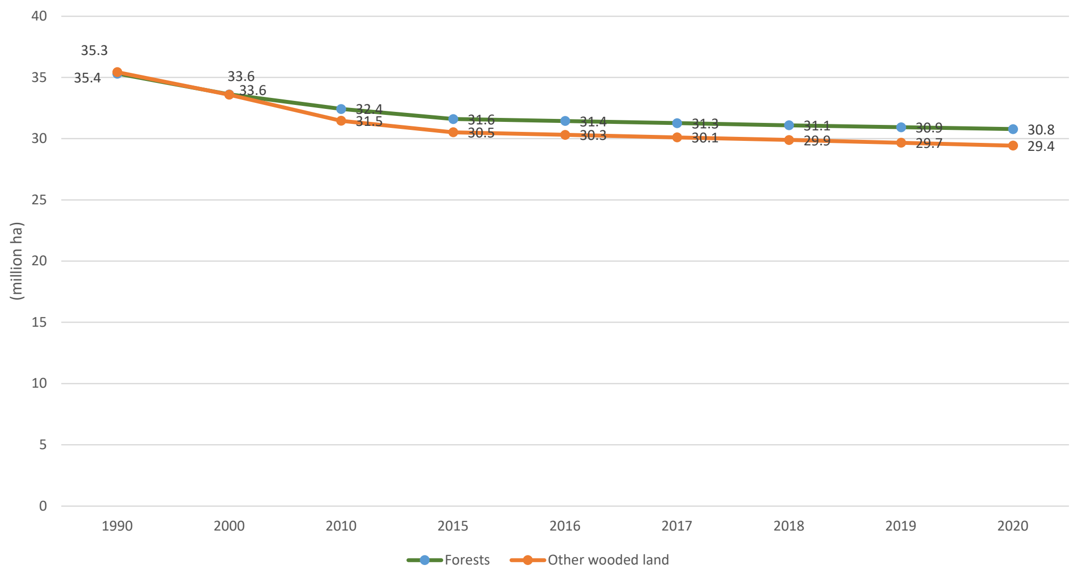
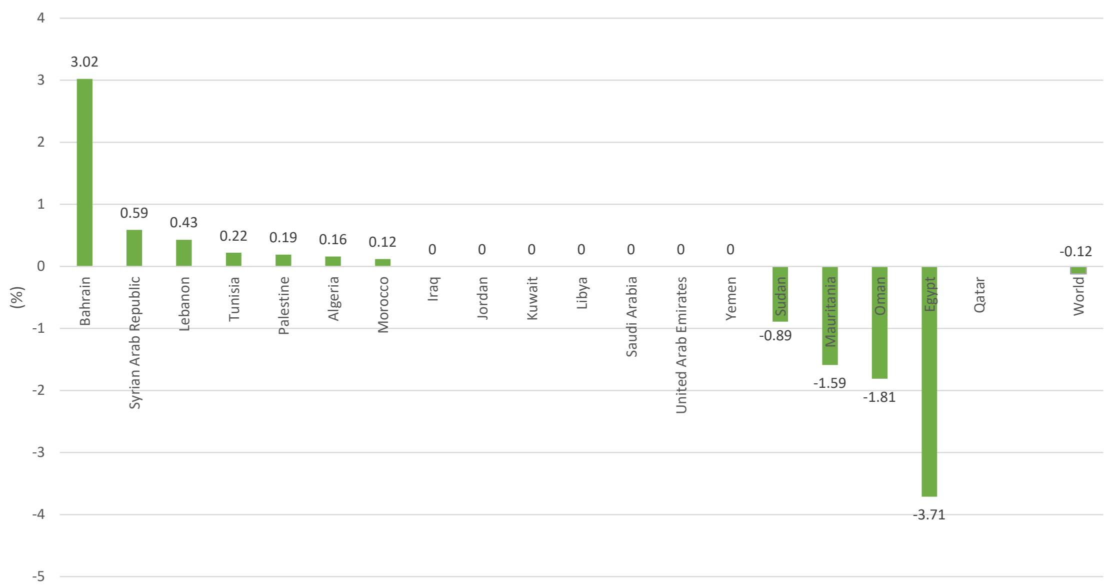


FIGURE 1.23 TRENDS IN NENA FORESTS AND OTHER WOODED LAND AREAS BETWEEN 1990 AND 2020



Source: FAO. 2021b. *Global Forest Resources Assessment.* Rome. https://fra-data.fao.org/WO/fra2020/extentOfForest/

FIGURE 1.24 FOREST AREA ANNUAL NET CHANGE RATE (%), NENA, 2010–2020



Source: FAO. Sus*tainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

1.3.6 Relevant subsystems

Mountains

Mountains are ecosystems of great importance that sustain many household livelihoods and provide vital ecosystem services. They supply areas with freshwater and constitute key sources of energy, and their diverse topography and climate render them extremely biologically rich. In the NENA region, mountains span national borders, highlighting their transboundary importance. Examples include the Atlas Mountains (Morocco, Algeria and Tunisia), the Sarawat Mountains (Saudi Arabia and Yemen), the Golan Heights and Mount Carmel (West Bank and Israel) and the Al Hajar Mountains (Oman and United Arab Emirates). Mountain ranges can also be found within countries such as Libya, Egypt, Jordan, Lebanon, the Syrian Arab Republic, Oman and Iraq (Balaghi, 2012).

Mountain agriculture relies heavily on family farming and is characterized by low investments, small size of plots, higher production costs and lower productivity in comparison with lowland agriculture. Areas most at risk in terms of food insecurity are remote mountain and arid regions characterized by a fragile natural resource base, poorly developed markets, and frail institutional environments. It has been estimated that the proportion of vulnerable people out of the total rural mountain population in Northern Africa increased from 27 to 41 percent during the period 2000–2017 (Romeo *et al.*, 2020).

Despite the terrestrial constraints, mountain agriculture contributes to environmental sustainability by maintaining and protecting soils from water and wind erosion. Dominated mostly by smallholder family farms, mixed farming is practised by growing rainfed and irrigated crops and raising livestock. Terraces are built to address steep slopes, prevent land degradation and preserve vulnerable landscapes. Traditional conservation strategies such as these are used in the NENA region in the Atlas Mountains in Morocco, as well as in Tunisia and Yemen. Successful examples of how mountain communities in NENA use sustainable practices and increased resilience for agricultural and livestock production include the oases system in the Atlas Mountains of Morocco and the hanging gardens located on the slopes of Jbel el Gorrâa Mount in Tunisia, which have both been designated as Globally Important Agricultural Heritage Systems.[12] Mountains in the region are, however, threatened by anthropogenic factors such as deforestation, urbanization, migration and tourism, as well as being subject to the effects of climate change and natural hazards. Water scarcity in NENA is a major limiting factor for sustainable mountain development and is expected to be aggravated by reduced precipitation and more frequent droughts. For example, climate change projections in the Anti-Atlas mountain range in Morocco show that water resources in the Rheraya catchment will be stressed at an increasing rate due to competition between different land uses by 2100 (Balaghi, 2012).

Urban and peri-urban agriculture

Urban and peri-urban agriculture refers to food production within and on the outskirts of cities; it can be practised in gardens, on rooftops and vertical surfaces, as well as on balconies, and in public open spaces, and can often be mixed with other land uses, creating multifunctional landscapes. Although there is scattered information on the implementation of urban and peri-urban agriculture in NENA, growing attention has been paid to its benefits in enhancing food security. Rising urbanization rates, urban encroachment at the expense of fertile land and a high percentage of urban poor (in some countries exceeding 20 percent of the population) have boosted interest in some countries to set in place more efforts to promote urban agriculture (for example in Jordan).

Urban and peri-urban agriculture in NENA is mainly practised by smallholder farmers who sell their products in urban food markets or

[12] See www.fao.org/giahs/giahsaroundtheworld/designated-sites/near-east-and-north-africa/en/.

directly to consumers. In many cases, produce is also used for their own consumption to ensure household food security. Vegetables and aromatic herbs, fruits and crops are major components of urban and peri-urban agriculture, with dairy products and meat as additional products. Home gardens are helping to increase resilience in refugee camps in Palestine by encouraging cultivation in backyards and greenhouses and on rooftops. The 2007 census in Yemen showed that more than 9 000 ha of agricultural land in the city generated income for around 10 000 households from vegetable and fruit production (Dubbeling *et. al*, 2010). However, studies in Tunisia have shown that to make ends meet and generate additional income, urban farmers were also engaged in other forms of employment (FAO, 2012a). Urban farming has also been introduced as a coping strategy during crises in the region, more recently to counter the impacts of the COVID-19 pandemic on vulnerable populations.

Complex land and water tenure systems in the region are an impediment to mainstreaming urban agriculture. Land used for farming usually consists of small plots. Short-term leases do not provide incentives for lengthy investments from the farmers' side. Poorly planned urban development, with little recognition of the potential role that urban agriculture can play in the local economy, is another issue. Strengthening legislation that protects farmland and provides land tenure security will help to support urban production in this highly populated and urbanized region.

Oases

Oases ecosystems are fertile pieces of land located in desert environments, relying heavily on springs and groundwater resources. These hotspots of biodiversity, found in scattered areas of the NENA region, contribute to food security, improve local communities' livelihoods, and offer a number of economic, cultural and environmental benefits. Water and its sustainable management are essential to sustain multilayer cultivation, whose major output is often dates intercropped with cereals, fruit trees, vegetables and medicinal plants. Crop production is frequently combined with animal husbandry. Traditional knowledge on managing land and water resources in these fertile areas (such as traditional irrigation systems, agroforestry and crop rotation) has been essential in safeguarding natural capital and increasing the resilience of local communities.

In NENA, oases are found in all countries of the Maghreb area covering more than 350 000 ha (FAO, 2020b), as well as in Egypt, Saudi Arabia and United Arab Emirates. The importance of oases systems in providing ecosystem services and ensuring food security has been emphasized by the recognition of five oases (in Algeria, Morocco, Tunisia, Egypt and United Arab Emirates) as Globally Important Agricultural Heritage Systems (GIAHS). More than 118 000 people are engaged in activities related to agricultural systems in these designated areas, including agro-tourism. Despite the multiple benefits that oases bring, they face environmental and socioeconomic challenges. Overexploitation of groundwater, climate change, land fragmentation and the rural exodus, along with a lack of effective governance are factors that hinder their sustainable management.

Inland fisheries and aquaculture

Aquaculture is the farming of aquatic animal and plants.[13] In 2018, NENA aquaculture production was worth USD 2.3 billion, two-thirds of which came from Egypt as the leading producer. Production has doubled over the past decade, reaching a historical high of 1.7 million tonnes in 2018. Egyptian fish farms accounted for 92 percent of production and Saudi Arabia for 4.2 percent, while other significant producers included Iraq (25 737 tonnes), Tunisia (21 826 tonnes), Algeria (5 100 tonnes), the United Arab Emirates (3 350 tonnes) and the Syrian Arab Republic (2 350 tonnes). A total of 43 species of finfish, shellfish and aquatic plants are farmed in the region. Tilapia is the most popular, produced

[13] In 2020, FAO engaged many aquaculture experts to produce six regional aquaculture reviews describing the latest trends in aquaculture globally. See www.aquaculture2020.org/reviews.

in 14 of NENA countries, representing 63 percent of total production in 2018. The next most popular fish is mullet (14 percent) and the major carp species (12 percent). Farming of marine finfish (mainly gilthead seabream and European seabass) and the whiteleg shrimp (mainly from Saudi Arabia) accounts for 6 and 3 percent, respectively. The capacity to grow marine finfish other than those typically produced in the Mediterranean, such as grouper, amberjack and yellowtail, is increasing in the Gulf States, but their quantities remain limited (Lovatelli, 2021).[14] Almost all countries, however, have high ambitions to expand their aquaculture production, for a series of reasons:

- the huge gap between fish production and consumption and large and growing dependency on imports (more than 90 percent for many countries);[15]
- the opportunity to use water sources not suitable for other food production – salty or brackish groundwater, and marine water;
- the availability of mature technologies for integrated farming of fish, livestock and crops in open (integrated irrigation-aquaculture (IIA)) or closed systems (aquaponics); and
- the emergence of new technologies for the mass production of fish with limited-to-no impact on the surrounding environment (land-based aquaculture in recirculated aquaculture systems (RAS) or marine-based in offshore aquaculture).

The local impact of aquaculture on land is limited, as the technologies employed are either integrated (IIA), highly land-intensive (aquaponics, RAS), or conducted at sea (offshore aquaculture). However, offshore aquaculture requires inland bases for vessel boarding and daily operations (net cleaning etc.), which can be an issue in countries where coastal areas are highly urbanized. This is the case in several GCC states. Moreover, total accounting for aquaculture land impacts should also consider the land used to produce feeds and their raw materials, which currently takes place in other regions of the world. In terms of water resources, the focus on marine species and the highly water-efficient technologies employed to produce freshwater species makes aquaculture an activity of relatively low concern.

Deltas and coastal areas

The main rivers in the NENA region – the Nile, Euphrates, Tigris and Jordan River and their surrounding water areas – host a wealth of species that are of great significance for preserving biodiversity resources (UNEP, 2007), encompassing water lilies, reeds and cattail in addition to various other submerged and emergent species. However, from an agricultural and socioeconomic point of view, low-lying areas, deltas and low coastal cities are vulnerable and under serious threat from sea level rise (SLR). Dasgupta *et al.* (2007) estimated that with a 1 m SLR, almost 3.2 per cent of the population of NENA countries will be impacted, a relatively higher percentage than for other regions (although not in absolute numbers). The global average according to Dasgupta (2007) is 1.28 percent. More recent analyses warn that people living in coastal areas worldwide must prepare themselves for much more difficult futures than may be currently anticipated (Kulp and Strauss, 2019).

[14] The Asian seabass is successfully being produced in Saudi Arabia and United Arab Emirates. Small amounts of bivalve shellfish are farmed in Algeria, Morocco, Tunisia and United Arab Emirates, while even smaller quantities of aquatic plants are grown in Morocco and Tunisia.

[15] Included here are countries of the Cooperation Council of the Arab States of the Gulf and Yemen, which covers Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen.

BOX 1.1 THE NILE DELTA

The Nile Delta contributes about 40 percent to the agricultural production in Egypt, and is home for nearly 50 percent of the country's population (IDRC 2011). The population density in the Nile Delta is around 1,000 inhabitants/km^2 with a population growth rate of 2 percent (Bucx *et al.*, 2010). Nile Delta has been affected by seawater intrusion causing loses of soil fertility due to salinization, which is a real threat to the livelihood for millions of small-scale farmers in Egypt. About 2.4 million feddan from the irrigated agricultural land in Egypt suffer from problems of waterlogging, salinization and sodicity; the majority of salt-affected soils are located in the northern central part of the Nile Delta (Negm *et al.*, 2017) (See also Box 6.1 on urban sprawl in the Nile Delta).

Source: IDRC. 2011. *Climate change adaptation in Africa program;* Bucx *et al.*, 2010. *Synthesis report: comparative assessment of the vulnerability and resilience of 10 deltas*; & Negm *et al.*, 2017. *Nile Delta biography: challenges and opportunities.*

PART I:
REGIONAL OVERVIEW

2 DRIVERS OF LAND AND WATER USE IN THE NENA REGION

© FAO/Heba Khamis

KEY MESSAGES

- **A rapid population increase has occurred in NENA since 1950.** While the world population increased three times since 1950, NENA grew sixfold. In 2020, there were 418 million inhabitants, but the figure is expected to rise until 2050, reaching over 633 million.
- **The region is rapidly urbanizing.** In 2018, people living in rural areas accounted for 40 percent of the total population, whereas in 1970 this figure was 60 percent.
- **Harvested areas are expected to shrink by 2050.** Population growth and urbanization aggravate already fragile land and water resources, with serious implications for sustaining or increasing food production in the region.
- **Countries in NENA rely on imports to meet the population's needs.** During a 50-year period (1960–2010), the food production-consumption gap increased.
- **The agriculture sector accounts for 13 percent of GDP.** The productivity gap between agriculture and non-agriculture sectors is quite high. In 2015, an agricultural worker produced around one-third of what is produced by workers in other sectors.
- **Poverty is a rural phenomenon across the region.** Two-thirds of the rural population is impoverished. Urban poverty is also notable, up to 20 percent in some urban centres.
- **Conflict affects several countries in the region.** Five out of 19 NENA countries are currently affected by conflict, which has a huge impact on livelihoods, food security, natural resource degradation and infrastructure, including tensions over water resources.
- **The NENA region hosts more than 40 million international migrants.** Almost 14 million migrants are intraregional, of whom more than 2 million are intraregional refugees. Jordan and Lebanon are among the top 10 countries in the world for hosting refugees.
- **The COVID-19 pandemic has impacted food security,** exacerbating inefficiencies. Increased food prices were recorded in 2020 (up to 167 percent). COVID-19-related hygiene measures have placed additional pressure on water resources for domestic use.
- **Climate change vulnerability is high, but does not yet receive adequate attention.** NENA is the most arid region in the world. Projections under the most severe scenario show a temperature increase of 2.6 °C by the end of the century, with some parts of the region reaching up to 5 °C. Despite projections for farming systems, climate change receives low recognition as a high-impact risk in the region.
- **Agricultural sector investment within NENA countries is low.** Agriculture remains an important pillar for economic development in many countries. Some have acquired land for agricultural use in other countries, with one NENA member state emerging as the region's most targeted country for land investments, both in terms of total area and number of agricultural land deals.
- **Political instability, conflicts, lack of cross-sectoral collaboration, poor governance and low public investment in agriculture are challenges.** Integrated policies are needed to revive local economies, support natural resource management and achieve food security.
- **International processes are stimulating interest in agriculture.** But much more action is required to promote sustainable resilient agriculture and natural resource management.

Introduction

The Near East and North Africa is the birthplace of some of the most ancient agricultural civilizations. Starting with the Sumers in Mesopotamia and the populations of ancient Egypt, these civilizations have developed rich food systems patterns based on crops and livestock, and refined food preparation and preservation, in a diverse environmental patchwork that includes coasts, lowlands, high mountains, inland plateaus, deserts, fertile plains and woodlands (Miller and Wetterstrom, 2000). Yet NENA, being one of the most land- and water-scarce regions worldwide, presents several agricultural constraints, which hinder food security and food self-sufficiency. The gap between production and consumption is currently growing. High population growth rates and rapid urbanization put pressure on limited natural resources. The fragile resource base in terms of water and arable land, coupled with changes in dietary habits and food security policies that favour low-value crops, have implications for both the agriculture sector and the environment. Countries rely heavily on imports to cover food deficits. With the outbreak of COVID-19, the need for local markets (rather than reliance on imports) has been intensified. Political instability and conflicts are exacerbating the challenges, along with poor governance, lack of cross-sectoral collaboration and low public investments in agriculture. Climate change is triggering changes in land and water use. Projections indicate that the region is among the most vulnerable in the world. It can expect increasing occurrences of drought and heatwaves, unpredictable precipitation and a reduction in water resources, with sea level rise affecting deltas and coastal areas.

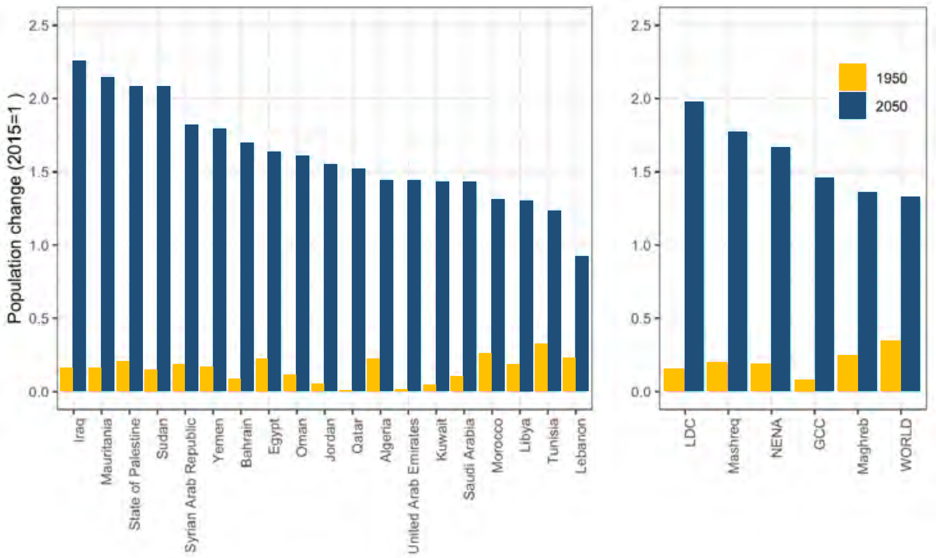
This chapter presents the socioeconomic drivers of land and water use in the NENA region, including population growth, urbanization, poverty, migration and climate change. Section 2.2 outlines how reductions in national agriculture-related investments have left the region less able to deal with climate change and unexpected events that arise, such as the COVID-19 outbreak. This section also discusses scenarios for future agricultural production. The final section outlines important global agendas and how they can direct land and water use in the NENA region.

2.1 The socioeconomic drivers

2.1.1 Population growth

The NENA region has experienced a demographic surge. From 1950 to 2020 the regional population grew sixfold, compared with a threefold increase worldwide. The current average annual growth rate (2 percent from 2015–2020) is almost double the global average (1.1 percent). By 2020, the region had almost 420 million (418 628 000) inhabitants. Of the 19 countries included in the NENA region, 7 had populations that exceeded 20 million. Egypt is the most populated country in NENA, while Bahrain is the least, although it is the most densely populated (UNDESA, 2019). Figure 2.1 indicates the relative population growth rate in the region and predictions up to 2050.

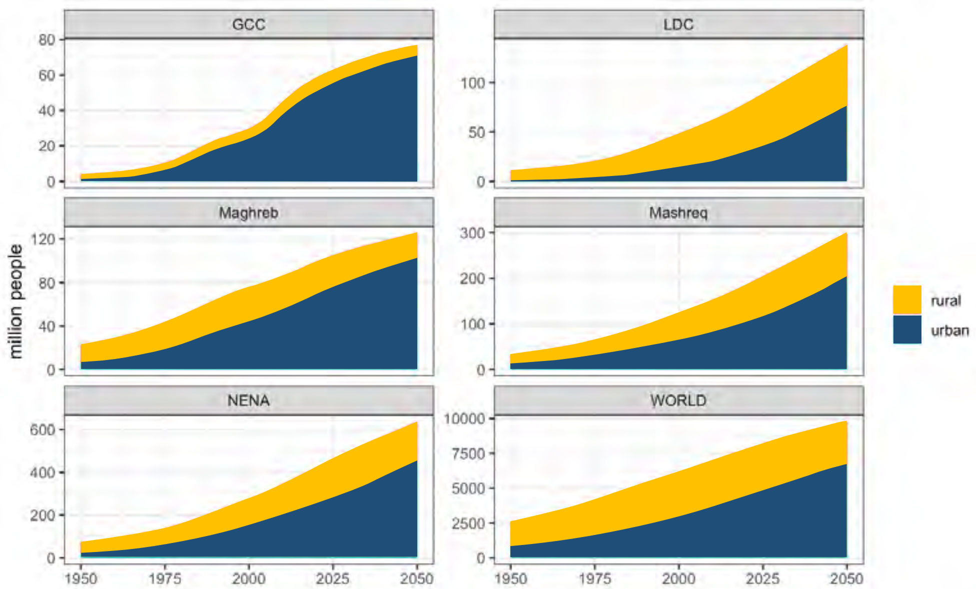
FIGURE 2.1 RELATIVE CHANGES IN POPULATION GROWTH 1950–2015 AND 2015–2050, INDEXED, 2015 =1



Source: United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2019. *World Population Prospects 2019,* online edition. Rev. 1, https://population.un.org/wpp/Download/Standard/Population/

By 2030 the NENA region is expected to have about 77 million more people than in 2020. By 2050, the region is predicted to reach an overall population of more than 633 million. While absolute numbers will rise between now and 2050 in both rural and urban areas (see Figure 2.2), the region's population growth rates are expected to level off by that date.

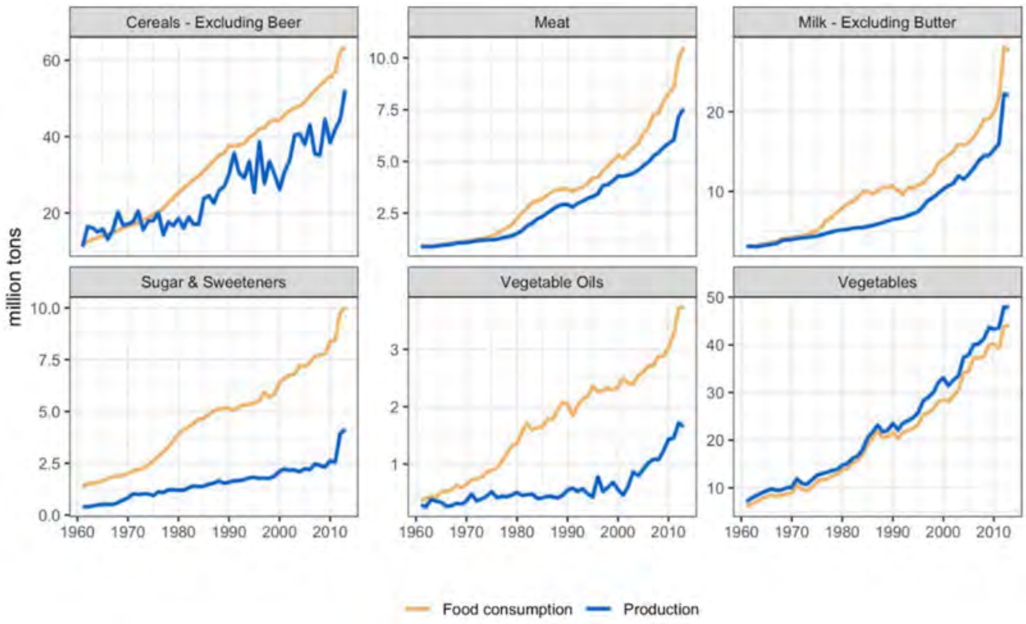
FIGURE 2.2 URBAN AND RURAL POPULATION TRENDS IN THE NENA REGION (MILLION PEOPLE)



Source: United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2019. *World Population Prospects 2019, online edition.* Rev. 1, https://population.un.org/wpp/Download/Standard/Population/

Pressure on scarce resources: Population growth, together with contemporary consumption patterns, place additional pressures on already scarce land and water resources, and on food demand in the region. NENA is the largest global importer of cereals and a significant importer of meats and fish, vegetable oils, oilseeds, and sugar and sweeteners (OECD-FAO, 2018). By 2019, the region was receiving about one-third of all international shipments of cereals, sheep meat and whole grains, and about one-fifth of sugar, poultry meat and skimmed milk. The region accounts for 40 percent of global cereal imports. NENA faces serious constraints in terms of arable land. A major challenge is to increase food production and productivity, while sustainably using scarce natural resources. Food production is not expected to keep pace with growing consumption (Borgomeo and Santos, 2019). Figure 2.3 illustrates that during a 50-year period (1960–2010), the production-consumption gap increased over time, especially for sugar, vegetable oil and cereals.

FIGURE 2.3 TRENDS IN PRODUCTION AND CONSUMPTION OF SELECTED FOOD ITEMS IN THE NENA REGION



Source: FAOSTAT, 2020.

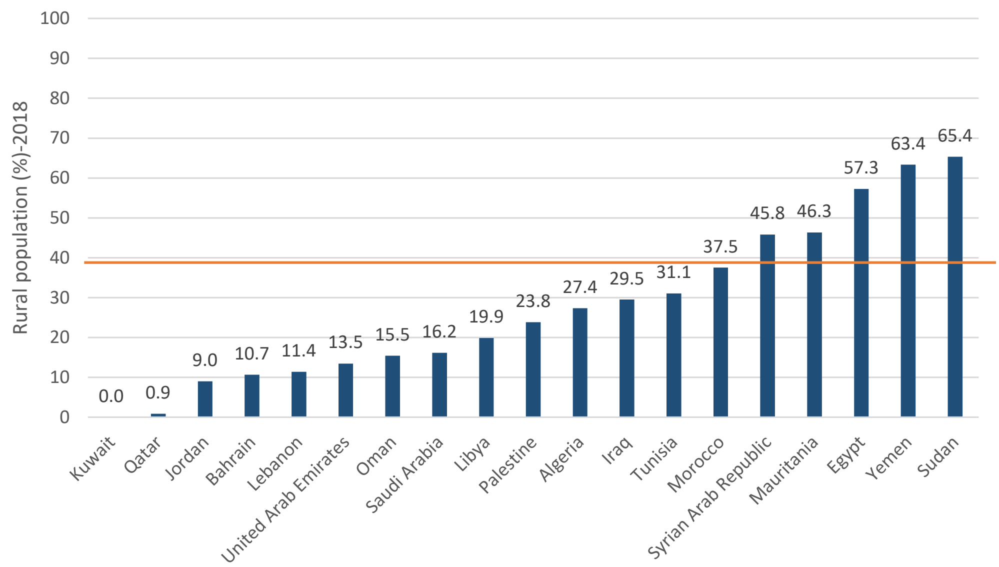
Food preference shifts: In the foreseeable future, the population is likely to be mainly concentrated in urban areas, as rural populations continue to migrate to cities (Mirkin, 2013). In general, urban consumers tend to shift their preferences to prepared and processed foods. In addition to this trend, high-income populations consume more animal-based and nutrient-rich foods, while micronutrient-poor and processed foods are consumed by low-income groups. More specifically, in the Gulf countries, the share of meat, fish and dairy in diets is expected to reach 15 percent by 2027, while rice consumption is forecast to increase, particularly among Asians. The consumption of other oil- and sugar-based products will continue to increase their share of the regional dietary mix (OECD-FAO, 2018).

2.1.2 Urbanization

Urbanization is rapidly increasing in the NENA region. In 1950, only two cities of the region had a population above 1 million people, whereas this number is expected to apply to 39 cities by 2025 and 48 by 2035 (UN-Habitat, 2020a; UNDESA, 2018). Large cities are mainly in coastal areas or along rivers. Urban expansion has generally occurred at the expense of productive soils along rivers and coastal areas (Woertz, 2019; Ward, 2016; Borgomeo and Santos, 2019; ESCWA, 2017; FAO, 2018c), and hence has implications for land and water, in some cases substantially impacting agriculture. Within 30 years, more than 70 percent of the region's population is expected to live in urban areas (UNDESA, 2018).

In parallel, the NENA region's rural population, as a percentage of the total population, has been declining steadily over the past 50 years, dropping from just over 60 percent in 1970 to 40.6 percent in 2018, which was less than the global figure of 44.7 percent (UNDESA, 2018). This percentage varies widely among countries, ranging from less than 1 percent in Kuwait and Qatar to 65 percent in Sudan. In the Maghreb countries, the rural population as a percentage of the total population is still relatively high, with Morocco approaching 38 percent, while in Mashreq countries such as Lebanon and Jordan, the percentage is around 10 percent. Countries with a higher than 50 percent rural population include Egypt, Yemen and Sudan, as demonstrated in Figure 2.4, with the regional average indicated as 40.6 percent (UNDESA, 2018).

FIGURE 2.4 RURAL POPULATION IN NENA COUNTRIES AS A PERCENTAGE OF THE TOTAL POPULATION



Source: United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2018. *World Urbanization Prospects: The 2018 revision, online edition.* https://population.un.org/wup/Download/

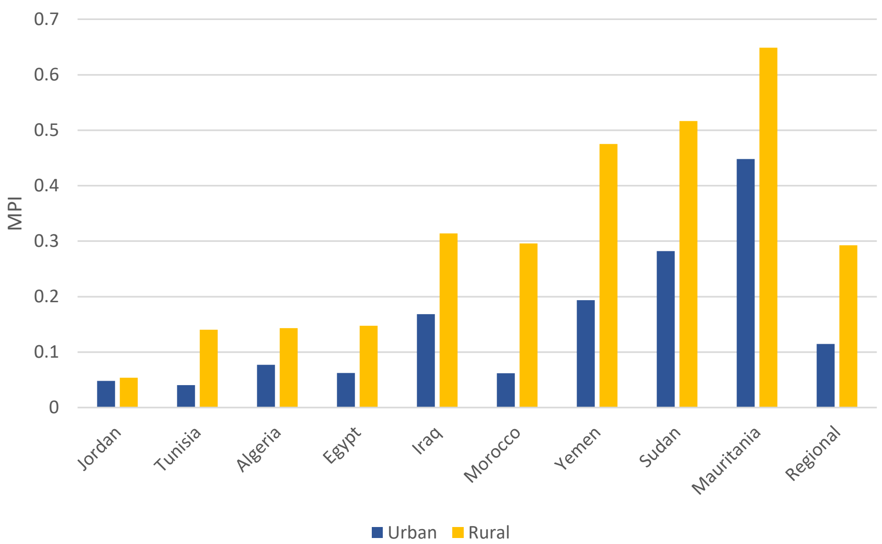
Urban population implications: A larger and growing urban population will present both opportunities and challenges for the agriculture sector. Inevitably, food trade will increase, food purchases will rise steeply, and the food consumption mix will become more complex and of higher value. Stronger demand for high-value foods and fresh products presents an opportunity for the region's agriculture sector, but also challenges for governments, as countries increase their dependency on the import of major food commodities. Seizing these opportunities is difficult in a land- and water-scarce region. The small percentage of arable land per capita in the region, together with high levels of poverty and tenure issues in rural areas, have led to increased geographic mobility to urban centres, resulting in rural land abandonment. Growing urbanization exerts enormous pressure on land and water resources in cities and towns. Other challenges include inadequate land policies that are exacerbating urban sprawl, unequal access to land and property, and unsustainable waste management and water consumption. Urban developments in NENA countries are often unplanned. Settlements, infrastructure and industries set up in urban and peri-urban areas require land resources, often at the expense of productive land and natural ecosystems. Infrastructure development to cater for urban populations results in land-use changes, by displacing productive land uses (UNCCD, 2017).

In an area with intense water stress, agriculture is the main water user, but now there is increased demand and competition from other sectors such as industry, tourism and domestic water supply. As outlined further in Chapter 6, urbanization also affects the water cycle processes and water quality. Sealed urban setting surfaces reduce the amount of water that infiltrates the ground, often leading to floods.

2.1.3 Economic growth and poverty

Poverty: Poverty in NENA is concentrated mainly in rural areas, where more than 40 percent of the population is considered poor. In some rural areas, livelihoods are only partially dependent on agriculture. Farmers who do not have other forms of income are among the most food insecure (Hamadeh *et al.*, 2014). Figure 2.5 shows the difference between poverty in rural and urban areas in nine selected NENA countries using a Multidimensional Poverty Index.

FIGURE 2.5 MULTIDIMENSIONAL POVERTY INDEX (MPI) IN URBAN AND RURAL AREAS IN SELECTED COUNTRIES



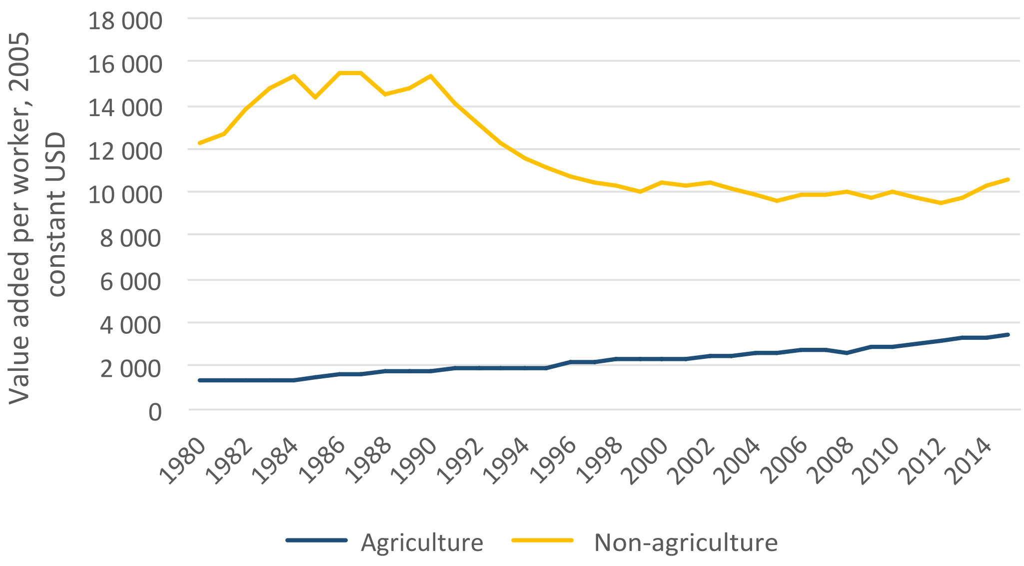
Source: United Nations Economic and Social Commission for Western Asia (ESCWA), United Nations Children's Fund, Oxford Poverty and Human Development Initiative & League of Arab States. 2017c. *Arab Multidimensional Poverty Report.* www.unescwa.org/sites/www.unescwa.org/files/publications/files/multidimensional-arab-poverty-report-english.pdf

The GDP per capita in NENA varies greatly among countries. In 2019, it ranged from USD 442 and USD 774 in Sudan and Yemen, respectively, to more than USD 30 000 in Kuwait, Qatar and United Arab Emirates. According to World Bank indicators, the average GDP per capita in GCC countries is USD 33 000, USD 4 545 in Maghreb, and USD 3 408 in the rest of the region (excluding the Syrian Arab Republic and Palestine, which do not have data for 2019) (World Bank, 2019). Estimates show that about 116 million Arabs (40.6 percent) are multidimensionally poor out of the 286 million people in the 10 countries analysed[16] (ESCWA *et al.*, 2017c), with more than 65 million people living in acute multidimensional poverty (OPHI, 2018).[17]

Unemployment: Unemployment rates across the NENA region are relatively high, and particularly acute in rural areas and among youth. Rural unemployment already averages 13 percent across the region and nearly 15 million additional jobs will be needed in the next decade to match population growth. Youth unemployment ranges between 26 and 53 percent, depending on the country, and has been above 25 percent for the past 20 years (Borgomeo and Santos, 2019). High youth unemployment rates, low wages and high poverty levels in rural areas, natural resource limitations and conflicts are major forces behind rural-to-urban youth migration.

Contribution of agriculture to GDP: Although more than 40 percent of the population is rural and agriculture is the primary occupation in rural settings (and provides 38 percent of jobs to the economically active population as a whole), the agriculture sector accounts for only 13 percent of GDP (FAO, 2019b). In 2015, an agricultural worker produced USD 3 400 worth of products – about one-third of that produced by workers across other sectors (see Figure 2.6).

FIGURE 2.6 PRODUCTIVITY GAP BETWEEN AGRICULTURE AND NON-AGRICULTURE SECTORS



Source: FAO. 2019d. *Rural transformation – Key for sustainable development in the Near East and North Africa.* Overview of Food Security and Nutrition 2018. Cairo.

[16] The Arab countries analysed in the report are: Algeria, Comoros, Egypt, Iraq, Jordan, Morocco, Mauritania, Sudan, Tunisia and Yemen.

[17] This analysis includes Sudan, Palestine, Jordan, Libya, Tunisia, Djibouti, Algeria, the Syrian Arab Republic, Egypt, Iraq, Morocco, Somalia and Yemen. Djibouti and Somalia are not covered in this report, even though they are sometimes included in statistics for Arab countries.

2.1.4 Conflicts and crises

The NENA region experiences ongoing conflicts and tensions related to both natural and human-induced issues. At present, more than one-quarter of the region's countries are affected by conflict, affecting 33 percent of NENA's population. Recognition of the resource challenges related to living in arid areas may contribute to a better understanding of some underlying causes of conflicts.

Consequences of conflict for food security and water: The impacts of conflict are grave for all, but particularly destructive for agriculture and resource management. Consequences include land abandonment, natural resource degradation, infrastructure decline, and an increase in poverty and hunger. In addition to being the main cause of migration, ongoing conflicts worsen hunger, food insecurity and malnutrition (for example, in Libya and the Syrian Arab Republic). Countries in conflict have five times more hungry and malnourished people than countries that are at peace (27.7 percent of the population versus 5.4 percent). NENA countries in conflict have a rate of undernourishment that is twice as high as that of developing countries (FAO *et al.*, 2020). The impacts of past and/or ongoing conflicts in Iraq, Kuwait, Libya, Sudan, the Syrian Arab Republic and Yemen (along with water scarcity, climate change, declining production of staple food crops, population growth and unemployment) are likely to drive further competition for limited resources, and an overall deterioration of livelihoods. With conflict, people flee their location. As a consequence, countries that are hosting refugees in the region (such as Jordan and Lebanon) are experiencing substantial pressure on their natural resources, including land and water.

Tensions have also long existed in the region in relation to managing transboundary water resources (both rivers and aquifers) (see Chapter 3). Such management is delicate and exacerbated by water scarcity and strong demand in all countries from agriculture and other sectors. Disputes also occur among farmers at community level when water flows are diverted, with early interventions required to avoid escalation.

BOX 2.1 FAO WATER REHABILITATION INITIATIVES

FAO has implemented projects in West Bank and Yemen, where irrigation systems have been rehabilitated to benefit local farmers. In West Bank, 32 water conveyance systems were rehabilitated, providing employment opportunities for 2 000 agricultural workers, and improving the efficiency of 147.6 km of water piping (FAO, 2018d). In Yemen, irrigation channels were restored, benefiting many farmers, with women participating in a water user association for the first time (FAO, 2018d; IOM, 2019). Yemen's water infrastructure has been heavily damaged by conflict and rendered dysfunctional due to lack of maintenance and high operational costs (mainly fuel prices). This has negatively affected agriculture and led to limited access to clean water, thereby hindering good hygiene practices and exacerbating health risks. In 2017, the country experienced the largest outbreak of cholera ever recorded in modern history.

Source: FAO. 2018d. *Supporting efficient irrigation systems in the West Bank.* www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1148985/ & IOM. 2019. *Decades-old conflict over water in Yemeni village comes to an end.* [online]. [Cited 15 December 2021]. www.iom.int/news/decades-old-conflict-over-water-yemeni-village-comes-end

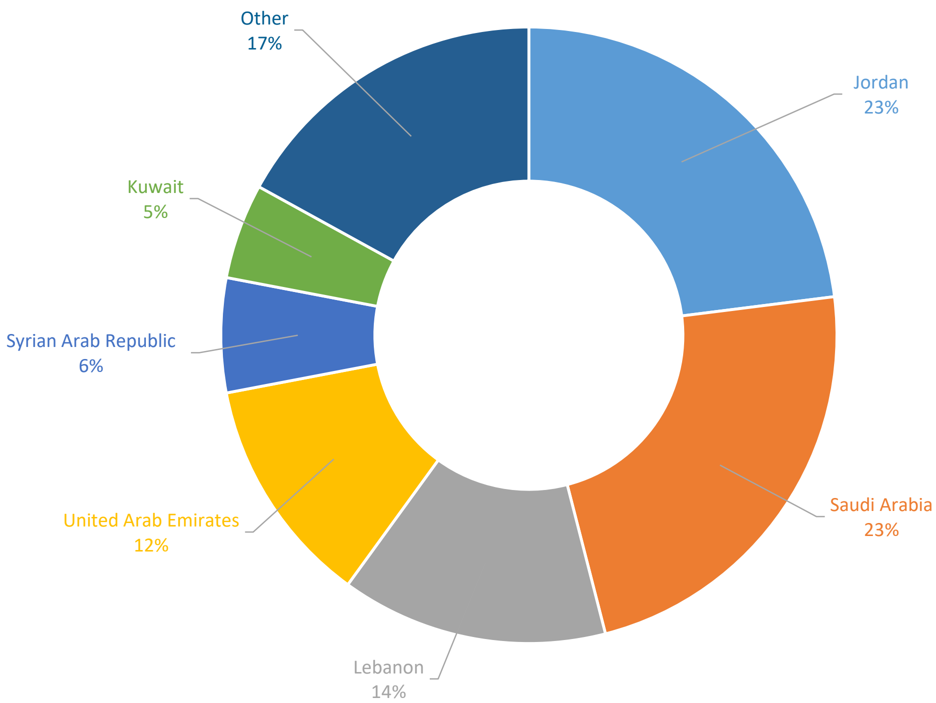
2.1.5 Migration

Historically, the movement of people has always taken place across the NENA region. Rural and urban transformations have caused increased migration flows and displacement in NENA. Recent large-scale migratory outflows from the region are driven mostly by war and conflict, although unemployment, increased rural-urban disparities and environmental pressures are also key triggers.

Categorizing those on the move: The NENA region hosts more than 40 million international migrants – accounting for some 15 percent of international migrants worldwide. Of these, 13.8 million are intraregional, meaning that they moved from one NENA country to another (UNDESA, 2019), of whom 2.2 million are intraregional refugees (as well as many others seeking asylum). In 2020, more than 14.5 million people were internally displaced (UNHCR, 2020a; IDMC, 2020), and 7.9 million refugees fled the region (UNHCR, 2020a). From the Syrian Arab Republic alone, approximately 6.6 million people fled to other countries, including about 2 million people who went to other NENA countries (UNHCR, 2020a).

Host countries: In 2020, the top three NENA host countries for intraregional migrants were Saudi Arabia (3.4 million), Jordan (3.3 million) and Lebanon (1.7 million) (see Figure 2.7). The top three NENA countries hosting intraregional refugees were Lebanon (889 522), Jordan (696 433) and Iraq (253 369). Around 13 percent of the current population in Lebanon and about 7 percent in Jordan are refugees (UNHCR, 2020a; UNDESA, 2019). The consequences of such movements of people are that host governments must address food needs (as well as other services) for the additional population. This translates into the need for more land and water (real and/or virtual).

FIGURE 2.7 INTRA-REGIONAL MIGRANT STOCK (2017)



Source: Wenger, C. & Abulfotuh, D. 2019. *Rural migration in the Near East and North Africa* – regional trends. Cairo, FAO. Licence: CC BY-NC-SA 3.0 IGO

Resource depletion driving movement of people: Aside from conflict, migration can also be triggered by land and water resource limitations, reductions in land productivity and recurrent drought cycles, possibly induced by climate change and unprecedented natural disasters. Water scarcity is expected to impact 80–100 million people in the region by 2025, while land degradation and desertification will also accelerate migration, as confirmed by many studies (IPBES, 2018b). Land degradation not only causes migration, but migration causes or exacerbates land degradation (IPBES, 2018b; ELD and UNEP, 2018).

Climate change and migration: People move to urban areas in search of employment opportunities, but also due to environmental degradation as a result of climate change, and a subsequent decline in agricultural production. A study of 5 countries in NENA estimated that 10 to 20 percent of migration occurs due to climate events (Wenger and Abulfotuh, 2019). As rural conditions worsen, the region can expect to see a major influx of rural migrants to urban areas (Waha *et al.*, 2017).

- In Algeria, for example, there has been continuous migration from rural to mid-sized cities due to water scarcity and general desertification processes (Gubert and Nordman, 2010).
- Shocks resulting from droughts in Iraq, the Syrian Arab Republic and Yemen are thought to have escalated fragile conditions (Sadoff *et al.*, 2017), leading to migration.
- As such, climate should be seen as a driver that multiplies existing risks and aggravates institutional fragilities, conflict and displacement (Borgomeo *et al.*, 2020). Section 2.3 outlines further consequences of climate change as a driver of land and water use in the NENA region.

2.1.6 COVID-19

When the COVID-19 pandemic struck in early 2020, many NENA countries were already facing food insecurity and malnutrition, with ongoing challenges with regard to water and sanitation in both urban and rural areas. Challenges triggered by COVID-19 include reduced input availability, higher transaction costs along the value chain, economic downturn linked to lower purchasing power and lower demand in local markets, lower demand in export destination markets, changing consumption patterns and, in the region's more fragile countries, unhealthy coping mechanisms at household level, leading to reduced diet diversity and food intake. These challenges are most acutely felt by small-scale family farmers, agrifood small and medium enterprises, rural women and youth. Macroeconomic losses had reached 7.5 percent of Middle East and North Africa's total GDP by December 2020 (World Bank, 2021). The long-term effects of economic contraction and unemployment, rising food prices, and the societal consequences of how COVID-19 will affect interconnected water-food systems in the region are still uncertain.

Immediate effects of COVID-19 have been food prices rising by 20 percent in most countries in the region (World Bank, 2021). In October 2020, Sudan, the Syrian Arab Republic and Lebanon recorded the highest increase in the cost of the food basket since January 2020 (167, 135 and 116 percent, respectively), while Libya recorded an increase of 21 percent (WFP, 2020). The dependency of countries on imports makes them vulnerable to international commodity market fluctuations. This was already evident in 2020 during the first wave of the pandemic. Initial reports, (December 2020), which looked at Lebanon, Libya, Sudan, the Syrian Arab Republic and Yemen concluded that food systems in NENA were at that time withstanding the effects of the COVID-19 health and economic crisis (WFP, 2020). However, evidence shows that agrifood systems in all countries of the region have been affected by COVID-19, but in different ways, depending on the country's economic status and the level of employment provided by agriculture (NERC, 2020).

It is also known that COVID-19 exacerbates existing challenges, such as protracted conflicts, the threat and presence of desert locusts, flooding, social unrest and economic downturn.

2.2 Climate change

Climate change is a driver of land-use and water-use change. Changes in climatic patterns adversely affect livelihoods by impacting natural resources, as well as financial and social capital. The poor are disproportionately affected, as well as those living in conflict-prone areas (UNGA, 2019). Climate change disproportionately affects the production and income of smallholders. This is especially significant in the NENA region, where poverty rates are highest in rural areas and where several countries are experiencing conflict. The NENA region is particularly vulnerable to climate change due to its limited and degraded natural resources and low adaptive capacity. Nonetheless, respondents of an Executive Opinion Survey in the Middle East and North Africa did not consider climate change as among the biggest threats (WEF, 2019). Chapter 5 presents climate change impacts in the NENA region in detail, with some key points outlined below.

2.2.1 Temperature increase

The NENA region is expected to be one of the hotspots for increased extreme heat, drought and aridity. Climate projections included in the 2017 report of the United Nations Economic and Social Commission for Western Asia (ESCWA) show that under a moderate scenario, temperatures will increase by 1.2 °C to 1.9 °C by mid-century (2046–2065), while under a more severe scenario, the temperature increase would be 1.7 °C to 2.6 °C (ESCWA *et al.*, 2017a). These data, coupled with projections of decreasing rainfall, indicate that water scarcity will be exacerbated, with agricultural production reduced.

2.2.2 Drought and its impact

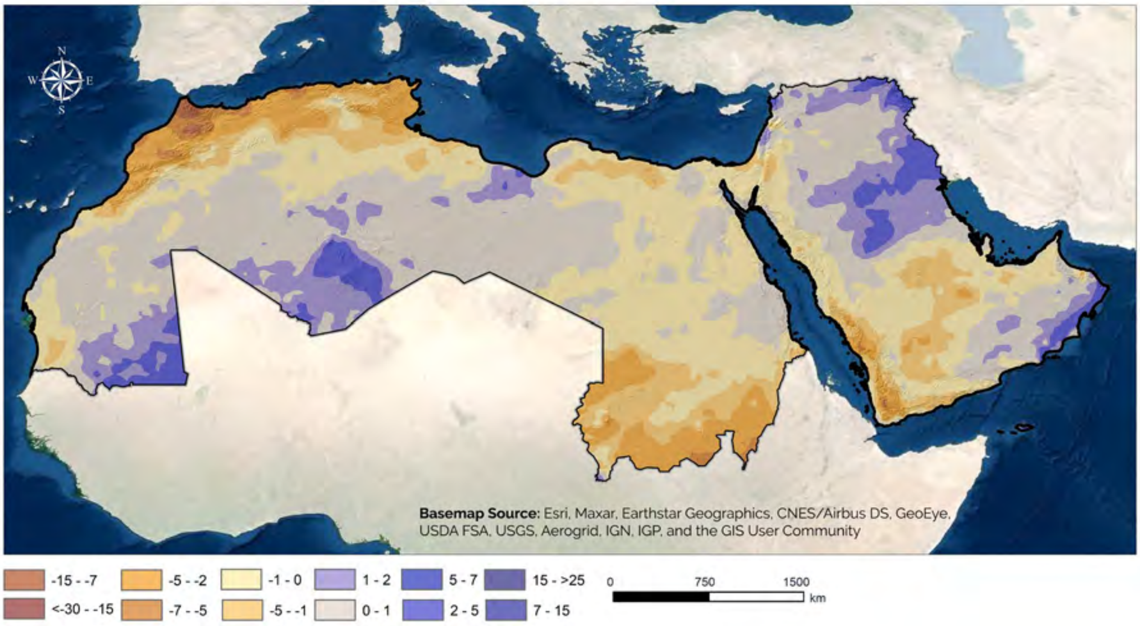
As indicated in Chapter 1, the NENA region is particularly vulnerable to water scarcity, which will be aggravated by climate change. The region is the most arid in the world and will become even drier. Annual rainfall varies between 0 mm and 650 mm. Countries have an annual average rainfall within a 160 and 400 mm range, although rainfall can exceed 900 mm in some areas (ESCWA, 2017c). By 2050, drought frequency is expected to increase by 20 to 60 percent, and by the end of the century annual rainfall is expected to decrease by between 8 to 10 mm, with large variations across the region and across seasons. For example:

Stronger precipitation changes are projected for countries along the Mediterranean coast for the winter months and could decrease as much as 40 percent in the Moroccan Highlands. Under increasingly hot and dry conditions, water recharge and water availability will decrease, while water demand for plants and animals will increase (ESCWA, 2017).

In the Jordan River area, general precipitation decreases would lead to reductions in river flow and available water of up to 44 percent (Givati *et al.*, 2019).

Figure 2.8 indicates the change in annual mean precipitation in NENA under the intermediate future scenario. Reduced water availability will further complicate the management of shared water resources (ESCWA, 2017; ESCWA, 2017b; Borgomeo and Santos, 2019).

FIGURE 2.8 CHANGE IN ANNUAL MEAN PRECIPITATION: RCP4.5 (2046–2065) (MM/MONTH)



Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017b. The regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socioeconomic Vulnerability in the Arab region (RICCAR), regional knowledge hub data portal. [online]. [Cited 15 December 2021]. https://rkh.apps.fao.org/home/1

2.2.3 Extreme events

The NENA region will experience further occurrence of extreme events and flash floods. For instance, as global temperatures rise, extreme flows and floods are estimated to become more common along the Nile (Paltan *et al.*, 2018). More frequent floods will lead to severe damage of key agricultural infrastructure, shifting groundwater recharge patterns, and losses in the soil capacity to absorb water (World Bank, 2017a). Indeed, since 1970 floods in the region have already caused more than 10 000 fatalities and annual economic losses of USD 200 million (Borgomeo *et al.*, 2020). Countries that are already experiencing conflict (Sudan and Yemen) are most affected due to their low adaptive capacities.

2.2.4 Impacts and projections

The regional spread of aridity is likely to result in the deterioration of about one-third of arable lands (Waha *et al.*, 2017). Low crop yields are expected to decline a further 21 percent by 2080 (ESCWA, 2017). Although climate change affects all farming systems across the region, rainfed systems and dryland pastoral systems will be especially affected (see Table 1.1). Pastoral activities will be severely affected by desertification and reductions in carrying capacities. Irrigated farming systems will suffer from more water stress, reduction in cropping intensities, and reduced yields as a result. Fisheries and aquaculture will also suffer from increased water temperatures, flood, drought, storms and extreme weather events. While agriculture will suffer from the impacts of climate change, the sector also contributes to global greenhouse gas (GHG) emissions. Globally, Agriculture, Forests, and Other Land Uses (AFOLU) represent 24 percent of total GHG emissions (IPCC, 2014). Policies, technologies, investments and actions should aim to foster the co-benefits of mitigation and adaptation.

Currently, the NENA region's arable land is unable to satisfy the increasing food demands. To understand how the future of agriculture is expected to develop in the region, FAO drew up three different scenarios i) Business as Usual (BAU), ii) Towards Sustainability (TSS), and iii) Stratified Societies Scenario (SSS).[18] Results for selected indicators in 2050 were compared (FAO, 2018b). In conclusion, FAO estimates that by 2050, NENA may be the only region where harvested areas, under both irrigated and rainfed systems, will shrink. Projections also show reduction in yields for vegetables, wheat and potatoes due to climate change (FAO, 2018b). Clearly some form of transformative action and investment in the agriculture sector is required.

2.3 Trends in agricultural investments

Given the challenges that the NENA region faces, agricultural investment that takes into account the sustainability of agricultural production systems and productivity is increasingly important. Ideally, investments in the agriculture sector should ensure a strong focus on reducing the variability of agricultural production, as well as on securing a stable income for farmers, especially smallholders and those relying on rainfed agriculture.

2.3.1 Public and private investment

The agriculture sector is generally not sufficiently represented in national priorities in NENA countries, with few of them investing adequately. Private sector participation in the sector is extremely low. The Agriculture Orientation Index (AOI) is how Sustainable Development Goal (SDG) 2.a.1 is measured (see Figure 2.10).[19] Where AOI is greater than 1 (>), it indicates a higher orientation of government expenditure. The NENA region is in the bottom 25 percent of countries for the AOI indicator. The agricultural share of government expenditure for countries reporting AOI in 2018 ranged from 0.02 percent in United Arab Emirates to 2.48 percent in Sudan (see Figure 2.9).

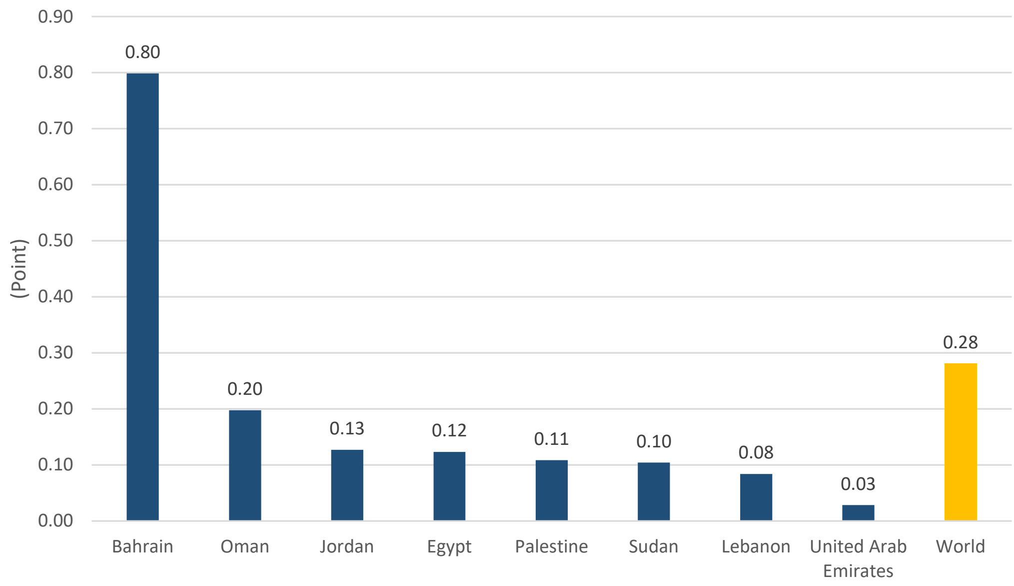
2 ZERO HUNGER

SDG 2.a.1 concerns the Agriculture Orientation Index for Government Expenditures. **Target 2.a** is to increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks, in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.

[18] The BAU scenario shows the status of several issues and challenges if the agriculture sector continues to function as usual. The TSS scenario presents how the future may progress, considering transformative changes towards sustainable development. The SSS scenario foresees a future with negative outcomes and increased inequalities between countries.

[19] The AOI for Government Expenditures is defined as the Agriculture Share of Government Expenditures, divided by the Agriculture Share of GDP, where Agriculture refers to the agriculture, forestry, fishing and hunting sector. The measure is a currency-free index, calculated as the ratio of these two shares. National governments are requested to compile Government Expenditures according to the international Classification of Functions of Government codes, and Agriculture Share of GDP according to the System of National Accounts.

FIGURE 2.9 AGRICULTURE ORIENTATION INDEX (AOI) FOR GOVERNMENT EXPENDITURES, ARAB WORLD, 2018

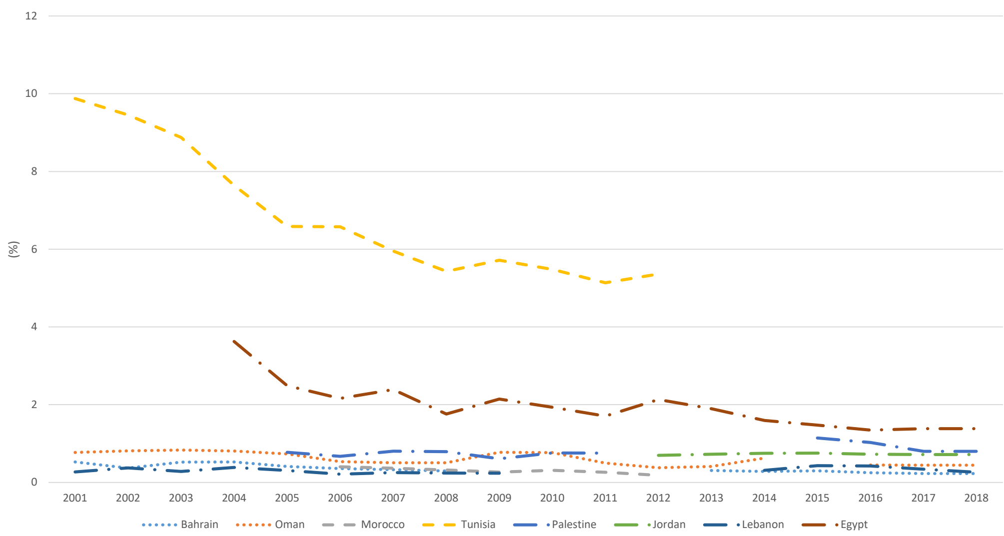


Source: FAO. *Sustainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

The share of government expenditure on agriculture actually declined at the start of the third millennium (during the period 2001-2018), as indicated in Figure 2.10. Taking two country examples from Figure 2.10, government expenditure on agriculture declined in Egypt from 3.6 percent in 2004 to 1.4 percent in 2018. In Tunisia, it fell from 9.9 percent in 2001 to 5.4 percent in 2012. However, agriculture has and continues to play an important role in the economic development of both countries, contributing around 11 percent of GDP (World Bank, 2018). Both Tunisia and Egypt have evolved, with diverse economies (Kassim *et al.*, 2018) and other sectors growing faster than agriculture. When the role of agriculture as a central pillar of the economy waned, public spending and institutional capacities to respond to the growing challenges and opportunities in the agriculture sector also declined.

© FAO/ Sheam Kaheel

FIGURE 2.10 AGRICULTURE SHARE OF GOVERNMENT EXPENDITURE, SUBREGIONAL COMPARISONS, ARAB WORLD, (2001–2018)



Source: FAO. *Sustainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

2.3.2 Data on land deals

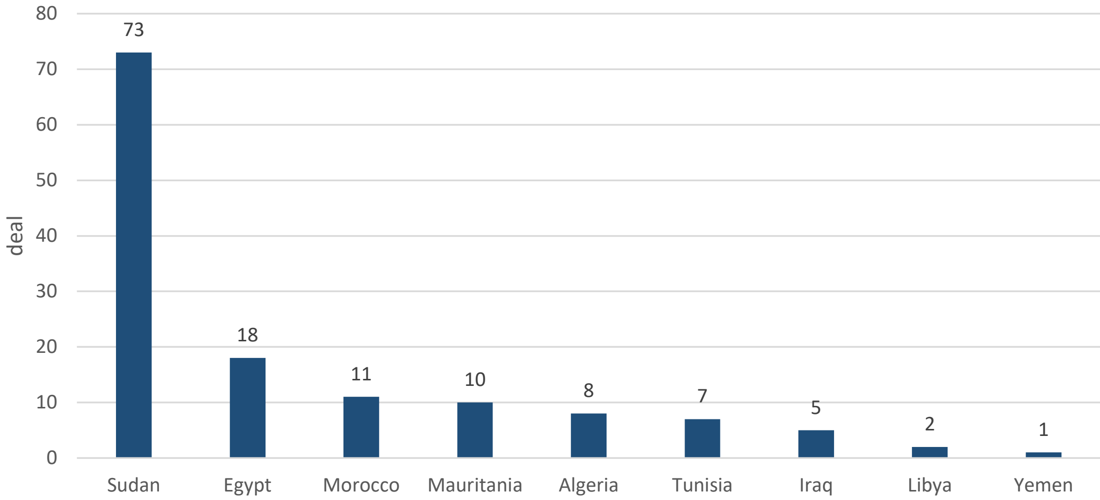
With demand for agricultural produce growing, there has been substantial interest from governments, state-owned enterprises and the private sector in investing in foreign land acquisition for agricultural use. Investment and acquisitions are gaining traction from water-scarce countries, with access to water being a key driver for investments. According to Bailey (2011):

> *Middle Eastern states are among the biggest land investors in Africa driven not by a lack of land but a lack of water.*

Indeed, water is considered a crucial factor in deciding the location for agricultural investments, which are focused around transboundary river basin areas such as the Nile (Anseeuw *et al.*, 2012). As explained in section 4.2.3., better governance for such deals may be required. It has been estimated that in 2019, 1 980 deals with foreign investors were concluded at global level, covering more than 50 million ha of land (Rose, 2019). In NENA, several countries have targeted other countries for land deals in the Arab region and in Africa. Countries that have invested include Bahrain, Egypt, Jordan, Kuwait, Libya, Qatar, Saudi Arabia and United Arab Emirates (AFED, 2014). The most targeted country in the region in terms of land investments during the period 2000–2020 was Sudan, with 73 agricultural land deals,[20] followed by Egypt and Morocco, with 18 and 11 deals, respectively (see Figure 2.11). Examining the area covered in terms of agricultural land deals, (between 2000–2015) Sudan again ranks first, with more than 7 million ha. Morocco is a long way behind, at around 723 000 ha and Egypt stands at approximately 440 000 ha (Land Matrix Initiative, 2021).

[20] According to the Land Matrix Initiative, a "deal is referred to as an intended, concluded or failed attempt to acquire at least 200 hectares of land through purchase, lease or concession".

FIGURE 2.11 NUMBER OF AGRICULTURAL DEALS FOR THE PERIOD 2000–2020



Source: Land Matrix Initiative. Land Matrix Public Database on Land Deals [online]. [Cited 15 December 2021]. https://landmatrix.org/list/deals

2.4 Global agendas of relevance to agriculture

Current food and agricultural systems are stretching boundaries in the NENA region and beyond. Natural resources such as land and water are needed for production, but must be sustained without further degrading the landscape. Food must be produced under climate change and extreme weather events. Evidently a profound change in the current food and agriculture system is needed to reflect key global agendas. The 2021 Food Systems Summit gave rise to a series of multistakeholder commitments to transform the world's food systems. Many NENA actors participated, discussing options to transform the region's food systems. Some of the important global agendas are summarized below.

2.4.1 The 2030 Agenda and the Sustainable Development Goals

The 2030 Agenda offers an ambitious framework within which to transform the world's agriculture and food systems. Out of the 17 Sustainable Development Goals and 169 targets, several SDGs are directly or indirectly linked to food security and natural resource management. For example:

- **SDG 2:** ending hunger and achieving sustainable agriculture
- **SDG 6:** protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
- **SDG 13:** combating climate change and its impacts
- **SDG 14:** conserving sustainable marine ecosystems
- **SDG 15:** protecting and restoring terrestrial ecosystems and promoting sustainable use of land.

Transforming agrifood systems (the way we produce, process, distribute and consume food) has been identified as one of the pathways to achieving many targets of the 2030 Agenda. Action within agricultural food systems can advance, impede or undermine progress toward other SDG targets.

2.4.2 Land degradation neutrality

At the Rio+20 Summit in 2012, world leaders committed to achieving a land degradation-neutral world. Land degradation neutrality (LDN) is defined as:

> *A state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specific temporal and spatial scales and ecosystems.*
>
> *(UNCCD, 2016).*

To maintain or enhance the land resource base, the United Nations Convention to Combat Desertification (UNCCD) and others stress that it is important to have national baselines and targets, and to monitor progress (Akhtar-Schuster *et al.*, 2017; Orr *et al.*, 2017; Liniger *et al.*, 2018).[21]

2.4.3 Paris Agreement on Climate Change

The Paris Agreement is an international treaty on climate change, adopted in 2015. With the adoption of the Paris Agreement, signatory countries have agreed to act on climate change mitigation, as well as to implement adaptation actions to reduce vulnerability to its impacts. Countries agreed to communicate their commitments to greenhouse gas emissions reduction, adaptation actions, and means of implementation such as finance, technology transfer and capacity-building. All countries in the NENA region communicated adaptation as a key component of their Nationally Determined Contributions (NDCs) (see also Chapter 5 section 5.3.3), with many countries prioritizing adaptation in water resources, agriculture and forestry subsectors, followed by biodiversity, ecosystems and natural resources (FAO, 2021). Countries update their NDCs every five years and submit biennial reports on progress towards climate goals. However, the 2021 COP26 Glasgow Climate Pact Agreement instructs countries to come back every year with strengthened emissions reduction commitments in their NDCs. The NDC updating process presents an opportunity to prioritize agricultural actions (and mobilize resources for scaling up suitable options).

2.4.4 Koronivia Joint Work on Agriculture

The role of agriculture in combating climate change was acknowledged as a significant element in addressing climate change at the 23rd Conference of the Parties of the United Nations Framework Convention on Climate Change (COP23 of UNFCCC) in November 2017. An important decision at this conference in Koronivia[22] was recognition of the crucial role of agriculture in the climate change agenda to address both adaptation and mitigation challenges. This Koronivia Decision launched a series of workshops aimed at discussing submissions by Parties on six topics: soil and water management, livestock, nutrient use, methods for assessing adaptation, and the food security and socioeconomic dimensions of climate change in the agriculture sector. The vulnerabilities of agriculture to climate change and approaches to addressing food security are now higher on the global agenda, recognizing the need to improve the enabling environment for mobilizing resources to implement action.

[21] Within its LDN Target Setting Programme, UNCCD developed a technical guide on how to define national baselines, identify voluntary targets and associated measures to achieve LDN by 2030 and monitor progress towards LDN targets.

[22] Decision 4/CP.23.

PART II: ELABORATION ON WATER, SOIL, CLIMATE CHANGE IMPACTS AND THE URBAN-RURAL INTERFACE

3 WATER RESOURCES AND WATER TRENDS

©FAO/Soliman Ahmed

KEY MESSAGES

- **Most NENA countries are characterized by high and extremely high levels of water stress.** Eight countries rank in the top 10 highest levels of water stress in the world. The global figure for per capita share of renewable water resources is 5 732 m^3 per annum. Thirteen countries of the region have a per capita share below 500 m^3 annually, with 7 countries below 100 m^3.
- **NENA is highly dependent on water resources from other regions.** Sixty percent of all renewable water resources are generated outside the boundaries of the region, including a high dependency on transboundary groundwater aquifers. Climate change, environmental degradation, population growth, conflicts and COVID-19 are some common challenges affecting water resources.
- **Agriculture is the major user of water.** On average, irrigation accounts for 85 percent of water use. Switching to crops that consume less water with higher returns should be encouraged. Incentives to construct, upgrade, operate and maintain irrigation infrastructure are required.
- **A shift in agricultural water planning is required.** About 82 percent of wastewater remains untreated or is not used following treatment and could be exploited as a new water source for the agriculture sector. Rainwater capture, use of wetlands and other green-based solutions, better use of green water, and artificial aquifer recharge via micro-catchment management are some options.
- **Regional economic benefits from improved water infrastructure could range between USD 7 and 10 billion per year.** The public sector must strengthen its role as a financing enabler or put in place legislation for public-private-partnerships for water resources. Virtual water trade is an important component of national water budgets.
- **Technology-based solutions also offer potential.** Potential technology-based solutions include solar energy-powered pumps for irrigation, unmanned aerial vehicles, digital soil and water map surveys, digital agriculture technologies, and mobile phone applications using remote sensing data combined with online analysis tools using free data sets and portals.
- **Nature-based solutions hold potential to reach some sustainability goals.** Community-led approaches should be explored, for example micro-water harvesting techniques and floodwater diversion. Cultural and sacred aspects of water should not be forgotten.
- **A paradigm shift in water management is required.** Adoption of a circular economy that considers water reuse, better water accounting, acknowledging the value of water, and more effective water allocation mechanisms are all urgently needed. Consultative processes are also necessary, including with different users and acknowledging gender roles.
- **Cooperation and sharing knowledge on what works should be enhanced in the region.** Countries that have advanced in data management and digital innovation should share capacities to help move the region towards more resilient, productive food-water systems.

Introduction

The NENA region is considered one of the world's most arid regions. Rainfall levels, water resources and arable land are very limited. Agriculture is the dominant water-using sector. Water scarcity in NENA countries results from a combination of low physical availability of water resources and increasing demand. Long-term water availability is affected by climate change impacts and population – the region's current population is expected to increase by 1.5 times, reaching around 633 million by 2050. Population growth is feeding urbanization and accompanying changes in lifestyle and dietary patterns.

With growing demand for the limited water, this chapter focuses on the need for greater efficiency and productivity of agricultural water use in order for agricultural production to be sustained. Firstly, it examines the status of the agricultural water sector in the NENA region, including data on physical availability, characteristics and management. Water stress is viewed in line with evolving challenges such as climate change and population growth. Section 3.2 examines water-use challenges, including significant challenges related to transboundary water sources. Section 3.3 outlines various directions and options for agricultural production under the current water scarcity challenges in the region. The chapter concludes that a paradigm shift is necessary for more efficient and productive management of water, embracing 'circular economy' concepts, while improving resilience and equity of water access.

3.1 Water resources in NENA

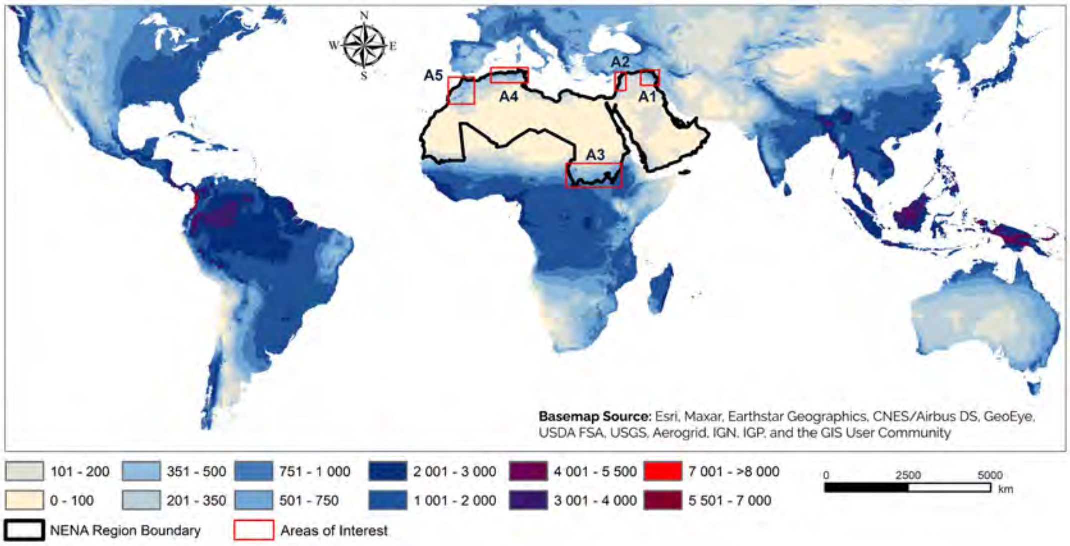
3.1.1 A region in physical water resource stress

Severe water scarcity distinguishes NENA from other regions. Excluding the vast hyper-arid deserts (0–100 mm of rain per year), the NENA region is still largely characterized as arid and semi-arid, within the four subcategories of drylands (dry; subhumid; semi-arid; and arid). Countries have an annual average rainfall within a 160 and 400 mm (mm/year) range, except Lebanon, which has 661 mm/year. In terms of precipitation depth, 11 countries in the region were ranked last in the long-term average annual precipitation (AQUASTAT, 2021). Limited rainfall, with increasingly erratic patterns due to climate change, coupled with a rapidly growing population, means that rainfed agriculture is facing growing challenges to increase or even maintain food production. Water scarcity has serious effects on livelihoods and economic activities.

3.1.2 Trends in rainfall levels for agriculture

While the rainfed farming system is found in many countries of the region, it is usually characterized by low yields and increasing uncertainty. Figure 3.1 highlights a few areas with higher rainfall levels than the rest of the region, where rainfed agriculture seems more viable. These are indicated on the regional map as A1 in the northeast of the region, A2 along the eastern Mediterranean coast, A3 along the southern border of Sudan, A4 along the North Africa Mediterranean coastline, and A5 in the northwest of the NENA region.

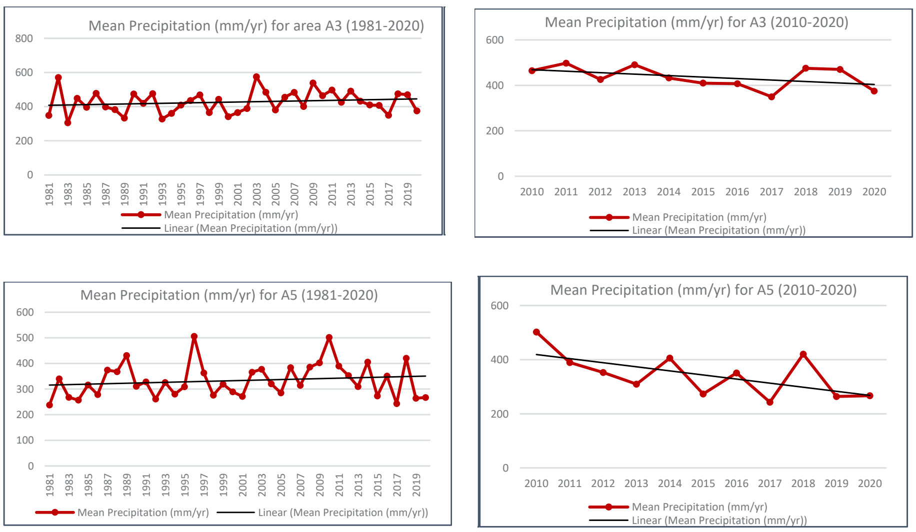
FIGURE 3.1 LONG-TERM AVERAGE ANNUAL PRECIPITATION (1981–2019) IN MM/YEAR



Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). 2021. [online]. [Cited 15 December 2021]. https://chc.ucsb.edu/data/chirps/

A closer look at the long-term precipitation data reveals that while areas A1 and A4 show a slightly increasing trend for both the long-term (past 40 years) and short-term (past 10 years) averages, A2 shows more of a constant trend for both long- and short-term averages. However, as can be seen from the graphs in Figure 3.2, A3 and A5 reveal a different trend, slightly increasing in the long term, but declining in the short term. These trends can inform agricultural planning for rainfed production systems, but need to be complemented by climate change modelling projections.

FIGURE 3.2 LONG-TERM AND SHORT-TERM MEAN PRECIPITATION FOR A3 AND A5 AREAS

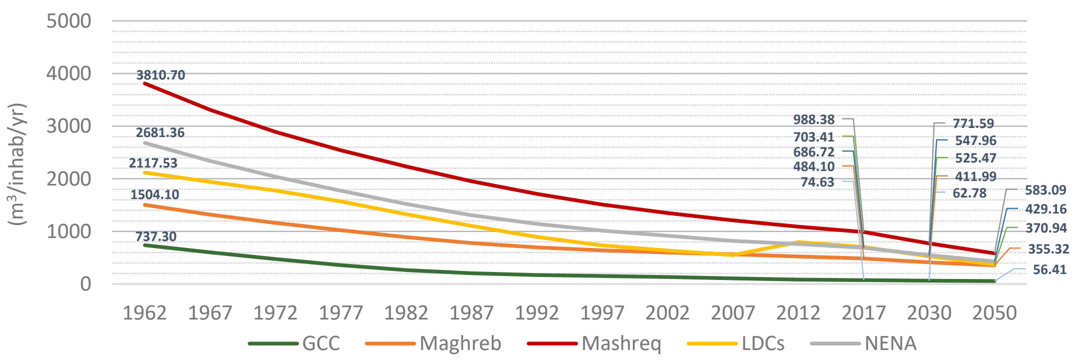


Source: Derived from CHIRPS.

The per capita availability of renewable water resources in the region declined by nearly 75 percent between 1962 and 2017,[23] and is projected to further decline by 2030 and again by 2050 (see Figure 3.3).[24] Water decline between 1962 and 2017 was highest in the GCC subregion at almost 90 percent, followed by a 78, 68 and 67 percent decline for the Mashreq, Maghreb and LDC subregions, respectively.

The adaptive capacity for water scarcity in the GCC subregion is high, however, as these countries have extensive investments in alternative non-conventional water sources, such as desalination. Other subregions remain reliant on conventional sources to meet growing demand, notably non-renewable fossil groundwater.

FIGURE 3.3 PAST RECORDS AND FUTURE PROJECTIONS OF RENEWABLE WATER AVAILABILITY PER CAPITA*



Source: United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2019. *World Population Prospects 2019, online edition.* [Cited 13 April 2021]. https://population.un.org/wpp/Download/Probabilistic/Population/

Note: *LDC figure increased between 2007 and 2012 due to the inclusion of Sudan data; projections for 2030 and 2050 assume that water availability remains constant and population projects use the median (50 percent) prediction interval of the Probabilistic Projection of UN Population Division.

Increasing water demand has resulted in increased stress levels of available surface and groundwater resources. An estimated one-tenth of surface water consumption in the Mashreq and Nile regions is unsustainable, or sustained at the expense of environmental flows (World Bank, 2017a). For example, in the North-Western Sahara Aquifer, which spans Algeria, Libya and Tunisia, water abstractions had increased by 300 percent (Steenbergen *et al.*, 2010).[25] Increasing rates of groundwater abstractions have led to overexploitation of aquifers throughout the region, causing salt intrusion, groundwater pollution and a decline in water levels, all leading to overall groundwater stress (Goode *et al.*, 2013; Al-Zyoud *et al.*, 2015). Levels of groundwater stress in the region are estimated to typically range from medium to extremely high (Gleeson *et al.*, 2012).

[23] from 2 681 m³ to 686 m³.

[24] to 548 m³ and 429 m³.

[25] from 0.6 to 2.5 billion m³/year.

3.1.3 Water stress levels

Most countries in the NENA region are characterized by high and extremely high levels of water stress (see Figure 3.4):

- Eight countries (Kuwait, United Arab Emirates, Saudi Arabia, Libya, Qatar, Yemen, Algeria and Bahrain), in that order, are in the global top 10 list of countries facing the highest levels of water stress.

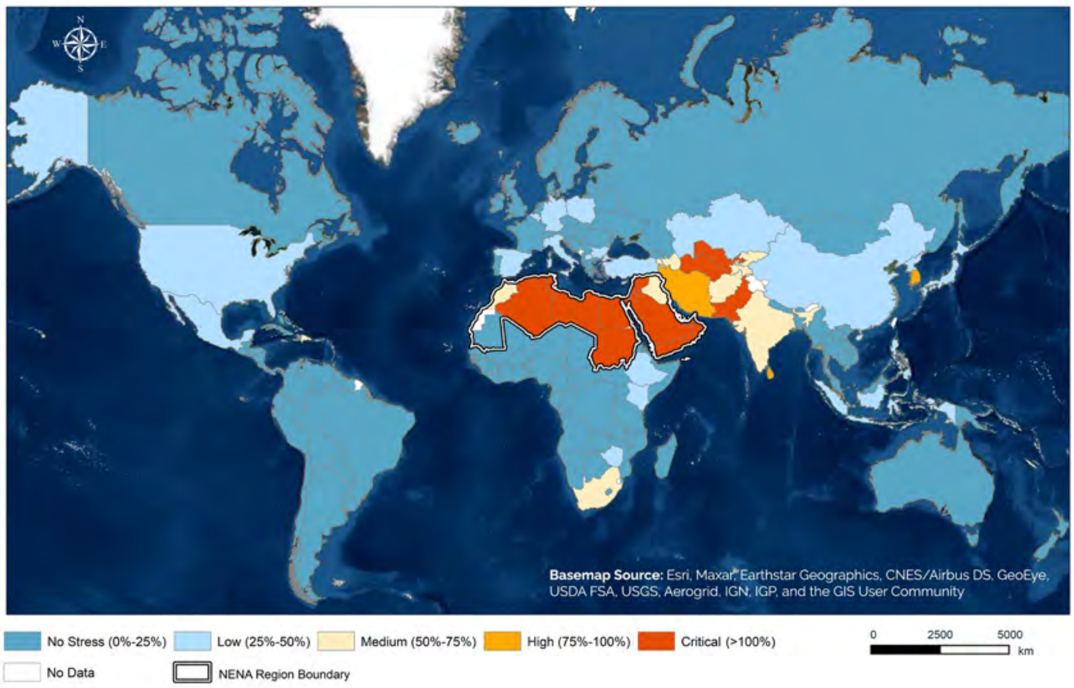
- More than 60 percent of the regional population and 70 percent of their economic activities are in areas that are characterized by high and very high levels of water stress (World Bank, 2017a).

Water-use efficiency across all sectors is essential to address water stress. Hypothetically, countries facing water shortages can maintain acceptable water stress levels by maintaining water withdrawals within sustainable limits. This must be done while also developing non-conventional water resources and increasing reliance on virtual water. This is easier said than done – although water resources are badly needed, they are influenced by local socioeconomic, environmental and political factors.

6 CLEAN WATER AND SANITATION

SDG Target 6.2 seeks to ensure sustainable withdrawals and supply of freshwater in order to address water scarcity. **Indicator 6.4.2** tracks water stress as the level of freshwater that is being withdrawn by all economic activities, compared with the total renewable freshwater resources available. It also takes into account environmental flow requirements. Data can be disaggregated geographically (water basin), by source (surface water/groundwater) and by economic activity.

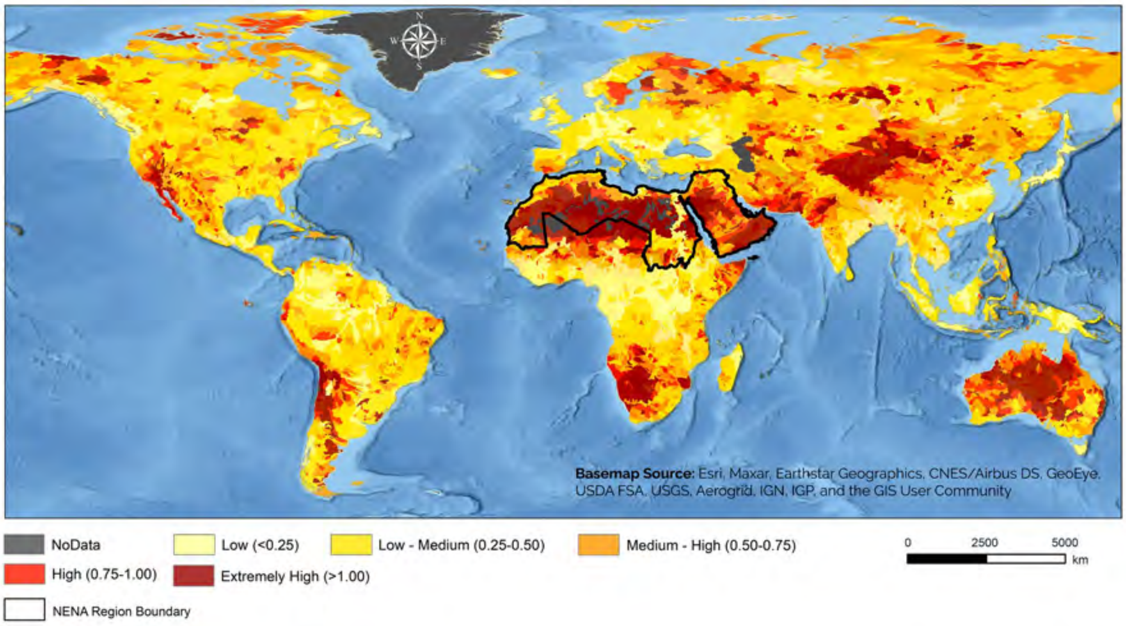
FIGURE 3.4 WATER STRESS LEVELS – SDG 6.4.2 (LATEST REPORTING YEAR)



Source: AQUASTAT, 2021. www.fao.org/aquastat/en/

Figure 3.5 illustrates that water resources in the NENA region are the most variable in the world.[26] Data suggest that year-to-year water variability is about 15 percent greater than the global average (World Bank, 2017; Antonelli and Tamea, 2015; Borgomeo *et al.*, 2020). In the GCC countries, such variability may even surpass 75 percent for surface water resources alone. Studies have also found changes in the regional, seasonal (multiyear) variability, where during the summer months, an overall decline in precipitation of about 0.5 mm/day per decade has been detected (Dogar and Sato, 2018).

FIGURE 3.5 INTERANNUAL VARIABILITY OF AVAILABLE WATER SUPPLY (1960–2014)



Note: Interannual variability measures the average between year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations in available supply from year to year .

Source: Hofste, R. *et al.* 2019. Aqueduct 3.0: Updated Decision-Relevant Global Water Risk Indicators, *WRI Publ.*, doi:10.46830/writn.18.00146

[26] Variability is measured as the deviation from historical average annual surface water availability.

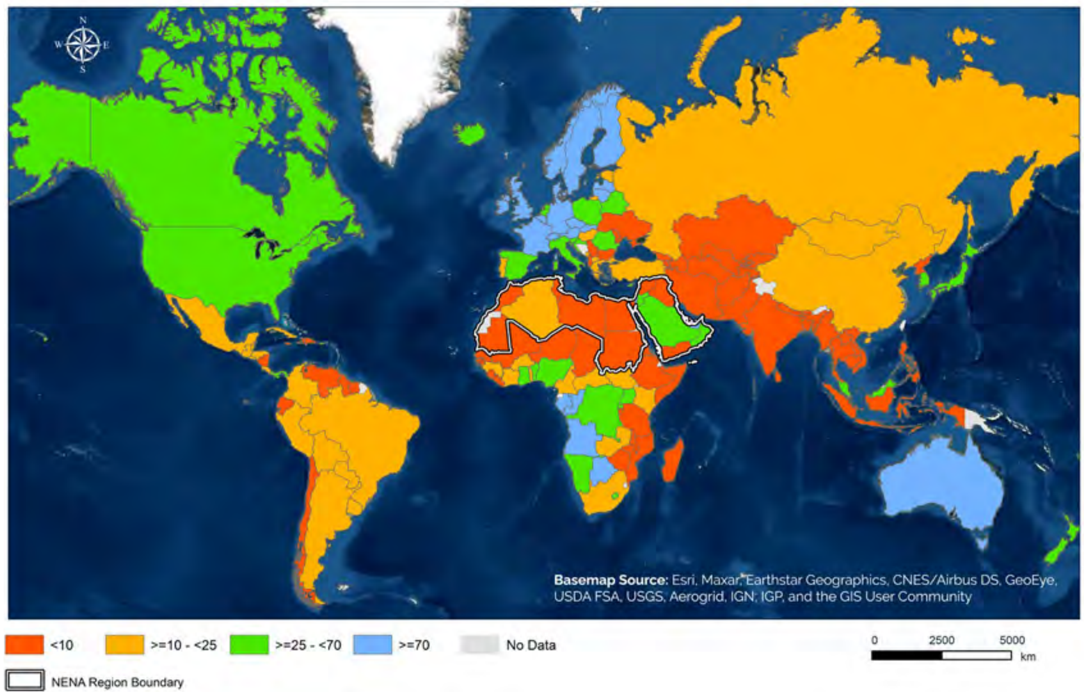
3.1.4 Water-use efficiency

The NENA region displays significant differences in water-use efficiencies. Figure 3.6 illustrates that the GCC countries have higher efficiency levels, as their economies are dominated by industries, manufacturing and other sectors with large monetary outputs (Borgomeo *et al.*, 2020). In GCC countries, particularly Kuwait and Qatar, each cubic metre of water returns in excess of USD 40 (UN Water, 2021). By contrast, in the rest of the region where the agriculture sector provides less returns, water-use efficiencies are rather low. The situation is particularly acute in countries such as Tunisia, Libya, Egypt and Iraq, where return per cubic metre of water is less than USD 4. Apart from Kuwait, Qatar Bahrain and Oman, the rest of the region has not made notable progress towards adding more economic value to water, and is therefore making slow progress towards SDG Indicator 6.4.1.

6 CLEAN WATER AND SANITATION

Indicator 6.4.1 of SDG 6 measures change in water-use efficiency over time. It complements the water stress **indicator 6.4.2.** While 6.4.2 evaluates the physical water availability in relation to demand, **Indicator 6.4.1** is considered an economic indicator that aims to monitor the dependency of the economy on water. The indicator provides a snapshot of water-use efficiency relative to other countries, disaggregating data for the major economic sectors. The indicator also has a temporal element that aims to monitor the increased efficiency over time (declining dependence on water for economic growth) and can be an indication of decoupling economic growth from water use.

FIGURE 3.6 WATER-USE EFFICIENCY IN USD/M³ – SDG 6.4.1 (LATEST REPORTED YEAR)



Source: AQUASTAT, 2021. www.fao.org/aquastat/en/

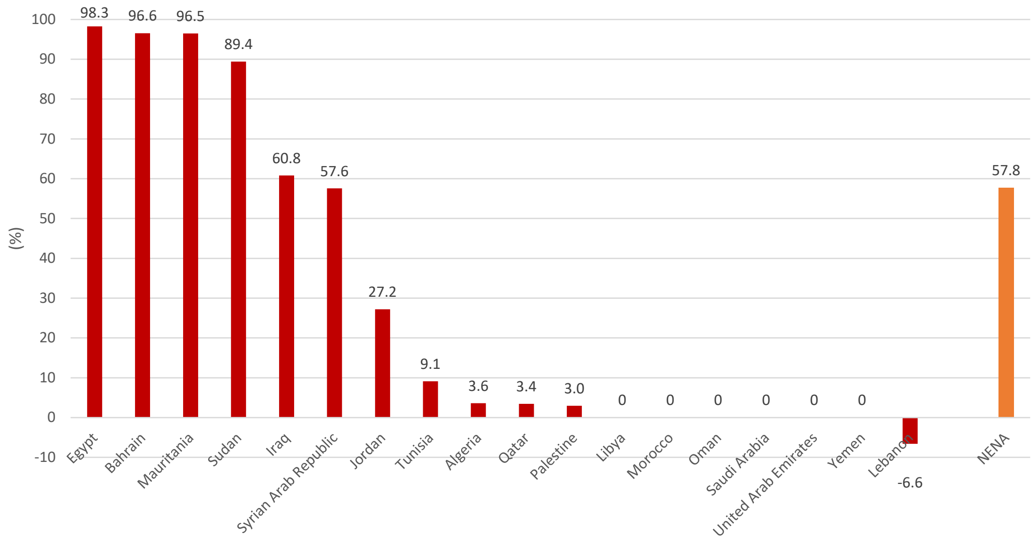
3.2 NENA region water-use challenges

3.2.1 Transboundary water-use sources and issues

Local-level water scarcity conditions may be accentuated by the decisions made upstream outside national borders. A distinctive feature of the NENA region is its high dependency on external water resources (see Figure 3.7), as transboundary surface and groundwaters constitute important sources. With the exception of Lebanon, where water outflows from its borders as an upstream country, other countries have a net inflow of water into their territories. Eight countries of the region do not have external water resources entering or exiting their national borders. On average, around 60 percent of all renewable water resources are generated outside the boundaries of the Arab region,[27] most notably through the Nile, Tigris, Euphrates and Senegal rivers. Many NENA countries are downstream of international rivers, with these resources accounting for the major portion of their renewable water. Apart from the Senegal River,[28] the other international rivers crossing into the region do not have comprehensive governing agreements. The lack of legal clarity among all riparian countries on water allocation is increasing the sense of vulnerability among the Arab riparian countries.

Some of the largest groundwater systems in the NENA region are also transboundary. Some examples include (FAO, 2010b) the Nubian Sandstone (Egypt, Libya and Sudan); North Western Sahara (Algeria, Libya and Tunisia); and the Disi Aquifer (Jordan and Saudi Arabia). Other minor groundwater systems also have significant repercussions on country-level water budgets. For example, Bahrain and Kuwait have very high dependency (97 percent) on groundwater flows from Saudi Arabia.

FIGURE 3.7 EXTERNAL RENEWABLE WATER RESOURCES AS A PERCENTAGE OF TOTAL RENEWABLE RESOURCES IN NENA (2018)



Source: AQUASTAT, 2021.

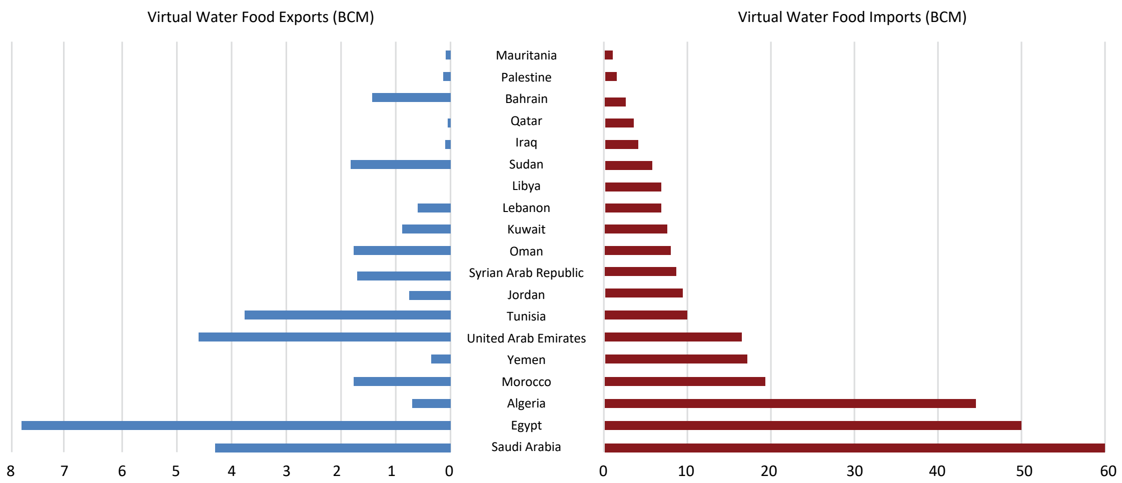
[27] In addition to the NENA countries, the Arab region includes three additional countries – Comoros, Djibouti and Somalia.

[28] Convention establishing the Organization for the Development of the Senegal River signed by the riparian countries in 1972.

3.2.2 Virtual water imports

Virtual water (water embodied in the production of food and non-food commodities) is gaining importance within the national water budget of all countries of the NENA region. The region imports virtual water from all over the world as it is the largest global food-importing region (Antonelli and Tamea, 2015; World Bank, 2017a; OECD-FAO, 2018). The biggest food importers in the region are Saudi Arabia, Egypt and Algeria, in that order (see Figure 3.8). According to Antonelli and Tamea (2015), in just 25 years (between 1986 and 2010), virtual water imports to the region increased by about 150 percent. Egypt and Algeria alone account for 10 percent of global wheat imports together, with the NENA region as a whole accounting for 40 percent of global cereal imports. AbuZeid and Wagdy (2019) indicate that Saudi Arabia, Egypt and Algeria account for more than half of regional food imports (20, 17 and 15 percent, respectively). On the other hand, the NENA region has become mostly self-sufficient in terms of fruits and vegetables. Interestingly, some countries export virtual water, as demonstrated in Figure 3.8.

FIGURE 3.8 VIRTUAL WATER TRADE IN COUNTRIES OF THE NENA REGION



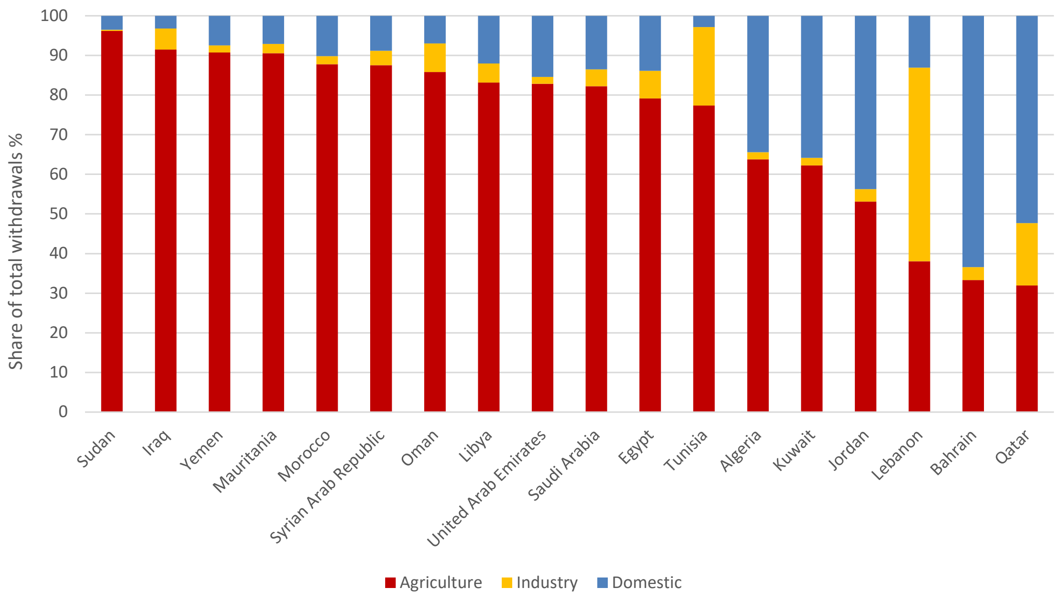
Source: AbuZeid, K., Wagdy, A. & Ibrahim, M. 2019. *3rd State of the Water Report for the Arab region – 2015*, Cairo

Dependency on food imports can be alarming in times of crisis or conflict. The United States of America, Brazil and Argentina are the major virtual water exporters to the region. In terms of volume, the Americas account for almost half of the NENA region's virtual water imports. Global food price shocks, such as the 2007–2008 food crisis, as well as climate impacts on production countries, political tensions, conflicts and blockades, general supply chain disruptions and other factors may, in turn, exacerbate the regional vulnerability of the food and water sectors (Breisinger *et al.*, 2012).

3.2.3 Growing competition for water use

Agriculture is the largest water withdrawing sector in the region, as demonstrated by Figure 3.9, which presents water withdrawals by sector for countries in the region. Overall, the agriculture sector accounts for nearly 85 percent of regional water uses (Nin-Pratt *et al.*, 2017). In some countries, agriculture accounts for 90 percent of water withdrawal (Iraq, Mauritania, Sudan and Yemen).

FIGURE 3.9 WATER WITHDRAWALS BY SECTOR IN NENA COUNTRIES, 2017



Source: AQUASTAT, 2017.

At about 5 percent, industrial water use in the region is only around one-quarter of the global average (which is about 20 percent). Figure 3.9 indicates that the industrial share in Qatar, Tunisia and Lebanon exceeds the global average. Domestic water withdrawals account for about 10 percent of total withdrawals (but in Bahrain and Qatar, this figure surpasses 50 percent). Clearly, agriculture is the dominant water-using sector in the NENA region. Limited water availability coupled with increasing demand means that the agriculture sector will face growing competition as domestic and industrial water supply are considered higher priorities in almost all countries. In Jordan, for example, priority is given to domestic uses in order to meet safety and hygiene requirements, and each sector of the economy is then prioritized according to its contribution to national GDP (Ministry of Water and Irrigation, Jordan, 2016). As a result, the agriculture sector is limited in its withdrawal allocations and can only be expanded when newly-treated wastewater is used. The shift in water allocation policies in Jordan is summarized in Box 3.1.

BOX 3.1 JORDAN'S WATER REALLOCATION POLICY

Jordan suffers from extreme water shortage, which has always been one of the most critical obstacles to economic growth. The influx of refugees from neighbouring countries, transboundary challenges, and climate change issues affecting Jordan's water supply have exacerbated the problem. In 2014, the total volume of water made available from all resources was 1,197 million cubic metres (mcm), with over 60 percent (729 mcm) allocated to agriculture, almost 36 percent (429 mcm) to municipal uses, and about 3 percent (39 mcm) to industrial activities. Due to population growth and other factors, neither renewable nor currently used non-renewable resources can meet municipal needs while sustaining current agricultural activities.

The Government has introduced a series of new policies to manage scarce water supplies and address these concerns. The Ministry of Water and Irrigation began desalinating brackish water, as well as collecting and treating domestic wastewater. This direction towards augmenting water supply through non-conventional resources comes under an overarching Water Reallocation Policy, which provides a framework for developing action plans for redistributing water flexibly across industries and governorates. Municipal use of water to maintain health and sanitary conditions is given top priority. For the different economic sectors, priorities are defined based on their importance and contribution to GDP in this order: the energy sector, tourism, industry and the agriculture sector. Irrigation water will be capped and will eventually be reduced in the highlands. In the Jordan Valley, water supply will increase with the collection and treatment of wastewater for safe agricultural use. Treated wastewater will replace other freshwater uses, except for drinking purposes. No additional freshwater is allocated to agriculture and only treated wastewater can be used to expand irrigated agriculture. To implement these initiatives, the private sector's role in treated wastewater reuse will expand, and irrigated agriculture in the Jordan Valley is encouraged. On the whole, the policy is expected to enhance physical water efficiency and economic water productivity.

Source: Ministry of Water and Irrigation, Jordan 2016. *National Water Strategy of Jordan, 2016–2025*, Water Reallocation Policy, Jordan.

Clearly a paradigm shift is required in most NENA countries to ensure sustainable water supplies for different sectors. Structured water allocation or reallocation between sectors should take place within an inclusive integrated approach. Some efforts in this regard from Morocco are highlighted in Box 3.2.


©FAO/Essam Alkamaly

BOX 3.2 EFFORTS TO PUT IN PLACE A PARTICIPATORY FARMER APPROACH, MOROCCO

Consecutive droughts and increased water consumption have intensified pressure on water resources during the past decades. The continuous decline in groundwater levels represented a challenge to the development and sustainability of Morocco's water sector. Groundwater was increasingly used as a 'strategic resource' to extend irrigation, alleviate water stress, and strengthen farmer resilience. In 2006, the Government started to implement a new approach to water resource management called the 'aquifer contract'. This approach intended to bring together all groundwater users in an aquifer area under a single participatory framework agreement to improve groundwater management and reverse resource depletion. Specific measures were applied, such as water fees and restrictions on cultivated areas.

Although an important initiative, some challenges have been noted. The voluntary nature of the scheme means that limited numbers of farmers are actually involved. Additionally, the institutional and legal frameworks require clarity and governance to ensure effective monitoring and enforcement. Streamlining environmental, agricultural and irrigation policy within a decentralized groundwater management structure may enhance the effectiveness of this initiative, along with a data management system to ensure that groundwater resources are managed in an integrated manner.

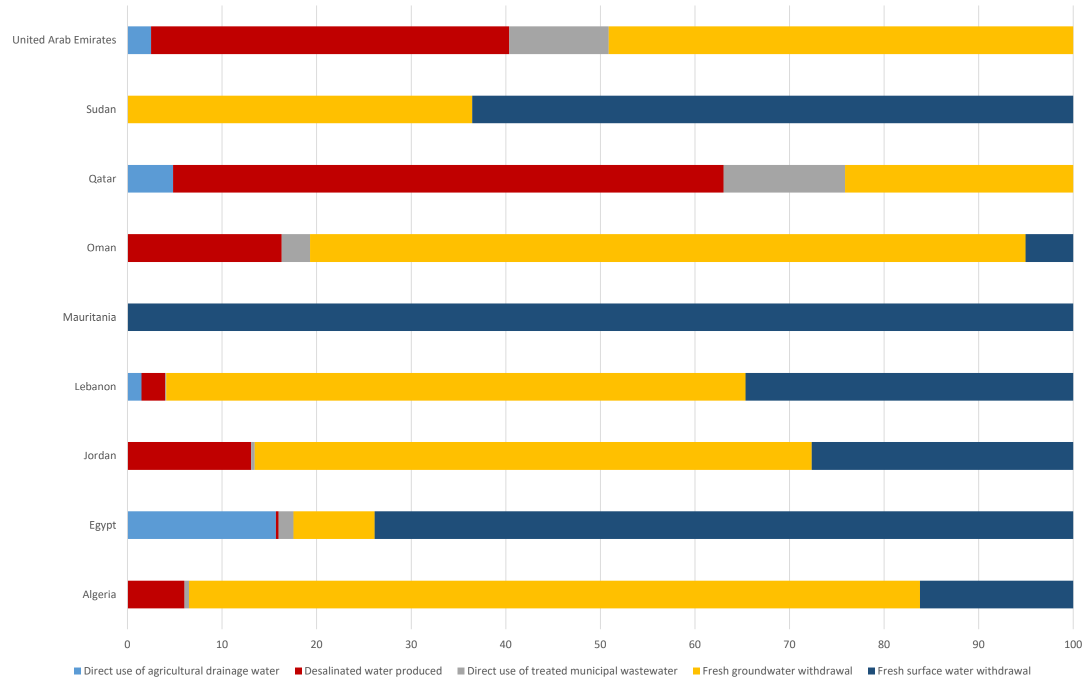
Source: Closas and Villholth, 2016. *Aquifer contracts: A means to solving groundwater over-exploitation in Morocco?* Colombo, Sri Lanka, International Water Management Institute (IWMI). 20p. (Groundwater Solutions Initiative for Policy and Practice (GRIPP) Case Profle Series 01). doi: 10.5337/2016.211

3.2.4 Over-reliance levels on specific water sources

Clarity on water use by sector is evidently important, as is an examination of the reliance level of countries on various water resources. A combination of groundwater, surface water, and to a lesser extent treated wastewater and desalination, dominate water withdrawals across the NENA region. Figure 1.14 in section 1 indicated a mixed picture across countries. Clearly some countries are reliant on fresh groundwater withdrawals (such as Algeria, Libya, Oman, Saudi Arabia and Yemen). Countries with limited surface water (such as Jordan, Libya, Palestine, Tunisia and Yemen) have developed extensive groundwater-based agriculture sectors. In general, available surface water resources seem to be utilized first, even at the expense of environmental flows, before turning to groundwater. This is the case in Egypt, Iraq and Morocco.

Non-conventional water resources are gaining ground in the region. Desalination is particularly important, and about 50 percent of the world's desalination capacity is in the NENA region (World Bank, 2017a; Borgomeo *et al.*, 2020). Desalination plants are mainly found in the oil-rich GCC countries that have the financial capacity to invest in energy-intensive desalination technologies. Reliance on desalination in the GCC countries is raising concerns over the impacts of brine disposal on the marine environment.

FIGURE 3.10 WATER WITHDRAWALS BY SOURCE AS A PERCENTAGE OF TOTAL WATER WITHDRAWAL, 2015 AND 2017*



Source: AQUASTAT, AbuZeid, K., Wagdy, A. & Ibrahim, M. 2019. *3rd State of the Water Report for the Arab region – 2015,* Cairo.

*Missing data for 2017 are imputed using 2015 data; data for Jordan, Lebanon, Qatar and Tunisia are all from 2017; data for Sudan are from 2015.

3.2.5 Treatment of wastewater

About 45 percent of the wastewater generated in the NENA region is treated. This is a relatively high share compared with other regions, but with large variations between subregions and countries. In countries such as Kuwait and United Arab Emirates, more than 90 percent of domestic and industrial wastewater flow is subject to tertiary treatment, whereas in Algeria, Iraq, Lebanon and Libya, this proportion falls to about 15 percent (UN Water, 2021). Although restricted by location and high investment, wastewater reuse schemes provide environmental protection and a growing renewable water source to reduce pressure on limited freshwater availability. Investment is needed for wastewater collection, treatment and reuse infrastructure. Moreover, adequate regulatory frameworks, as well as strong institutional and enforcement capacities, are necessary to effectively incorporate treated wastewater within integrated water resource management.

3.2.6 Agricultural water use versus productivity

High levels of water withdrawal for agriculture contrasts with the region's poor agricultural productivity. Since 1980, the NENA region has been ranked close to the bottom of global agricultural productivity – only the sub-Sahara African region has lower productivity in terms of gross agricultural production per hectare of agricultural land (FAO, 2017b). Low productivity compromises regional efforts to achieve SDG 2.3 (agricultural productivity and incomes of small-scale food producers). As already indicated in section 1.3, cereals cover about 60 percent of total harvested land in the region, but contribute just 15 percent of the value of agricultural production. Horticulture products, which have higher water productivity and economic value, occupy less than 20 percent of the region's harvested land and account for 40 percent of the value of agricultural production. The agriculture sector in the NENA region also experiences a significant loss of water along the food supply chain. Water losses average 86 m^3 per capita per year, reaching 180 m^3 in some NENA countries, compared with the global average of 30 m^3 per capita per year (Kummu *et al.*, 2012). These losses stem from poor agricultural processing, distribution, consumption and disposal practices.

SDG 2 concerns hunger, food security, improved nutrition, and sustainable agriculture. **Indicator 2.3.1** measures the volume of production per labour unit by classes of farming/pastoral/forestry enterprise size.

3.2.7 Agricultural water policy and management

Since the 1960s, large-scale irrigation systems and drainage expansion have been set up in different countries of the region. Such infrastructure-based strategies often ceased being feasible a few decades after implementation due to land and water constraints, as well as inadequate operation and maintenance. Since the 1990s, the agricultural water sector strategies have slowly shifted towards a more integrated approach (Ghazouani *et al.*, 2012; Borgomeo and Santos, 2019). In other words, approaches have moved towards more decentralized and participatory-based approaches, with a focus on being financially sustainable. Such approaches have included policies that encourage local management systems, better participation by those on the ground in the decision-making process, financial autonomy to lessen the burden on public finances, and the transfer of functions from national level to local water associations. While the application of this new set of policies has not been uniform across the region, various experiences have shown promising results. Morocco, for example, has implemented a national programme (Plan Maroc Vert) for irrigation, which seeks wide adoption of drip irrigation systems (Oudra and Talks, 2017). Protected agriculture is viewed as a successful regional direction to address water scarcity. For example, in the Algerian Sahara, more than 130 000 greenhouses were erected between 2000 and 2014 to support horticulture activities (Naouri *et al.*, 2017). This approach increases yields in fruit and vegetable production, maintaining water-efficiency rates. Other regional challenges include the following:

- Many countries in the region do not have water subsectors with a high level of participation by users and communities (UN Water, 2021). This, in turn is reflected in low regional scores towards achieving SDG 6.b.1, which concerns the participation of local communities in improving water and sanitation management.
- The region still lacks active strategies to tackle gender inequalities (Fisher and Reed, 2018) and women in water user associations. Currently, the design of many policies and programmes does not systematically include women's views, needs or knowledge.
- Operation and maintenance, as well as the implementation of modernization and water-saving policies, still rely heavily on public finance (Toan, 2016). Several countries in the region provide irrigation water free of charge or at negligible fees, which results in spending of about 2 percent of regional GDP on subsidies for the sector (Kochhar, 2015). The monitoring, enforcement and legal frameworks for coordination of these public incentives are insufficient (Bazza, 2003; Jeuland, 2015).

- Weak institutional arrangements and lack of recognition of the real price of water for irrigation translate into widespread undervaluing of water (World Bank, 2017a). This results in a lack of incentives to efficiently use and manage water and a tendency to overexploit water sources, even when new technologies are put in place. Public-private partnerships are still nascent in the region and their real benefits, while mixed, need to be evaluated (OECD-FAO, 2018).

- The NENA region is generally facing a data gap in terms of quality, quantity, access and dissemination of information. Within the region, availability of stations and records differs across countries. For example, Morocco has more than 700 surface water gauging stations and over 130 groundwater monitoring wells; Lebanon has about 50 gauging stations and 13 monitoring wells (Fragaszy *et al.*, 2020).

- Many national and regional institutions lack the resources for effective data acquisition and when data are collected, do not have capacity for adequate analysis or effective arrangements for dissemination. At present, there are no regional regulatory or guiding frameworks to facilitate data sharing.[29]

3.2.8 Population and climate change water challenges

Population and climate change are closely linked, and both are key drivers for water use and demand in the NENA region. The current population is 418 million, and this figure is expected to grow by 100 million inhabitants in the next 10 years, and further increase to reach 633 million by 2050 (UNDESA, 2019).

Climate change impacts will also influence the way that water is managed in the region. Temperatures in the region are expected to increase by between 1.2 °C and 1.9 °C under more modest pathway projections, and by between 1.7 °C and 2.6 °C under other possible climate futures, with some parts of NENA increasing by as much as 5 °C towards the end of the century under the most extreme climate emission scenario (ESCWA, 2017). Areas likely to experience the highest rise in temperature are the Maghreb subregion, the upper Nile River Valley, and the central and western parts of the Arabian Peninsula. Temperature rises will translate into more evaporative losses, as well as more heatwaves (Waha *et al.*, 2017; Bucchignani *et al.*, 2018). Precipitation levels are projected to decline in the region, particularly in the Mashreq and Maghreb subregions and in Egypt (UNDP and GEF, 2018). The consequences of this decline are severe, for example:

- In the Atlas Mountains, projections estimate a reduction in mean annual precipitation by about 90 mm, whereas in the coastal zones, the decrease is projected at 120 mm (ESCWA, 2017).

- In the Jordan River, reduction in precipitation is expected to lead to further reductions in river flow and water availability by up to 44 percent (Givati *et al.*, 2019).

The NENA region is expected to become a global hotspot for droughts (Prudhomme *et al.*, 2014; Cook *et al.*, 2018; Driouech *et al.*, 2020), which will deeply aggravate the region's current water stress conditions. Under the highest climate emission scenario, current water stress conditions will significantly increase in most of the region. As a whole, the NENA region will be at the forefront of global economic losses resulting from climate-related water scarcity (World Bank, 2017a). Unless action is taken, water scarcity induced by climate change is projected to cause losses of between 6 and 14 percent of regional GDP by 2050. As rural living conditions worsen, there will be more movements of people to urban areas (Waha *et al.*, 2017).

[29] This is also the case in other sectors such as food, infrastructure and the environment.

3.3 Options for agricultural production under water scarcity

The NENA region requires novel transitions that allow countries to better align their agricultural water sector with other sectors, to lessen the impacts of water scarcity on achieving sustainable development. The SDGs and their indicators provide a practical framework for such a transition. Policy responses are urgently required, along with improved investments in and management of infrastructure. The adoption of circular economy principles for water reuse must be put in place (see also Chapter 6). A major change in how water is valued must be instilled, while at the same time acknowledging and addressing existing social and gender equity gaps. Technological innovations and other tools to help the region make tangible progress towards achieving the SDGs are explored below, providing examples of what is possible in the NENA region in the following areas:

- Improved water management
- Narrowing gender inequality gaps
- Improved evidence and data
- Investment in the water sector and infrastructure
- Resilience-based water management
- New institutional policy designs
- Valuing water
- Wastewater use
- Circular economy planning
- Innovative approaches and technology options
- Improved evidence and data
- Resilience-based water management
- Valuing water
- Innovative approaches and technology options

Suggestions on how resilience-based planning can become engrained in national policy are also presented.

3.3.1 Improved water management

Water management attempts to enhance the delivery and reliability of water systems through rehabilitation, improvement and upgrading of storage, distribution and other facilities and practices. Improving water management practices in agriculture can reduce income variability for farmers. Estimates suggest that if the management of water storage and delivery infrastructure were improved in the NENA countries, regional economic benefits could range from USD 7 to USD 10 billion per year (Sadoff *et al.*, 2015). Along with this, a coordinated and optimized conjunctive management of surface and groundwater resources will also help to offset depletion and droughts. Existing estimates show a range of returns of between 16 and 36 percent, depending on the intervention or activity (Borgomeo and Santos, 2019). For example:

- In Tunisia, projects for the intensification of irrigated agriculture have provided an economic return range of between 11 and 19 percent.
- In Yemen, groundwater and soil conservation projects aligned with other agricultural activities have provided 36 percent of economic returns.

Aside from SDG 1 and SDG 2 (ending poverty and zero hunger), investing in the agricultural water sector provides other benefits, such as decent work (SDG 8). For example, in Iraq, the return of displaced people and improvements in incomes have been associated with investments in agricultural water systems

(FAO, 2018f). Apart from infrastructure-type interventions, other interventions related to management practices must be considered. Some existing examples from NENA include:

- Egypt is currently engaged in a major rehabilitation of nearly 7 000 km of irrigation canals at an overall cost of more than USD 1 billion.

- The potential for deploying smart and automated irrigation systems in the Jordan Valley has been acknowledged as a mechanism to make water canals more efficient (Massadeh, 2014).

3.3.2 Investment in the water sector

A major investment gap in the water sector exists in many countries. The public sector must increase its investment capacity and strengthen its role as the central enabler of water sector financing. For instance, the public sector could provide subsidies to technological innovations to make water use more efficient, such as occurred in Morocco, with high subsidies introduced for medium and small farms as part of the Plan Maroc Vert programme to expand drip irrigation (Alonso *et al.*, 2019).

The private sector and public-private partnerships (PPPs) can become supporting agents for funding in the NENA region. Apart from closing the financial gap, they can support the development of the agro-industrial sector, incorporating technological advancements, and promote water-saving practices and technologies. In post-conflict areas, PPPs may also initiate or resume construction, maintenance, and the implementation of abandoned projects. The PPP model has been deemed promising in Iraq, for example, to offset the Government's lack of financial resources and take over a series of projects in the country (Khudhaire and Naji, 2021). The private sector is generally more interested in developing market opportunities, when irrigated agriculture offering higher-value crops is pursued. In turn, market-based mechanisms could substantially increase water productivity. A favourable enabling environment for effective PPPs is required to ensure that adequate regulatory mechanisms are in place for investment opportunities (to construct, rehabilitate, upgrade, operate, maintain and manage irrigation infrastructure). For example, ongoing activities in Jordan that follow a market approach are showing promising results in increasing water saving and efficiencies. In Egypt alone, it is estimated that about USD 70 million could be saved if wheat infrastructure were managed and owned by the private sector (McGill *et al.*, 2015).

3.3.3 Wastewater reuse, circular economy

The linear approach to water management (extraction and distribution – usage and collection – treatment and disposal of water) must be acknowledged as obsolete. Rainwater capture and the use of green water (water stored as soil moisture) have been acknowledged as good options to increase water storage in the region (Borgomeo *et al.*, 2020), but require much more exploration. Artificial aquifer recharge and rainwater harvesting via micro-catchment management has shown promising results in terms of water productivity for open crops in Egypt, Jordan and the Syrian Arab Republic (Borgomeo and Santos, 2019).

Acknowledging and developing the role of wastewater is an important step for water supply augmentation. Over 55 percent of the region's wastewater is still discharged as untreated water to natural water bodies (World Bank, 2017a), and even if treated, much of it is still usually discharged directly into the sea. About 82 percent of water remains untreated, or is not used following treatment. Water should not be discarded or wasted under a circular economy paradigm (Toop *et al.*, 2017; Korhonen *et al.*, 2018), where wastewater (and nutrients) is exploited as a new water source for the agriculture sector. Moreover, treated wastewater can be used to recharge aquifers, which can serve to increase groundwater supplies and combat seawater intrusion in coastal aquifers. These circular economy principles offer an opportunity to strengthen links, not only within the agricultural water sector, but also with other sectors, such as energy, environment, finance and sanitation (Rodriguez *et al.*, 2020), in line with SDG 6.3 (reducing untreated wastewater and substantially increasing recycling and safe reuse). Treated wastewater provides key nutrients such as nitrogen and phosphorus needed for crop production. Besides reducing the pollution load on the environment, treated wastewater provides an alternative, nutrient-rich water source that reduces the pressure on freshwater resources (Jurgilevich *et al.*, 2016). Nature-based treatment systems such as lagoons and wetlands provide cost-effective solutions, especially in rural areas where land is abundant and skilled labour is not readily available. However, these systems need to be carefully designed to minimize any impacts on the surrounding ecosystem. The Nimr Water Treatment Plant in Oman, for example, uses a wetland treatment system to filter wastewater for reuse in irrigation.

Agricultural drainage is another water source that can be viewed with a circular economy lens. In Egypt, more than 3 billion m^3 of agricultural drainage water is reused for agricultural production and, in turn, reduces the demand for irrigation water by about 20 percent (Barnes, 2014; World Bank, 2017a). The Mahsama Water Reclamation Plant in Egypt offers a good example in this regard. In other regions, such as Latin America (for example, Chile and Mexico), as well as some countries of the NENA region, wastewater treatment facilities are producing energy, in the form of methane gas. This gas is being used to run electricity operations and in some cases to supply energy for nearby urban centres, thereby generating financial revenues (Rodriguez *et al.*, 2020). Under these circular economy principles, the agricultural water sector can contribute to supporting SDG 7 (affordable and clean energy).

Yet despite these possibilities, the NENA region still lacks a robust diagnostic on the financial implications and overall gains of these directions. The region requires a comprehensive examination of the regional and local-level opportunities (and challenges) for the adoption of circular economy principles for the agricultural water sector.

3.3.4 Resilience-based water planning

Even with improved regional supply, other strategies are required to address current, rapidly evolving and sometimes unpredictable challenges (such as those derived from climate change, population growth, conflicts and COVID-19). Clearly a shift in the agricultural water planning and management paradigm is urgently required. This shift involves the inclusion of resilience principles in the sector, requiring an understanding of agricultural and water systems' capacity to adapt and transform over time and in the face of stress conditions. To enhance resilience, the response, recovery and flexibility of agricultural (and other) water systems when facing crises, resilience-based planning must improve (Wang and Blackmore, 2009; Marshall, 2010; Rodin, 2014). To date, there are no known initiatives in the region where the resilience paradigm has been fully mainstreamed and applied for integral agricultural water systems.

Reliability refers to the probability that agricultural water systems may fail, whereas vulnerability describes how severe such failures could be (Hashimoto et al., 1982).

Robustness allows for measurement under potential scenarios (climatic, demographic, demand, geophysical and others) at which the performance levels are maintained (Herman et al., 2015).

3.3.5 Valuing water and virtual water trade

In the NENA region, the adequate pricing of water (reflecting its scarcity) is deemed to be an important step towards addressing the growing water scarcity (World Bank, 2017a), in order to deter wastage and overexploitation. Other linked strategies include switching to crops that consume less water and produce higher returns (such as high-value horticulture or fruits and vegetables) (Scheierling *et al.*, 2006; OECD-FAO, 2018). It has been estimated that a 30 percent reduction in agricultural water withdrawals in the region would translate into USD 68 billion in gains, or 2.5 percent of the regional GDP (World Bank, 2017a). That same 30 percent reduction in agricultural water withdrawals would reduce water stress for about 9 million people in NENA.

Virtual water trade can be a driver for increasing water productivity in agriculture and the returns generated by the sector (FAO-RNE, 2015; Borgomeo and Santos, 2019). This requires support for exports of high-value crops, which in turn provide revenues. Such revenues could then be used to import low-value or high-water-demand crops (thereby influencing water productivity). With integration in other sectors, such a process can contribute to job creation, leading to broader economic benefits. Maximizing crop values rather than focusing on trade deficits is a sensible strategy, which may provide high water returns and also support development in other sectors. Countries in the region that have already made significant strides towards pursuing virtual water trade strategies include Jordan, Morocco and Tunisia. Morocco, for example, reduced its food trade deficits by USD 1.3 billion between 2007 and 2009 by encouraging exports of high value-added products, such as fruits and vegetables (Borgomeo and Santos, 2019). However, caution is required in middle and low-income countries, where subsistence farming is extensive. Without adequate strategies in place, cheap food imports may reduce local agricultural jobs or weaken the control of communities over their local resources and food preferences (Vos and Boelens, 2016). Maystadt and Ecker (2014) warn that a high dependence on food imports may also compromise food security, leading to social instability. For example, Soffiantini (2020) indicates that the rise in food prices was strongly associated with social unrest and protests in 2011 in Egypt, Morocco and the Syrian Arab Republic, in the so-called Arab Spring. Appropriate protection measures, such as the expansion of social safety nets, targeted nutrition programmes and the reduction of food trade deficits should accompany virtual water trade.

Another market-type approach relates to the trading of water rights. This scheme allows established water users to buy, sell and transfer their rights, depending on their needs and circumstances. These schemes have proved to be efficient in managing water amongst agricultural uses under conditions of scarcity in other regions (Wheeler and Garrick, 2020). Yet testing of such approaches in the NENA region requires careful assessment of their applicability, and more particularly the socioeconomic and environmental impacts on society. The success – or failure – of market and trade strategies relies on clear and adequate legal, regulatory and institutional frameworks. Unclear regulatory frameworks are constraining the progress of directions in countries where water rights and permits are still vaguely defined, and are frequently tied to land ownership and transferred with property (Suárez-Varela *et al.*, 2018). See also section 6.2.1.

3.3.6 Narrowing gender inequality gaps

Country-level policies should also acknowledge gender, as well as environmental and social equity considerations when evaluating protections for trade-based strategies. The implications of water trade on social settings require careful balancing, in order to put adequate safeguards in place that ensure social, economic and environmental cohesion and stability. Women in the region play an important role in water management. They are often the collectors, users and managers of water in the household, as well as farmers of irrigated and rainfed crops. As a result of these roles, women have considerable knowledge about water resources, including quality and reliability, restrictions and acceptable storage methods. Review of the agricultural water sector in the region (Fortmann, 2009; World Bank, 2017b) suggests some actions to be prioritized, including:

- expanding women's access (including ownership) to land and rural finance;
- better options for inclusion of women in agricultural value chains, from crop production to processing and marketing;
- improving women's access to information, training, skills and general knowledge of techniques throughout value chains; and
- the overall production and use of knowledge to guide and promote gender equality in the sector.

Taking one example from the NENA region, market reforms in Jordan, such as lifting price controls and liberalizing external trade to benefit agro-industrial transformations, have gone hand-in-hand with the increasing participation of rural women in the sector (Figueroa *et al.*, 2018). The SDGs call for leaving no one behind. The poorest do not obtain fair access to water or land resources (especially during conflict, disruption or challenging times). Equity metrics are required to evaluate not only how rapidly an adequate level of service is re-established during crises, but also the way in which water is allocated and distributed across various users.

3.3.7 New generation of institutional and policy designs

Clearly, policy reform is required to address the water scarcity challenges and strategies outlined in this chapter. The coming decade is critical, not only for COVID-19 recovery, but also due to climate targets and the pressure to achieve the SDGs. If policy coherence is pursued, it can lay the foundation for linking the agricultural water sector with other issues, such as gender equality, environment, trade and jobs and health. Country-level analyses of the trade-offs and opportunities that result from the adoption of specific sectoral policy reform are required to ensure that actions, which may appear beneficial to the agricultural water sector, do not lead to collateral effects on other SDGs.

Under the auspices of the League of Arab States (LAS) (see Box 3.3) efforts have been made to institutionalize coordination between the water and agriculture sectors at the wider regional level. However, the region still lacks strong policy instruments that link the agricultural water sector with climate adaptation and mitigation. Under the Paris Agreement, NDCs can offer opportunities for the sector to integrate water, agriculture and climate agendas. Many countries have already included efficient water resource management in their NDCs (Djoundourian, 2021). regional actors such as the LAS have a catalytic role to play in the coordination of these strategic initiatives and efforts. Such actors can exert a top-down influence to shape regional policy directions, while also reinforcing a bottom-up approach by sharing successful experiences of individual countries (Al-Sarihi and Luomi, 2019).

BOX 3.3 A PROMISING APPROACH TO COORDINATION FOR ARAB REGION WATER AND AGRICULTURE SECTOR POLICY COHERENCE

In response to the challenges associated with water and food security in the Arab region, the League of Arab States, supported by FAO and ESCWA, has institutionalized coordination between the water and agriculture sectors through the establishment of a High-Level Joint Technical Committee. This committee informs meetings of two regional ministerial councils (the Arab Ministerial Water Council and the General Assembly of the Arab Organization for Agricultural Development (AOAD), comprising Ministers of Agriculture). The first Joint Meeting of Arab Ministers of Agriculture and Water was held in Cairo on 4 April 2019. During this meeting, the Joint Ministerial Council adopted a resolution that formally established the High-Level Joint Technically Committee and a Joint Secretariat comprising AOAD and the Technical Secretariat of the Ministerial Water Council. The mandate and procedures of this coordination mechanism were also established. The joint ministerial resolution adopted the Cairo Declaration, which acknowledged the necessity of enhancing coordination and collaboration between the water and agriculture sectors, as well as the need to develop a new generation of policies and innovative investments in the agricultural water sector in the region. The resolution also called for enhanced policy coherence through reviews of sectoral policies on cross-cutting issues, including water allocation, non-conventional water resources, trade and social protection, in order to achieve water and food security in the Arab region.

The Joint Technical Secretariat, FAO-RNE and ESCWA have been working closely with the Joint High-Level Joint Technical Committee to improve and activate collaboration between the water and agriculture sectors and put the Cairo Declaration into practice. In this regard, the first High-Level Joint Technical Committee meeting was convened in October 2019 to identify and prioritize cross-cutting issues for the Water and Agriculture Ministries and recommend follow-up actions to operationalize the Declaration. One of the first cross-cutting issues that the committee decided to incorporate into its agenda was water allocation for agriculture. In response, guidelines for the sustainable allocation of water for agriculture are being developed with assistance from FAO and ESCWA. Supported by FAO, the Joint Secretariat has developed a draft action plan to operationalize the Cairo Declaration. Both the draft action plan and the water allocation guidelines for agriculture were reviewed by the Joint High-Level Joint Technical Committee in October 2021, and the draft action plan and guidelines are likely to be endorsed in the next meeting of the Joint ministerial council.

Source: M. Al Hamdi, personal communication, 2021

3.3.8 Innovative approaches and technology options

Community-led and so-called 'nature-based solutions' hold potential, including for sustainable solutions to water resource use. Countries in the region could learn from successful local experiences in order to implement them on a broader scale. For example, spate irrigation often provides an important alternative water source in rural areas where aridity prevails (Bashir, 2020). Attention should be paid to community-based micro-water harvesting techniques using landscaping and indigenous knowledge that support environmental protection. Community-based approaches and nature-based solutions must be embedded in policy and social frameworks, so that their potential can be reached. For example, the Government of Jordan acknowledges the potential of water harvesting as part of its national water strategy (Ministry of Water and Irrigation, Jordan, 2016).

Renewable energy-powered pumps represent a cost-effective and environmentally clean alternative to water supply for irrigation. Pilot projects in Egypt, Morocco, Saudi Arabia and Yemen emphasize the cost-effectiveness of solar pumping to both governments and farmers (Sahin and Rehman, 2012; Mahmoud *et al.*, 2017; Borgomeo and Santos, 2019). However, they need be monitored and governed according to the sustainable limits of aquifers, so that they do not accelerate the depletion of groundwater resources (Shah *et al.*, 2018).

The agricultural water sector (and other sectors) could also benefit from advances and innovations in desalination technologies. In Palestine, for example, public authorities have led pilot studies that show how desalinated water could be beneficial to the agriculture sector in terms of water efficiency (FAO, 2019e). Private investments in desalination for cash crop production exports in Morocco is a case that requires closer examination, as it could pave the way for similar initiatives elsewhere in the region. Yet as desalination is energy intensive, its use has mostly been limited to the region's wealthier countries. High environmental impacts associated with the disposal of brine water resulting from the desalination processes are considerable constraints when considering this option. Various efforts that seek to utilize renewable sources (as opposed to fossil fuels) to sustain the energy costs of the process would help to minimize some of its negative economic and environmental impacts (Alklaibi and Lior, 2005).

The development of farming practices in controlled environments and use of hydroponic systems are also promising in water-scarce regions. With this latter technique, plants are grown using controlled amounts of water and fertilizer. This controlled environment can reduce water consumption by more than 80 percent compared with open field irrigation (Verner *et al.*, 2017).

The concept of climate-smart agriculture (CSA) embraces sustainable agricultural productivity and income, resilience to climate change, and greenhouse emissions reduction. Smart practices include examining stress-tolerant crop varieties, conservation practices, improved home gardens, and small-scale irrigation. While CSA is covered in detail in Chapter 5, suffice to state here that CSA highlights the need to transform and reorient agricultural systems to ensure food security (FAO, 2019f).

3.3.9 Evidence and data requirements

To overcome data gaps, more attention is now being paid to accessing 'big data sets'. Such data sets have been developed by international organizations, often through global and regional projects. These include FAO-AQUASTAT, FAO WaPOR and Earth Map, the Hand-in-Hand geospatial platform, WRI-Aqueduct, World Bank Climate Change Knowledge Portal, World Meteorological Organization databases, and precipitation reanalysis products (for a full review, see Sun *et al.*, 2018).

The use of remote sensing data is probably the fastest growing technology in the agricultural water sector, and can help to close the data gap in the region. A series of free and rapidly available data sets and portals can be used to assist with the mapping of resources and assessment of water consumption in NENA. For example, the National Aeronautics and Space Administration's Earth Observatory and the European Union Copernicus Data and Information Access Services platforms are important allies in retrieving satellite information. Data can be used to obtain water balances at various scales and thematic maps for the sector, and then monitor changes and crop and water patterns, supporting data collection in areas where data are typically scarce or unreliable. Traditional remote sensing tools offer opportunities for mapping the sector at the regional scale. Progress in information and communication technology (ICT) has played a crucial role in supporting farm-level decisions and practices (Hussmann, 2018). Tools include unmanned aerial vehicles, digital soil mapping surveys, digital agriculture technologies, internet of things, and mobile phone applications. Used together, these tools could provide data on soil moisture, status of irrigation, crop yields, pests and harvest times, to name a few. The evidence should inform enhanced water assessment, allocation and management for agriculture.

Finally, a notable regional effort to assess the impacts of climate change on agriculture, water and other sectors is the regional Initiative for Climate Change Impacts on Water Resources and Socioeconomic Vulnerability in the Arab region, (RICCAR), which is presented in Chapter 5. This platform provides climate-related data and analysis, and serves as a knowledge hub for decision-makers, practitioners and the overall public.

PART II: ELABORATION ON WATER, SOIL, CLIMATE CHANGE IMPACTS AND THE URBAN-RURAL INTERFACE

4 RESTORING LAND AND SOIL HEALTH FOR SUSTAINABLE AGRICULTURE

©FAO/Essam Alkamaly

KEY MESSAGES

- **The estimated cost of land degradation has been valued at USD 9 billion per year in the NENA region** (between 2000 and 2015). Land degradation has reduced the potential productivity of soil by about one-third in recent years.
- **Degradation of rangelands in the Arab countries has been estimated at 3.3 percent of land area.** Sixteen NENA countries mention forest- and rangeland-related adaptation in their NDCs as measures to address climate change.
- **Salt-affected soils in the NENA region cover 11.2 percent of total land area.** There is significant variation of salt-affected soils and secondary salinization among NENA countries.
- **Inappropriate use of agro-chemicals adversely affects soil fertility and water quality in the region.** Six NENA countries are among the world's top 20 countries in terms of fertilizer consumption, expressed in kg/ha of arable land. The region applied more than 43 000 tonnes of pesticides in 2018.
- **The NENA region is highly prone to sand and dust storms (SDS).** These cause losses of GDP estimated at about USD 13 billion every year. It is estimated that almost 94 million tonnes of dust per year is generated by SDS in the Middle East and that 80 percent of it is deposited within the area.
- **Some NENA countries do not have sufficient regulatory frameworks for governing land tenure and land-use rights.** Urbanization is increasing in many NENA countries, with cities encroaching on the best soils and impacting agricultural production.
- **Conflicts have a direct adverse impact on land use and management.** Refugees and IDPs add pressure on the land in the areas where they settle, leading to land degradation and desertification. A recent FAO study covering six conflict-affected countries found strong correlations between conflict densities and the percentage of degraded land.
- **Fourteen countries in the region have set voluntary targets to achieve land degradation neutrality (LDN) by 2030.** LDN is related to Target 15.3 of the Sustainable Development Goals.
- **The UN Decade on Ecosystem Restoration (2021–2030) provides a focus for mainstreaming rehabilitation approaches in the NENA region.** An estimated 3.5 million km² of land are potentially suitable for better sustainable land and water management (SLWM) practices (irrigated, rainfed and rangeland agro-ecosystems). The FAO Voluntary Guidelines for Sustainable Soil Management (VGSSM) suggest practices that lead to minimizing soil erosion, enhanced soil organic matter content and soil biodiversity to foster soil nutrient balance and cycles, and improved soil water management.
- **Digital innovations offer plenty of opportunities for the region.** The use of digitalization, remote sensing data, information technology and knowledge management systems can help to avoid, reduce, restore and monitor soil health. Digital soil information systems are useful for harmonizing soil maps and disseminating good practices in soil management.

Introduction

Managing soils and land is critical for sustaining local communities in rural areas and achieving food security, while safeguarding the environment. With a scarcity of available land suitable for agriculture, this is even more imperative in the NENA region. This chapter provides an overview of soil issues and challenges in the region, as well as responses that align with more sustainable management systems. Starting with an explanation of why soil health is an important concept, section 4.1 provides an overview of the status of soils in the region, outlining degradation trends and threats to soil. Global policy processes that affect land restoration and soil health are also summarized. Section 4.2 describes the key drivers of soil degradation (biophysical and environmental degradation, socioeconomic factors, unsustainable agricultural practices). The final section presents a range of technical, social and policy responses, providing examples from the region.

4.1 Status of soil in the NENA region and trends

4.1.1 Soil health linkages to food security

The concept of soil health, which includes the quality of air, water, vegetation, biota and how they impact the health of soil, plants, animals, and people, has led to the introduction of the One Health concept that has been useful for understanding the relation between soil, environment, plants, animals, people and the planet.[30] Over the past decade, the phrase 'soil health' has been widely used to describe soil functions and services (European Commission, 2020). Activities such as deforestation, biomass burning, excessive soil tillage, indiscriminate use of agro-chemicals, overgrazing, and extractive farming practices have accelerated soil degradation. Indirectly, soil health may impact human health through contamination of water and air. For instance, soil pollution by industrial effluents and urban waste can impact the nutritional quality of food, which can deteriorate with heavy metals in soils, a deficit of essential micronutrients, or contamination by pests and pathogens. Such deterioration is present in the NENA region, impacting soil health and food security.

4.1.2 Soil characteristics in the region

The characteristics of soil types and scarcity of vegetation are determined by the dominant geomorphologic[31] processes and pedoclimatic conditions.[32] Soils of NENA can be grouped in two major pedoclimatic domains: (i) areas with aridic climate and dry conditions,[33] and (ii) areas with xeric conditions, tolerated or adapted to dry conditions.

i. Soils under aridic conditions are located mostly in the Arabian Peninsula, including Bahrain, Iraq, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen (European Commission and FAO, 2021), as well as in large parts of Algeria, Egypt, Libya, Mauritania and Sudan (Jones *et al.*, 2013). In the Arabian Peninsula and the Gulf (Bahrain, Iran, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen), sandy desert soils are widely distributed (FAO and ITPS, 2015).[34]

ii. Soils with xeric conditions are located mostly along the Mediterranean coast of

[30] See www.who.int/news-room/q-a-detail/one-health

[31] Form of landscape and other natural features and sediments on the surface of Earth.

[32] A microclimate within soil that integrates the combined effects of its temperature, water content and aeration.

[33] More evaporation over precipitation, desert-like with little moisture.

[34] Arenosols or sandy soils, are widespread in Saudi Arabia, extending over 30 percent of its land area (650 000 km2), while in United Arab Emirates they cover 80 percent of the country.

North Africa and the Middle East (Algeria, Egypt, Jordan, Lebanon, Morocco, Palestine, the Syrian Arab Republic, Tunisia, and partially in northern Iraq).

4.1.3 Land degradation trends and livelihood impacts

Land degradation negatively impacts the livelihoods of 3.2 billion people globally, causing losses of 10 percent of annual global gross product (IPBES, 2018a). In NENA, the cost of land degradation has been estimated at USD 9 billion per year (FAO and ITPS, 2015). While more recent and in-depth estimates across the NENA region are required, earlier studies (Sarraf *et al.*, 2004) on the annual cost of land and wildlife degradation indicated a loss of 0.6 percent of GDP for Lebanon in 2000, which corresponds to USD 100 million per year. In Tunisia, the cost of land and wildlife degradation was estimated at 0.52 percent of GDP (TND 129 million or USD 44.6 million). Different situations are evident across NENA countries, with Kuwait and Iraq experiencing 64 and 26 percent of degraded land, respectively, in 2015 (FAOSTAT, 2021). Estimated soil erosion rates in NENA are on average 1–2 times greater than rates of soil formation. Many experts warn that the depletion of soil as a non-renewable resource could become extremely critical for the region (Montgomery, 2007; Stockman *et al.*, 2014, FAO and ITPS, 2015). In recent years, land degradation in the NENA region is thought to have reduced the potential productivity of soil by about one-third (ESCWA, 2017).

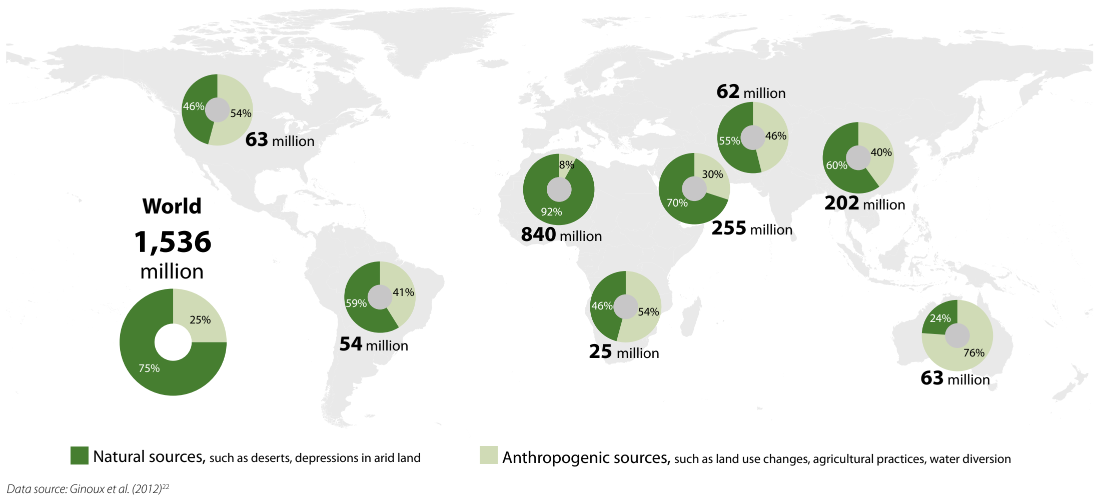
4.1.4 Threats to soil in NENA

The most common soil threats in NENA are explored below, namely soil erosion, salinization and sodification, organic carbon change and soil contamination.

Soil erosion by water: Water erosion is caused by improper land use and management, especially in hilly areas and on sloping agricultural lands. Continuous cultivation of arable lands, exploitative tillage practices (on slopes), absence of intercropping and crop rotations, and destruction of vegetation cover contribute to soil erosion. Soil nutrient losses, and organic carbon followed by a decline in crop productivity, sedimentation of reservoirs, flash floods and diminished ecosystem services are some of the associated consequences of erosion. Since 2002, Abahussain *et al.* have identified Sudan, Yemen, Algeria, Tunisia, Morocco, Oman, Libya, the Syrian Arab Republic and Iraq as the countries most affected by water erosion in NENA, (arranged in order of surface area affected). Later reports show that erosion by water continues to be a persistent threat to NENA soils (FAO and ITPS, 2015).

Soil erosion by wind: Wind erosion is another severe process in the NENA region. The annual rainfall of less than 150 mm, and limited vegetation growth, which is under grazing pressure, exacerbates wind erosion, affecting approximately 60 percent (or 135 million ha) of the soil surface (FAO and ITPS, 2015). Saudi Arabia, Libya, Sudan, Mauritania, Algeria, Yemen, Tunisia, Oman, Jordan, the Syrian Arab Republic, Iraq and Egypt are most impacted by soil erosion caused by wind (arranged in order of surface area affected) (Abahussain *et al.*, 2002). A direct consequence of wind erosion is sand and dust storms, which take place when highly erodible dry bare soils and sediments are affected by strong winds. Such storms are governed by both human-induced and natural factors, and have attracted growing attention in past decades due to transboundary impacts. An *IPCC Special Report on Climate Change and Land* (2019) indicates that the frequency and intensity of dust storms have increased over the past few decades due to land-use and land cover changes, and climate-related factors in many dryland areas. Figure 4.1 indicates the global sources of dust emissions, indicating the NENA region's susceptibility to SDS.

FIGURE 4.1 SOURCES OF DUST EMISSIONS (TONNES/YEAR)



Source: United Nations Environment Programme (UNEP). 2017. *Sand and dust storms: Subduing a global phenomenon.* UN Environment Frontiers 2017 Report. https://wedocs.unep.org/bitstream/handle/20.500.11822/22267/Frontiers_2017_CH4_EN.pdf?sequence=1&isAllowed=y

The NENA region is highly prone to SDS as it faces three contributing constraints: aridity, recurrent drought and desertification. Some alarming statistics include:

- An estimated 94 million tonnes of dust per year is generated by SDS in the Middle East and 80 percent is deposited within the area (FAO, 2015b).
- Iraq experienced an average of about 122 dust storms and 283 dusty days in one year.
- In the Middle East, 30 percent of dust emissions are anthropogenic (UNEP, 2017) due to unsustainable practices in the crop, livestock and forestry sectors.

Economic losses from sand and dust storms are significant. For example:

- The NENA region loses about USD 13 billion in GDP each year due to dust storms (UNEA).
- Dust storms between 2000 and 2005 in the southeast Sistan region of Iran led to losses of around USD 125 million (Miri *et al.*, 2009).

Sand and dust storms also contribute to soil degradation through the transport and deposition of salt-rich or polluted dust particles eroded from saline or polluted ground. Prevention and mitigation measures at local level are required to mitigate the negative effects of SDS. FAO is currently gathering information from five sand and dust storm-affected countries, in order to set up a large-scale programme.

Soil salinization and sodification: Salinization is both a natural and human-induced process, but is accelerated by patterns of water use. Annual economic losses from salinity in the region are estimated at USD 1 billion (FAO and ITPS, 2015). Globally, annual crop production loss caused by salt-induced land degradation in irrigated areas has been estimated at USD 27.3 billion (Qadir *et al.* 2014). The percentage of soil salinization in the NENA region varies from country to country, as can be seen from the examples below, drawn from various sources (FAO and ITPS, 2015; Global Soil Partnership, 2014; Goma, 2005):

- Salinity is a major issue in Sudan, with 23 percent of the land area exposed due to low precipitation and high evaporation rates.
- Salinization and waterlogging affect around 50 percent of reclaimed lands in the Euphrates plain in Iraq and the Syrian Arab Republic.
- Salinization and waterlogging effects are responsible for 25 percent of yield reduction in Egypt, where more than 1 million ha are turned saline by the overuse or salty drainage water reused for irrigation.
- Salinization is a major hazard in Saudi Arabia, with 54 percent of the cultivated area moderately affected.
- Secondary salinization is affecting 10–15 percent of total irrigated land in Algeria.
- Secondary salinization due to irrigation is an increasing concern in agricultural soils, which in Iraq affects about 75 percent of cultivated land.

Soil organic change: The decline of organic matter and soil fertility are other degradation challenges. Drylands store much less organic carbon per hectare than humid regions, but the vast surface area that they cover globally (nearly 40 percent of land cover) make them a highly significant global carbon sink (Zdruli and Zucca, 2018).[35] Weather variability, drought and depleted vegetation are dominant causes of the decline in soil organic matter. According to FAO and ITPS (2015), predicted organic carbon stocks in the world's soils have been estimated to comprise 1 500 petagrams of carbon down to 1 m depth and 2 500 petagrams down to 2 m.[36] In the Arab countries, despite the dry and arid conditions that characterize the region, the average soil organic carbon stock is in the range of 37 ± 36 tonne/ha in the topsoil and 78 ± 69 tonne/ha in the standard soil depth. Sudan, Saudi Arabia and Algeria are the 3 out of the 22 countries of the Arab region with the highest total organic carbon stock due to their larger territories, followed by Libya, Mauritania and Egypt. Water erosion and urban sprawl caused annual losses of 25 and 53.6 GT tonnes of organic carbon (Darwish and Fadel, 2017).

Contamination of soil: Soil pollution is caused by unsustainable agricultural practices, namely the overuse of pesticides and fertilizers, as well as inadequate waste management from industrial activities. A reduction in soil fertility followed the construction of the High Dam in Egypt, and farmers increased their use of inorganic fertilizers to counterbalance the reduction of sediment load. The Nile River is now burdened with high levels of nitrogen and phosphorus from agricultural activities and from industrial waste originating from sugar factories, cement and fertilizer plants (FAO and ITPS, 2015). Similar contamination processes are occurring along other river watersheds in the NENA region. Land-based pollutants are responsible for the increased contamination of coastal zones through riverine inputs across the Mediterranean (UNEP-MAP and Plan Bleu, 2020).

4.1.5 Linkages with global policy processes

The 2030 Agenda for Sustainable Development, and more specifically, land degradation neutrality (LDN) and the Paris Agreement, are examples of key global policy processes that link to natural resource management. The situation across NENA in terms of country commitments to global policy processes and LDN reporting varies. Most countries have set voluntary targets to achieve land degradation neutrality by 2030, which refer to the conservation and restoration of degraded lands, raising levels of carbon stock, and improvement in legislative and institutional frameworks.[37] Only half of these countries have set specific LDN targets.

[35] The potential for storing organic carbon in dryland soils may be comparable on a per hectare basis to that of humid areas because, in comparison with soils in humid regions, dryland soils have suffered previous higher losses of soil organic carbon from degradation (Farage *et al*., 2007) so there is 'sink capacity' to be filled.

[36] A petagram is a unit of mass equal to 1 000 000 000 000 000 (1015) grams.

[37] Algeria, Egypt, Iraq, Jordan, Kuwait, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Tunisia and United Arab Emirates.

The others have not yet taken any measures (NEFRC, 2019). Following the adoption of the Paris Agreement (on climate change) in 2015, a FAO analysis indicated that many countries included mitigation and adaptation targets for the agriculture sectors (crops, livestock, forestry, fisheries and aquaculture), explaining that these sectors are important in their response to climate change. As described further in Chapter 5, sustainable land and water management has been identified by many countries as part of efforts to achieve climate change targets through the NDC process (FAO, 2018e), with countries referring to adaptation action in the Agriculture sector, and mitigation targets/actions in Agriculture and/or Land Use, Land-Use Change and Forestry (LULUCF) (FAO, 2017d). LULUCF and Agriculture have been highlighted as important target sectors for reducing GHGs. Examples of countries that have set quantified afforestation/reforestation targets to enhance their carbon sink are Jordan (25 percent of barren forest areas by 2030); Morocco (50 000 ha per year up to 2030); and Sudan, which has set a target of 790 795 ha annually to reach 25 percent forest cover by 2030 (NEFRC, 2019).

15 LIFE ON LAND

SDG Target 15.3 is to protect and restore terrestrial ecosystems and promote sustainable use. The focus is on deploying tools and strengthening countries' capacities in regular data collection and analysis through appropriate methodologies and databases (Liniger *et al.*, 2018). **SDG Indicator 15.3.1** concerns the proportion of land that is degraded over total land area (%).

Land degradation neutrality (LDN) *is strongly linked to Target 15.3 of the SDGs. Countries aim to achieve LDN by addressing the mismanagement of land resources through sustainable forest and rangeland management. These can play a pivotal role in halting land degradation.*

4.2 Drivers of soil degradation

Land degradation and desertification are driven by a combination of natural processes and human-induced factors, including climatic, pedologic, socioeconomic, institutional and policy aspects. This section looks at a range of drivers to soil degradation, including biophysical factors, socioeconomic factors and unsustainable agricultural practices, as well as issues related to governance and policy.

4.2.1 Biophysical factors and climatic constraints

Variations in temperature and rainfall patterns represent a massive threat to food security by affecting crop yields. Climate change and recurrent severe droughts are among the major problems facing many countries in the region. As outlined in Chapters 2 and 5, the NENA region is expected to be one of the hotspots for worsening extreme heat, drought and aridity, and a higher frequency and intensity of floods, droughts and extreme weather events has already been experienced (ESCWA *et al.* 2017a). Soil health can be adversely impacted by climate change. Effects include a reduction in the amount of organic matter in the soil; a deterioration in the structure of soil; and an increase and vulnerability to erosion, along with other degradation processes. Climate change will also cause sea level rise in coastal areas, leading to an increase in groundwater salinization as water moves further inland, compromising freshwater used for agriculture. Sea water intrusion into aquifers is also an issue of concern.

Inadvertently, reduced precipitation coupled with increasing heat will cause land degradation and desertification. Frequent droughts and an increase in evaporation will impact soil ecosystems that are necessary for the growth of plant cover in general and field crops in particular. For example, in Morocco, climate change and prolonged droughts are increasing soil degradation and desertification, threatening 80 percent of the land. In fact, Morocco (and Tunisia) almost doubled their cereals imports in 2000–2001 due to drought and in order to meet food demands (FAO, 2018a). Drought in a country is often followed by famine, rural displacement, immigration, social disruption and conflicts over the resource base (FAO, 2018a).

4.2.2 Socioeconomic factors and overuse of land

Poverty in rural areas: Poverty in the NENA region is more prevalent in rural areas and has links to soil and land degradation. The rural poor tend to have less access to productive fertile lands and are often pushed onto marginal lands or lands that are excessively used, leading to further land degradation.[38] Land degradation in turn exacerbates poverty, as poor households get diminishing returns on their land. Rural people represent more than two-thirds of the poor population and over four-fifths (approximately 83 percent) of the acutely poor population (ESCWA *et al.*, 2017c). The COVID-19 pandemic has caused an increase in poverty, which is estimated to affect more than 115 million in the region (FAO, 2020f). The NENA region's economy had already shrunk by 5.7 percent by 2020, with the economies of some conflict countries projected to contract by 13 percent and endure an overall loss of USD 152 billion (FAO, 2020f). These projections will invariably lead to an overuse of available resources, including soil and land resources, leading to further land degradation.

Conflicts: Social and political conflicts are ongoing and frequent in the NENA region, with negative effects on people's lives and on natural resources. There have been continued outbreaks of violence since the Arab Spring in 2011. The devastating armed conflicts in Iraq, Libya, the Syrian Arab Republic and Yemen have led to widespread food insecurity, with massive displacement. Jordan and Lebanon host about 46 per cent of all refugees (including asylum-seekers) in the region (UNDESA, 2020). Host locations experience substantial pressure on natural resources, including land and water, and the effects of conflict have severe repercussions for farmers and rural populations, disrupting livelihoods. A case in point is the Darfur region of Sudan, where 2.4 million people were displaced in 2007 (IDMC, 2007).[39] Conflicts affect land use and management in two ways:

- Refugees and internally displaced persons (IDPs) put excessive pressure on the land in the areas where they settle, leading to land degradation and desertification.
- The areas that IDPs have abandoned may show some improvements in vegetation cover and the status of soils.

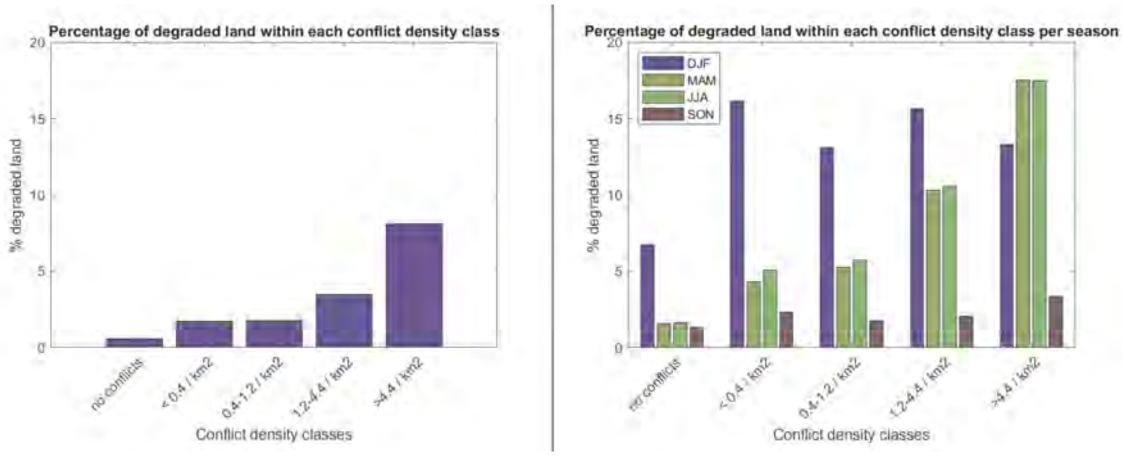
One study that developed vegetation trend maps for six conflict-affected countries (Iraq, Lebanon, Libya, Sudan, the Syrian Arab Republic and Yemen) found strong empirical correlations between conflict densities and the percentage of degraded land (see Figure 4.2) (FAO, 2020d).[40] The relation confirms that with higher conflict density, the multiannual trend values become more and more negative, indicating strong land degradation.

[38] Aside from a lack of income and productive resources, manifestations of poverty include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion, as well as lack of participation in decision-making.

[39] The conflict in the Darfur region, which initially started over natural resources and escalated to a political armed conflict, caused the death of several hundred thousand people and led to the huge number of internally displaced persons of whom 1.6 million people are still unable to return home (UNHCR, 2020b)

[40] The impact of the war on natural resources becomes visible when correlating conflict density using Armed Conflict Location and Event Data (ACLED), a disaggregated data collection, analysis and crisis mapping project (Raleigh, *et al.*, 2010) and which has remotely observed degradation trends.

FIGURE 4.2 PERCENTAGE OF DEGRADED LAND FOR SIX DIFFERENT CONFLICT DENSITY CLASSES (LEFT) AND PERCENTAGE OF DEGRADED LAND PER SEASON (DJF STANDS FOR DEC-JAN-FEB, ETC.) (RIGHT).[41]



Source: FAO. 2020e. Forthcoming. Effect of conflicts on forests and rangelands. Assessment report prepared for FAO regional Office for the Near East and North Africa. Cairo.

Urban sprawl and inadequate land-use planning: A process of urban sprawl is evident in many NENA countries, particularly in conflict- and drought-affected countries.[42] The *Atlas of Urban Expansion* has recorded very high annual percentage rates of urban expansion for some NENA cities up to 2014 (Lincoln Institute of Land Policy *et al.*, 2014).[43] This issue is covered in more detail in Chapter 6, but one example from Sudan is given in Box 4.1.

BOX 4.1 URBAN EXPANSION IN SUDAN

Sudan is witnessing continuous loss of its fertile lands due to urbanization, which is affecting large areas along the River Nile and its tributaries. The uncontrolled urban expansion of Khartoum City has led to the progressive reduction of available fertile land. This process causes major problems for inhabitants whose main income comes from agriculture (Zerboni *et al.*, 2020). Almost a decade ago, Abdel Magid and Siddig (2012) had indicated that about 9 712 ha of protective shelterbelts established around major cities and towns in Sudan had been lost to urban sprawl and unplanned settlement.

Source: Abdel Magid, T. D. & Siddig, A. J. 2012. *Development strategy of the traditional rain-fed agriculture: Forestry sector.* Zerboni *et al.*, 2020.. *The Khartoum-Omdurman conurbation: A growing megacity at the confluence of the Blue and White Nile Rivers.*

[41] The conflict density information is derived from the ACLED database and depicts the number of conflicts per 5x5 km² area during for the available reporting time (2017–2018).

[42] Furthermore, unlike in sub-Saharan Africa where refugees have mostly settled in rural areas, 84 percent of refugees In the Near East and North Africa are resettled in urban areas (FAO, 2018c).

[43] For example, the following percentage urban expansion rates have been recorded: Khartoum 7.2, Marrakech 5.6, Sana 2.8, Riyadh 4, Baghdad 2.2, Cairo 2.7 and Algiers 2.5.

4.2.3 Governance and land acquisition

Land tenure refers to the conditions under which land can be occupied, held or managed, by whom and for how long. It can be expressed in physical, socioeconomic and governance terms that include land acquisitions or transactions. As outlined in section 2.3.2, a relatively recent trend is large-scale land acquisitions of agricultural land, particularly in Africa. Morocco, for instance, is a recipient country of land acquisitions, with internal support for this form of foreign investments if accompanied by employment and domestic productivity (Mahdi, 2014). In Sudan, large areas of lands adjacent to the Nile or along seasonal water courses (which are traditionally considered grazing areas for local agropastoral communities) are leased to foreign investors for long periods at minimal rates. For the investors and their countries, such land acquisition processes are attractive, as they compensate for natural resource deficits at a low cost. Some NENA countries may not yet have adequate regulatory frameworks for governing land tenure and land-use rights.

4.2.4 Unsustainable agricultural practices

A range of unsustainable agricultural practices are practised in NENA. The following is a discussion of some practices such as overgrazing and deforestation, as well as the inappropriate use of pesticides and fertilizers.

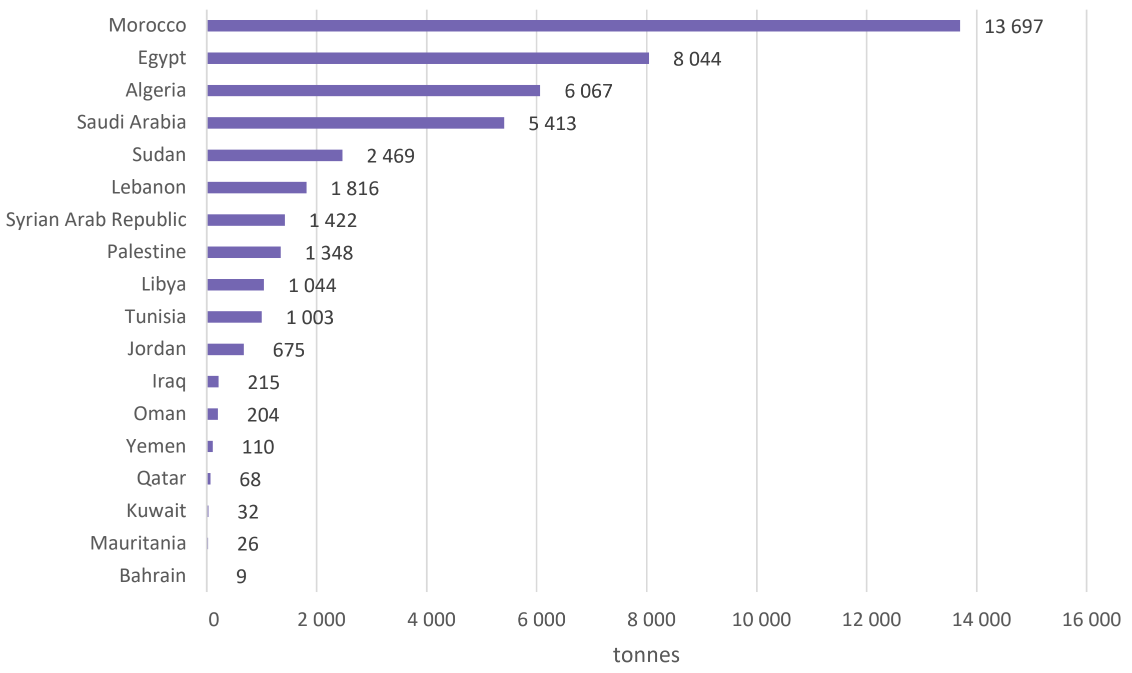
Overgrazing and deforestation: Overgrazing leads to loss of vegetation cover and soil organic carbon, thus reducing land productivity, and accelerates erosion. The process is accentuated by uncontrolled grazing, unregulated numbers and movement of herds, as well as undefined tenure and user rights of the rangelands. Many government policies have led to the abolition of traditional rangelands management systems, replacing them with a collective open-access grazing system. This weakens land-use rights and enables the excessive use of rangeland resources. Darfaoui (2018) estimated rangelands degradation in the Arab countries at 3.3 percent of regional land area during the period 2000–2015.[44] Mauritania, Iraq, Tunisia and Morocco show the highest degradation rates (30, 23, 20 and 16 percent, respectively). The NENA region lost 6 percent of its forest cover between 1990 and 2020.[45] This is equivalent to an annual loss of 0.2 percent (FAO, 2020e). Four NENA countries (Lebanon, Morocco, the Syrian Arab Republic and United Arab Emirates) signed the Glasgow Leaders' Declaration on Forests and Land Use in November 2021, to halt and reverse forest loss and land degradation by 2030. The Declaration is considered a significant step in delivering sustainable development and promoting inclusive rural transformation.

Use of pesticides: Excessive pesticide use can have a number of environmental implications, affecting soil and water quality. Inappropriate use of pesticides is a regional challenge, with NENA accounting for use of more than 43 000 tonnes in 2018. Global annual pesticide use in 2017 was 4 113 591 tonnes (FAO and UNEP, 2021). Figure 4.3 indicates that Morocco ranked first in NENA, with almost one-third of total regional consumption of pesticides. Egypt, Algeria and Saudi Arabia featured high on the list. According to a FAO and UNEP report (2021), when calculating the application of pesticides per area of cultivated land, Egypt has the region's highest consumption level (2.15 kg/ha). There are significant variations when it comes to use of pesticides per area of cultivated land. The application in the Syrian Arab Republic is around 0.2 kg/ha, while in Lebanon and Palestine it reaches 7 kg/ha and 9 kg/ha, respectively (FAO and UNEP, 2021). Bahrain, Mauritania and Kuwait are the smallest consumers of pesticides in the region, each using less than 32 tonnes in 2018.

[44] 104 107 km^2.

[45] more than two and a half the size of Lebanon.

FIGURE 4.3 PESTICIDE USE, NENA, 2018*



Source: FAOSTAT, 2021.

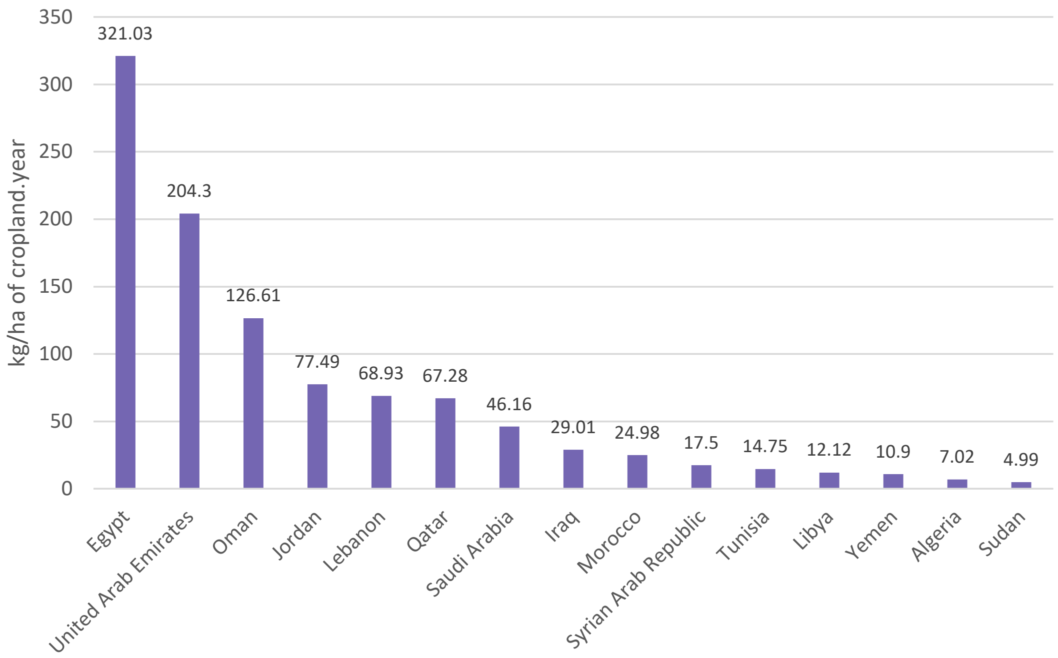
*United Arab Emirates does not have any available data on total pesticide use.

Use of fertilizers: The adverse impacts of the overuse of chemical fertilizers in NENA have been well documented, and six countries from the region are among the world's top 20 countries in terms of fertilizer use. Use is expressed as kilograms per hectare of arable land (Knoema, 2017).

- The average consumption of nitrogen in Egypt in the period 2007–2018 reached 320 kg/ha of cropland, which is seven times more than in other countries of the region (see Figure 4.4). Shamroukh *et al.* (2005) used a groundwater modelling system to predict shallow groundwater (30 m) pollution related to the use of high doses and incorrect methods of applying fertilizers.
- The impacts of the overuse of chemical fertilizer on water quality were illustrated by a study in the Bekaa Valley in Lebanon, where groundwater contamination was due to excessive use of nitrogen fertilizers (Charara, 2008; El Sakka, 2009).

©FAO/Marco Longari

FIGURE 4.4 NITROGEN FERTILIZER USE PER AREA OF CROPLAND, NENA, AVERAGE FOR THE PERIOD 2007–2018



Source: FAOSTAT, 2021.

4.3 Responses to restoring land and soil health

Looking ahead, some technical, social and institutional responses for land and soil health are outlined in this section, with examples from the region. Resource constraints and weak governance, with low priority given to tackling land and soil degradation in national policies, remain a concern.

4.3.1 Technical responses

A range of technical innovations may support and help to address land and soil degradation in NENA. Four are outlined below, namely sustainable land and water management, drought-resistant crops, sustainable fertilizer use and programmes to restore degraded land.

Sustainable land and water management (SLWM): According to Schwilch (2010), SLWM is "the utilization of the land (including soil) and water resources with their ecosystem services to support crops and livestock production, to respond to the ever-changing human needs for livelihood of food and fiber, while at the same time guaranteeing the possibility of the long-term production and conservation of their ecosystem roles". An estimated 3.5 million km² of land are potentially suitable for introducing SLWM practices in irrigated, rainfed and rangeland agro-ecosystems in the NENA region (Ziadat *et al.*, 2015). However, better efforts towards implementing SLWM are clearly required. When the cost of SLWM interventions are estimated, this approach tends to move higher up the policy and investment agenda. Some estimates are outlined below.

- Acting against soil erosion in Africa could generate an estimated economic return of USD 2.48 trillion (ELD and UNEP, 2018).

- In Jordan, a study that provided an economic evaluation of the Hema traditional practice of managing common rangeland within the Zarqa River Basin showed USD 203–408 million of net benefits through carbon sequestration, increased water infiltration and reduced sediments (Ziadat *et al.*, 2017).

Scaling-out SLWM practices requires consideration of barriers to adoption by populations, politicians and other stakeholders.

Drought-resistant crops: Where yield gaps exist, improved crop varieties could support the challenge of producing more food per unit of land and water.[46] Improved germplasm must be supported by optimal crop management practices, better seed supply systems, and more professional support services. In Tunisia, yield gain of up to 30 percent was predicted if water-saving wheat genotypes were used in the food-insecure region of Sidi Bouzid (Sadok *et al.*, 2019). These and other climate-smart agriculture practices are outlined further in Chapter 5.

Sustainable fertilizer use: Rational use of chemical fertilizers is required in the region. FAO's International Code of Conduct for the Sustainable Use and Management of Fertilizers (FAO, 2019g) particularly addresses deficiency in soil nutrients and their contamination. The code promotes interventions that improve soil health, including rational use of land and water resources and agronomic practices. Actions must be implemented by both governments and other stakeholders involved in the fertilizer industry. Awareness-raising programmes and training for all value chain stakeholders is highly recommended.

Restoration of degraded land: Massive areas of NENA are already experiencing serious degradation, with reduced plant cover and loss of species diversity, depleted or eroded soils, and low potential for recovery. Nevertheless, some technical innovations can help to slow land degradation. Sand dune stabilization, rehabilitation of overgrazed agropastoral systems and restoration of deforested lands are among the most frequent types of intervention conducted in the NENA region. Primary fixation entails the mechanical stabilization of sand masses, either by slowing their speed and movement or by preventing the formation of such masses, as well as biological fixation by planting trees and perennial vegetation (FAO, 2010a). The United Nations Decade on Ecosystem Restoration (2021–2030) offers a good opportunity for adopting more effective restoration approaches and frameworks.[47] Ideally, restoration programmes are mainstreamed in national policies, including national plans for climate change adaptation, biodiversity conservation and those combating land degradation. To this end, financial resources must be mobilized, and some sources of these are outlined in Chapter 5. Box 4.2 provides an example of restoration practices in Egypt.

[46] Yield gaps are estimated by International Center for Agricultural Research in the Dry Areas (ICARDA, 2017) to be as high as 60 percent in North Africa and 49 percent in West Asia.

[47] See https://wedocs.unep.org/bitstream/handle/20.500.11822/30919/UNDecade.pdf?sequence=11.

BOX 4.2 COMMUNITY MANAGEMENT OF NATURAL RESOURCES TO ENSURE FOOD SECURITY, EGYPT

Natural resources are facing serious challenges in Egypt, due to population increases, land degradation and drought. Agricultural activities along the northwest coast are mainly rainfed, using unsustainable soil and crop management practices. The MARSADEV project (2014–2017) focused on increased efficiency of crop production through interventions that prevented environmental degradation of limited soil and water resources, combating land degradation and extreme occasional flooding events. The aim was to improve crop and livestock productivity and contribute to the livelihood of local Bedouin communities. The project was implemented in the Wadi Kharrouba area, where an abandoned watershed (13 ha), with winter precipitations of 140 mm/year and intense gully erosion was rehabilitated. Indigenous solutions were integrated with innovative ideas to recover degraded lands, reduce erosion, enhance water saving and harvesting, and increase soil fertility. The production of olives, figs, rainfed barley and vegetable crops was improved, providing additional income for Bedouin farmers.

The processes of land restoration included land levelling, dam construction and the establishment of semi-circular terraces on the slopes to control erosion. Local drought-resistant plants such as Opuntia ficus-indica, Atriplex litoralis spp, Moringa oleifera and Medicago arborea were planted, while Vicia Faba was cultivated and mixed with the soil to increase soil organic matter and nitrogen content. Water harvesting techniques provided water for supplementary irrigation. A total of 50 000 m^3 of water was stored in the terraced soil during the rainy season of 2015–2016 (230 mm/year), of which 18 000 m^3 remained available in the soil until late July 2016. The rehabilitated area has been used as a demonstration site, with soil moisture control hydraulic sensors implemented to measure surface water flows.

Source: Zdruli P., Zucca C. 2018. *Maintaining soil health in dryland areas.*

4.3.2 Social responses

The land and soil challenges described in previous sections pose profound risks to human well-being in the NENA region, particularly for rural and marginalized communities. Transformative and innovative social responses, new partnerships and deep engagement with local communities are required, together with the above technological and institutional responses. Policy and planning should strive to move towards an approach that is guided by knowledge sharing, trust-building, and active stakeholder participation. This section highlights the need for participatory planning and a focus on gender equality and youth.

Land resource planning: Integrated land resource management starts with assessments of the land resource base, followed by identification of needs and challenges, ideally using participatory land-use planning approaches. Different instruments can support this form of planning, such as assessment of land value; discussions and trust-building practices between the different stakeholder groups; and developing governance rules to help the overall planning processes (Ziadat *et al.*, 2015). Experiences of participatory restoration are still not sufficiently frequent in rural areas of NENA countries, although there is room for their promotion.

Gender equality and women's empowerment: The Global Land Outlook stresses the importance of guaranteeing gender equality in SLWM strategies (UNCCD, 2017). Gender equality and women's empowerment issues are of specific importance in the NENA region, where women's contribution to agricultural production is significant, but often invisible. The female share of the economically active population in agriculture showed an overall increase from 30 to 45 percent between 1980 and 2010 (FAO, 2011b),[48] with more than 60 per cent in some countries such as Jordan and the Syrian Arab Republic (FAOSTAT, 2021).[49] However, the female share of agricultural holders is very low (estimated to be 9, 8, 4 and 1 percent in Lebanon, Oman, Egypt and Saudi Arabia, respectively) (FAO, 2019d). Women in the region still face financial, cultural and legal constraints in accessing knowledge, innovation, finance, markets, institutions and resources, particularly land and water resources (ICARDA, 2017).

Rural youth focus: Youth have high capacity to innovate and engage meaningfully in the agriculture sector, but require incentives to stay and engage in sustainable land management practices. A number of statistics indicate the need for a stronger and concentrated focus on youth, with incentives for them to engage in sustainable agriculture.

- UNICEF (2020) indicated that more than half the population of the Middle East and North Africa region are youth under 24 years, with an expectation of a 50 percent increase by 2050 compared with the population in 2015.
- Some countries (Iraq, Palestine and Sudan) are expected to almost double their youth population by 2050 compared with 2015.
- Brookings (2019) reported that the rate of youth unemployment in the NENA region has been the highest in the world for more than 25 years.

4.3.3 Agricultural institutional support responses

Guidelines have been developed by agencies to enhance the appropriateness of agricultural practices, improve quality and lead to better food security outcomes. FAO's code of conduct for fertilizer use (FAO, 2019g) has already been mentioned, and some others are outlined below.

Guidelines for improved land tenure: FAO produced the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT) in the context of national food security (FAO, 2012b) to improve governance that encourages sustainable land management and enhances food security. So far, only a few countries in the NENA region have taken steps to use these guidelines to inform their land-use and land tenure policies. Sudan is one example (see Box 4.3).

[48] those available for work, which includes both employed and unemployed.

[49] Other data show 17.5 percent, 15.3 percent, 13.3 percent, 4.4 percent and 0 percent for Palestine, Egypt, Lebanon, Jordan and Qatar, respectively, in 2019.

BOX 4.3 PROMOTING LAND TENURE RIGHTS USING THE VGGT IN SUDAN

Sudan is implementing a project following the VGGT principles on promoting the provision of legitimate land tenure rights for conflict-displaced communities, including small-scale rural farmers, pastoralists and IDPs in the Greater Darfur region. Based on an EU-supported project mid-term review (2019), the initiative is a pioneer in addressing land tenure and land registration issues in Darfur. The project has introduced and emphasized the five VGGT principles and made efforts to promote government consideration of establishing a harmonized land registration procedure within the Darfur States. A major project achievement has been to raise awareness of the land issues, creating a platform for open and free discussion on the need for standardization and simplification of the processes and fees, as well as recognizing the importance of harmonizing the informal/traditional land tenure processes with formal legislation in accordance with the principles of VGGT.[50]

Source: FAO project GCP/SUD/074/EC: Promoting the provision of legitimate land tenure rights using Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT) in the Context of National Food Security for conflict-displaced communities, including small-scale rural farmers, pastoralists, and Internally Displaced Persons (IDPs) in the Greater Darfur region of the Sudan

FAO Voluntary Guidelines for Sustainable Soil Management (VGSSM): The VGSSM are a useful instrument to enhance soil health and sustained food production and can be used in the NENA region (FAO and ITPS, 2017). VGSSM suggest practices that help to:

- minimize soil erosion, salinization, alkalinization and acidification;
- enhance soil organic matter content and preserve and enhance soil biodiversity;
- foster soil nutrient balance and cycles;
- prevent and mitigate soil compaction and sealing; and
- improve soil water management.

Legal instruments: Information on legal tools that prevent land degradation and soil conservation are always useful to share among countries. The Global Soil Partnership hosted by FAO has established the SoiLEX1 Global Database, with the objective of providing such information. The platform was developed in harmonization with FAOLEX, one of the most comprehensive databases of legal rules and instruments related to the management of natural resources for food production and agriculture.[51]

Attracting responsible investment for SLWM: There is a clear need to attract good investment and mobilize resources for improving and upscaling SLWM practices in NENA. Investment and technical cooperation must be encouraged, both inside each country and at regional level to support the scaling up of this approach. The quality of investment is also important, as is ensuring that it reaches those who need support. In this regard, FAO is promoting principles for responsible investments in agriculture, which are outlined in an easily accessible document (CFS and FAO, 2014).

4.3.4 Digital tools for knowledge management

A reliable information base is required for implementing zoning schemes, setting limits and monitoring compliance. The availability of and easy access to good soil information is therefore critical for decision-making with respect to restoring soil and land health, and innovative digital technologies offer

[50] GCP/SUD/074/EC: Promoting the provision of legitimate land tenure rights using Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT) in the Context of National Food Security for conflict-displaced communities, including small-scale rural farmers, pastoralists, and Internally Displaced Persons (IDPs) in the Greater Darfur region of the Sudan.

[51] See www.fao.org/soils-portal/soilex/en/.

important opportunities. The FAO regional Conference for the Near East (FAO-NERC, 2020) recognized the need to develop a Digital Agriculture and Innovation Hub to act as an incubator for digital innovations in NENA technical, social and policy areas. The Hub helps to develop capacities and enhance the engagement of youth and women, as well as to raise digital literacy. Another feature of the Hub is the provision of training in digital services for small-scale farmers, as well as for other players in the food supply chain.

Precision agriculture practices: Precision agriculture practices rely on a range of geospatial methods and equipment for the exact application of inputs, and monitoring, for example by remote sensing data captured by satellite and drone. The goal is to match fertilizer dosing with actual crop needs, maximizing application efficiency (Basso *et al.*, 2019). These techniques are being applied in parts of the NENA region, such as Egypt, to optimize fertilizer use while controlling soil salinization risk (Shaddad *et al.*, 2019). With due care, fertilizer micro-dosing is a promising CSA technology to complement traditional fertilizer management strategies.

4.3.5 Monitoring and assessment of soil health

Soil mapping: In the NENA region soil information is fragmented and diverse. In most countries, soil maps are old, have low-detail scales (e.g. 1:1 000 000), or are based on different and obsolete soil classification systems. Digital soil mapping and national soil information systems were established recently in Sudan (FAO, 2019h). Such tools also monitor land degradation over time. FAO is implementing a capacity development programme for the sustainable management of soil resources in the NENA region, and the project has a strong capacity development focus, providing technical support to soil laboratories in the region. [52]

Land degradation mapping: Assessing and mapping land degradation and desertification is challenging, since these processes are highly contextual and their measurable symptoms highly variable (Zucca *et al.*, 2014; Zdruli *et al.*, 2017). Blended methods that integrate scientific data sets and expert knowledge have been among the most successful during the 1990s and the 2000s. Degradation of agricultural land in Egypt was monitored and assessed using the Moderate Resolution Imaging Spectrometer (MODIS). MODIS spatial resolution indicated that the New Valley area scored the highest level of land degradation, while agricultural land lost about 10 percent of its area in South Sinai due to degradation (Khalil *et al.*, 2014). Guidelines for mapping soil degradation and improvements at (sub) national scale are given in a Land Degradation Assessment in Drylands (LADA) Manual produced by FAO (FAO, 2011c). Some practical examples of using soil assessments include:

- The LADA-WOCAT methodology was applied in Tunisia in 2007,[53] assessing land degradation at national and local level during implementation of a FAO LADA project. Tunisia continued with application of the methodology, and land degradation maps have been developed and sustainable land management practices identified for three pilot sites. [54]
- Morocco conducted subnational and local-level assessments of land degradation, developing maps of land-use systems, land cover and types of degradation, and identified the impacts on land productivity, biodiversity and livelihoods.

Monitoring soil health indicators by remote sensing: An increase in the number of satellite and sensors, and the increased global availability of earth observation (EO) data during the past decade has led to significant developments in remote sensing (RS) applications for soil mapping. In the NENA region, important advances have been made

[52] TCP/RAB/3802

[53] The Land degradation Assessment in Drylands (LADA) World Overview of Conservation Approaches and Technologies (WOCAT) LADA-WOCAT

[54] This was in the context of a project entitled Decision Support for Mainstreaming and Scaling up of Sustainable Land Management.

in (i) mapping soil organic carbon (Gholizadeh *et al.*, 2018; Thaler *et al.*, 2019); (ii) mapping soil salinity based on remote sensing (Wu *et al.*, 2018); and (iii) geospatial modelling (Shaddad *et al.*, 2020).

4.3.6. Knowledge sharing

Sharing experience and lessons learned on various practices to enhance soil health could be intensified in the NENA region. This should start when pilot projects are set in place, with knowledge platforms and other modalities to collate lessons, and disseminate them for onward upscaling. FAO has collected and organized several guidelines and methods related to land and landscape planning and management, and turned them into integrated packages for users (or toolboxes).

The global WOCAT (World Overview of Conservation Approaches and Technologies) Sustainable Land Management Database is the primary recommended database developed by UNCCD for the reporting of good practices.[55] The WOCAT methodological frameworks for sustainable land management provide reference methods to document available practices.

The International Center for Agricultural Research in the Dry Areas (ICARDA), in collaboration with WOCAT, has developed the Global Geo-Informatics Options by Context (GeOC),[56] an online tool that supports targeting of sustainable land management practices and their outscaling to achieve land degradation neutrality.[57] GeOC is designed to provide stakeholders running projects with plausible, robust extrapolation domains, based on socio-ecological contexts. These should be used to guide decisions on sustainable land management (SLM) options.

[55] See www.wocat.net

[56] See https://mel.cgiar.org/user/login?geoc=true

[57] LDN has been defined by the UNCCD Parties to the Convention as: "A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security remains stable or increases within specified temporal and spatial scales and ecosystems".

PART II: ELABORATION ON WATER, SOIL, CLIMATE CHANGE IMPACTS AND THE URBAN-RURAL INTERFACE

5 CLIMATE CHANGE, LAND, WATER AND AGRICULTURE: IMPACTS AND RESPONSES

KEY MESSAGES

- **NENA is one of the regions in the world that will be most affected by climate change.** It will experience an average mean temperature increase of 1.7 °C to 2.6 °C under RCP 8.5, with parts of the region seeing a rise of 4.8 °C by 2100 compared with the period 1985–2005. Highest increases in average mean temperature of more than 3 °C are projected for non-coastal areas, including the Sahara Desert.
- **The increase in floods and droughts is already having serious implications for agricultural yields.** Precipitation is projected to generally decrease across the region, with increased seasonal and annual variability, including an increase in extreme events. Droughts are expected to increase in frequency by 150 percent up to 2070, and flash floods will threaten coastal and low-lying agricultural areas.
- **Specific areas are particularly vulnerable to water stress. All populated and arable lands are vulnerable to water stress,** but the highest water-induced climate vulnerability areas (including in terms of adaptive capacity) will be the upper Nile Valley, the southwestern Arabian Peninsula and the northern Horn of Africa.
- **Crop yields are expected to decline.** Due to a decrease in productivity accompanied by a shortage in the length of crop cycles, negative impacts on crop quantity and quality will affect food production. Rainfed farming systems are the most vulnerable.
- **Smallholders will be hardest hit by climate change, as well as populations living in LDCs and countries under conflict, due to low capacities to adapt.** Higher negative effects are likely despite relatively more moderate increases in temperature. Populations living in situations of protracted conflict are particularly vulnerable.
- **On- and off-farm diversification is necessary to secure rural livelihoods.** On-farm options include climate-smart agriculture approaches, crop diversification, conservation agriculture, crop rotation, modification of sowing and planting times, and strategies to address degradation of land and water resources.
- **The Arab Declaration on Climate Change in 2007 spurred a regional response.** Coordinated studies and operational responses to water scarcity are being initiated. Examples include the RICCAR regional Knowledge Hub, the Arab Centre for Climate Change Policies, and the 2019 Cairo Declaration emanating from the first joint meeting of ministers of water and ministers of agriculture in the Arab region.
- **Climate finance flows to the agriculture,** land-use, forestry and water sectors require much greater attention. Funding is currently insufficient. Although water, salinization and productivity losses are adaptation priorities, funding for water and sanitation and AFOLU sectors is five to seven times lower than for energy, transport, storage, industry and banking/finance.

Introduction

Climate change is a threat multiplier for already scarce land and water resources. It has the potential to push currently stressed agricultural, land and water systems to limits that impede present management efforts. The effects of climate change are already evident. Globally, crop and livestock production is 21 percent lower than without anthropogenic global warming (Vicedo-Carera *et al.*, 2021).

This chapter describes recent efforts in the NENA region to measure and map the impacts of climate change – temperature and precipitation changes and the onset of extreme events – on agriculture and livelihoods. Using recent projections, section 5.1 describes expected conditions at mid-century for agriculture and their implications for livelihoods and agricultural policies. Given the regional diversity in terms of agricultural systems and impacts, a farming systems lens is employed to describe the five agriculture systems at greatest risk from climate change in section 5.2. The chapter concludes with institutional, policy and technical responses to enhancing adaptation and mitigation of greenhouse gas emissions in the agriculture sector and outlines the urgent need for attention to climate finance flows for agriculture, land and water priorities.

5.1 Climate change impacts on land and water

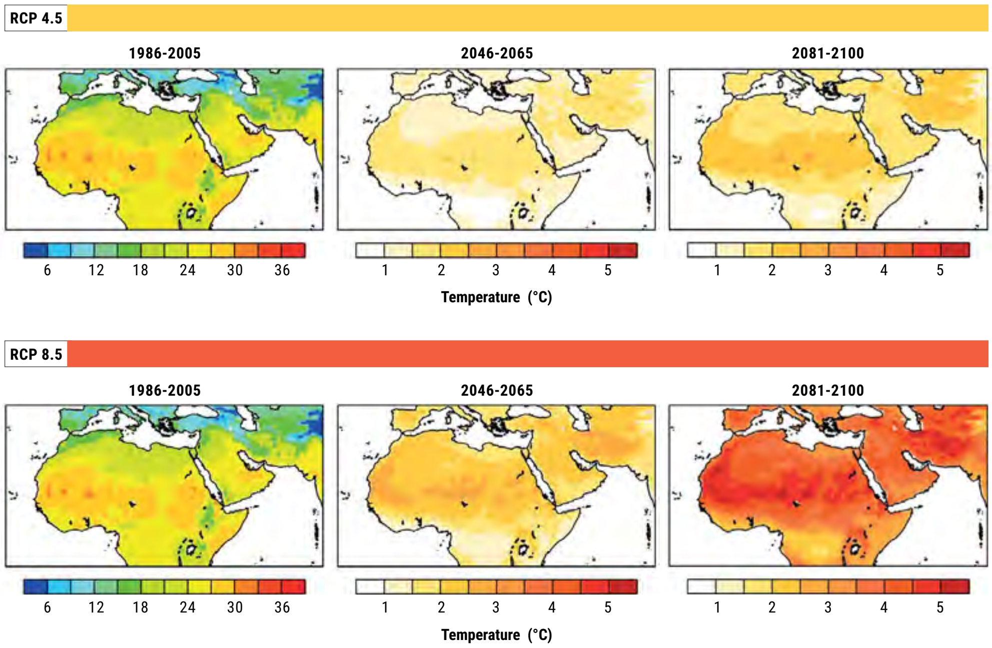
The temperature is expected to increase through to the end of the twenty-first century in the NENA region, with localized areas reaching new maxima due to climate change. RICCAR is a regional initiative for the assessment of climate change implications on water-dependent sectors in the NENA region.[58] Assessment is undertaken through climate and hydrological modelling, and a vulnerability assessment to provide a scientific basis for priority-setting. Under this initiative, projections for the Arab region were generated for two Representative Concentration Pathways (RCPs), namely RCP 4.5 and RCP 8.5 to the end of the century (see Figure 5.1). The subsequent report from the analyses (ESCWA *et al.*, 2017a) shows that the Arab region is expected to experience an average mean increase in temperature of:

- 1.2 °C to 1.9 °C at mid-century (2046–2065) under RCP 4.5; and
- 1.7 °C to 2.6 °C under RCP 8.5, with parts of the region reaching an increase of 5 °C by 2100 compared with the reference period (1985–2005).

More pronounced temperature increases (>3 °C) are projected in non-coastal areas, particularly the Sahara Desert (ESCWA *et al.*, 2017a). Other areas expecting a significant increase in temperature include the Maghreb and the southwestern Arabian Peninsula.

[58] The regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socioeconomic Vulnerability in the Arab region or RICCAR was launched in 2009 under the auspices of the Arab Ministerial Water Council. It is coordinated by ESCWA in partnership with 11 institutions active in water and climate in the region. RICCAR collaborating institutions include the League of Arab States, the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), ESCWA, FAO, GIZ GmbH, the Swedish Meteorological and Hydrological Institute, UNESCO Cairo Office, the UN Environment Programme, the United Nations Office for Disaster Risk Reduction, the United Nations University Institute for Water, Environment and Health and the World Meteorological Organization (WMO). Funding for RICCAR has been provided by the Swedish International Development Cooperation Agency, the German Federal Ministry for Economic Cooperation and Development, and from contributions by partners.

FIGURE 5.1 MEAN CHANGE IN ANNUAL TEMPERATURE (°C) FOR THE FOR MID- AND END-CENTURY FOR AN ENSEMBLE OF THREE RCP 4.5 AND RCP 8.5 PROJECTIONS COMPARED WITH THE REFERENCE PERIOD

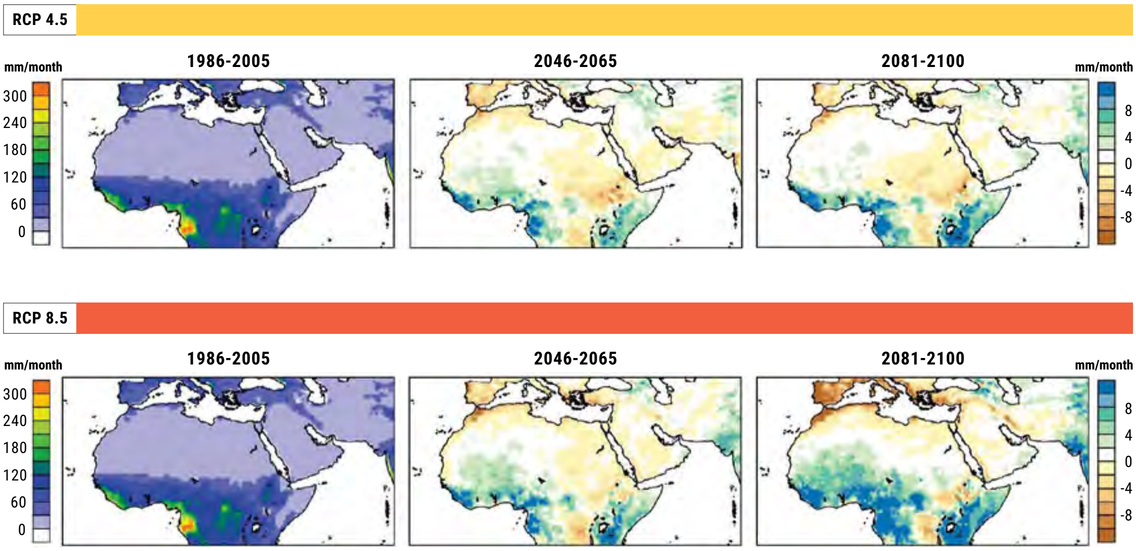


Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a. *Arab Climate Change Assessment Report – Main Report.* Beirut. www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

Figure 5.2 presents average change in annual precipitation under both scenarios (RCP 4.5 and RCP 8.5). Precipitation trends are largely decreasing across the region. More pronounced changes are expected for the Mediterranean coast over the winter months, with precipitation decreases of up to 40 percent (compared with the reference period) projected in the Moroccan Highlands. The result is likely to be severe vulnerabilities to water availability and an increase in drought conditions. On the other hand, some areas are expected to experience an increase in the intensity and volume of precipitation due to extreme weather events. The NENA region has already experienced a dramatic shift in rainfall patterns, which have led to flash floods in different urban areas in the region (for example Cairo 2020, Kuwait 2018, Riyadh 2016, Casablanca 2016, Doha 2015, and Muscat 2007) (Loudyi *et al.*, 2020). Flood events since 1970 have caused more than 10 000 fatalities and incurred annual economic losses of USD 200 million (Borgomeo *et al.*, 2020]. Precipitation variability is expected to continue through to 2100.

In the Arab region, evapotranspiration is limited by water availability, and is therefore expected to decline in areas where precipitation is also decreasing, although a rise in temperature does not necessarily result in increased evapotranspiration. regional hydrological modelling indicates a projected decrease in evapotranspiration along the North African coast and in sub-Saharan Africa up to 6 mm/month by 2100.

FIGURE 5.2 AVERAGE CHANGE IN ANNUAL PRECIPITATION (MM/MONTH) FOR RCP 4.5 AND RCP 8.5



Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a. *Arab Climate Change Assessment Report – Main Report.* Beirut. www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

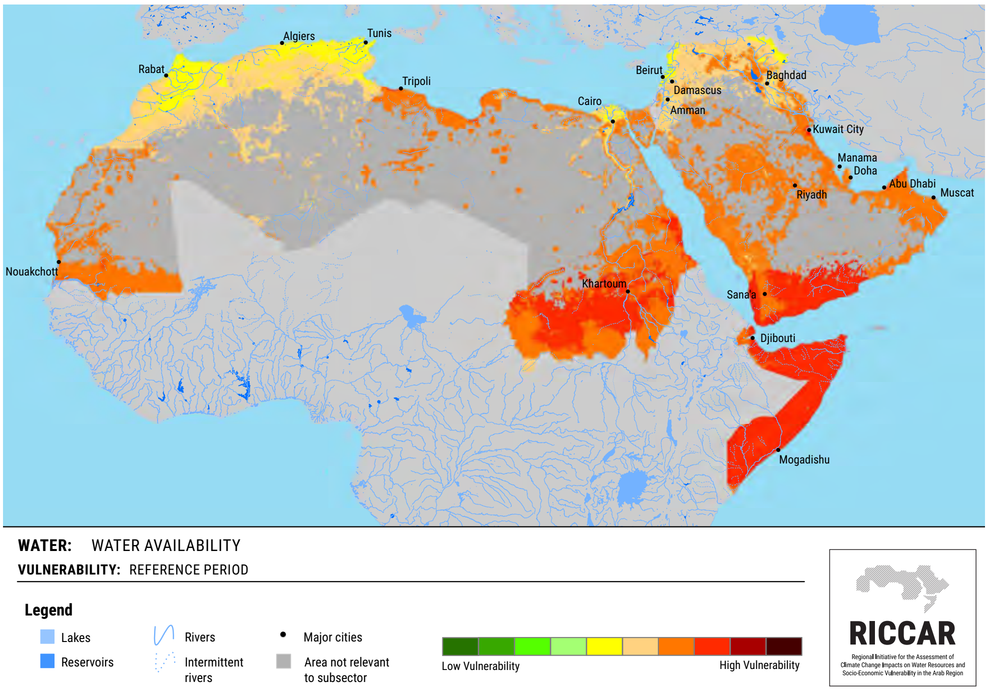
Coastal areas are threatened by sea level rise (SLR). Cities such as Alexandria in the Nile Delta are vulnerable to the increasing frequency and intensity of coastal storms associated with SLR. An increase in frequency and severity of storm surges is already evident, with the southern Mediterranean seeing a rise in the number of natural disasters, from 3 per year in 1980 to more than 15 per year in 2006 (El-Shinnawy, 2008). Countries most affected by extreme events that are also experiencing protracted conflict include Somalia, Sudan and Yemen.

Temperature, precipitation, soil moisture content and wind affect dust emission transport. An increase in sand and dust storms (SDS) tends to occur with increased aridity. Further studies and data are needed to better understand the linkages between climate change and SDS.

5.1.1 Water availability vulnerabilities

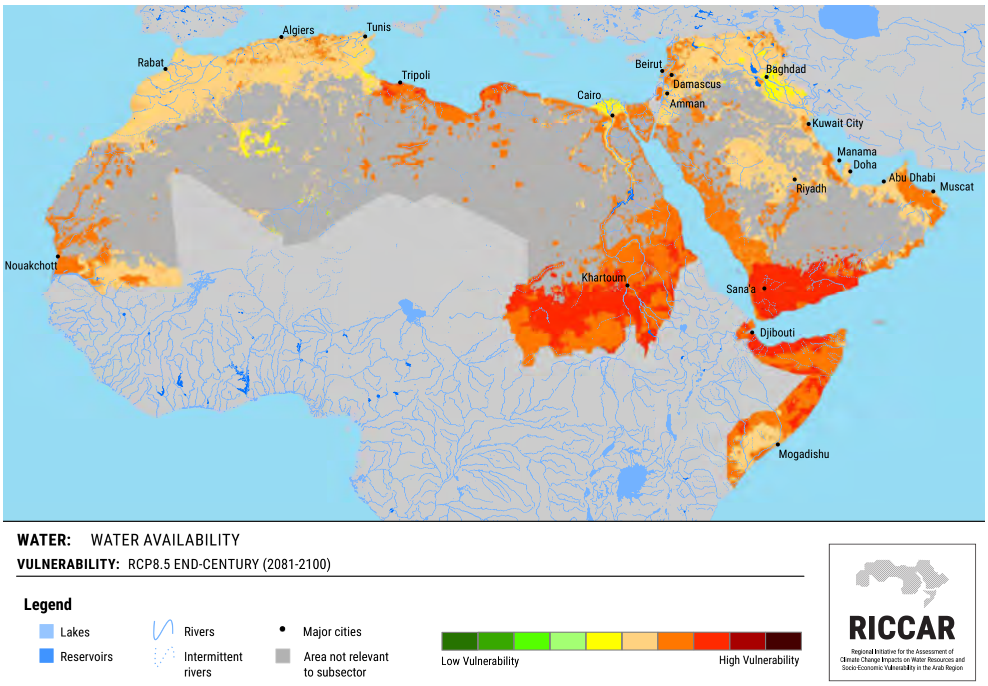
The RICCAR vulnerability assessment found that all populated and arable land in the Arab region (representing 49 percent of its surface area, the rest being deserts) suffers from water availability vulnerability, as shown in Figure 5.3 and Figure 5.4 (RCP 8.5 for end-century) (ESCWA *et al.*, 2017a).

FIGURE 5.3 WATER AVAILABILITY VULNERABILITY: REFERENCE PERIOD



Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a. *Arab Climate Change Assessment Report – Main Report.* www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

FIGURE 5.4 WATER AVAILABILITY VULNERABILITY: RCP 8.5 END CENTURY



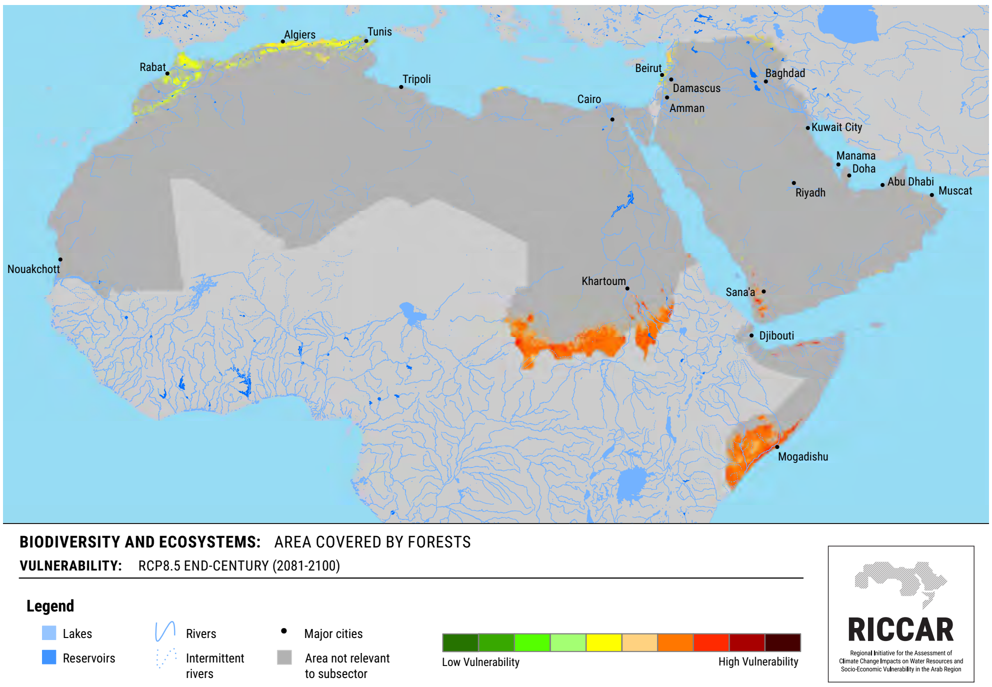
Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a. *Arab Climate Change Assessment Report – Main Report.* www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

The RICCAR vulnerability assessment considers climate change, along with socioeconomic and environmental factors and adaptive capacity, when evaluating potential impact. Areas with the highest vulnerability generally occur in the Sahel extending northwards into the Sahara Desert, the southwestern Arabian Peninsula along the Red Sea, and the Horn of Africa. All hotspots exhibit low adaptive capacity, although their exposure to climate change varies. Large areas within the NENA LDCs are projected to see increases in precipitation, with moderate average increases in temperature relative to other parts of the region over the course of the century. Such moderate trends are insufficient to offset low levels of adaptive capacity.

5.1.2 Forest and wetland ecosystems and climate change

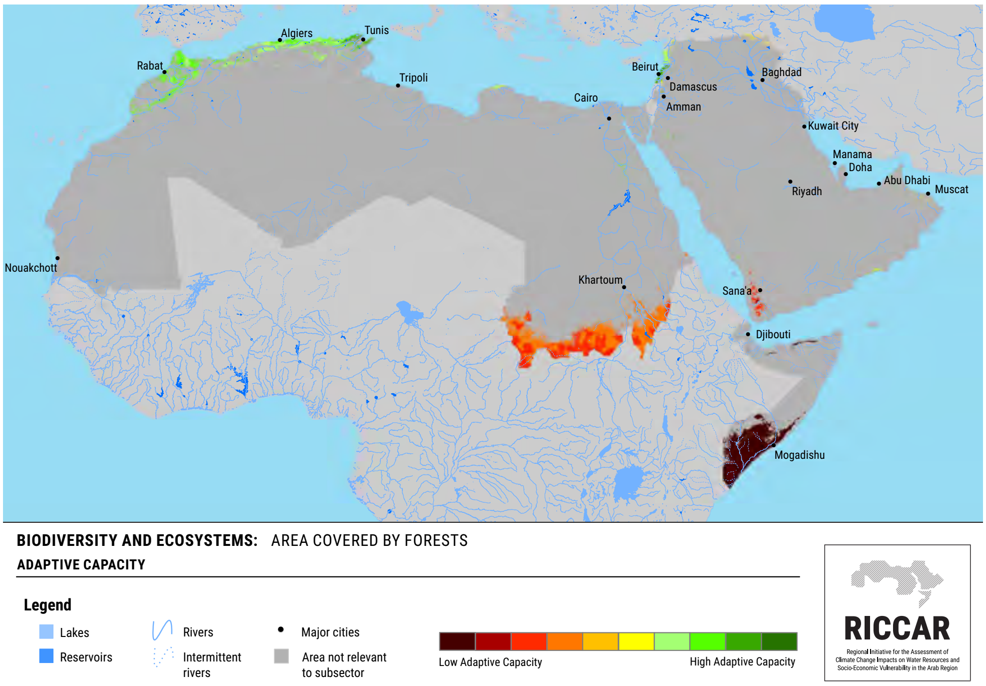
Forests: Forests are important carbon pools, with approximately 31 percent of the carbon stored in the biomass and 69 percent in the soil (IPCC, 2000). While forests are not widespread throughout the Arab region (Table A9 in the Annex presents an estimate of 4.8 percent in 2020), regional projections have found that forests and wetland ecosystems are highly vulnerable to changing temperatures and reduced water availability. Indeed, forests in the NENA region face three main threats from climate change: environmental degradation; declining quality and quantity of forest; and loss of biodiversity. The areas of greatest vulnerability are in southern Sudan, southern Somalia, and the western part of Yemen (see Figure 5.5) On the other hand, forestation and restoration of degraded forest areas contribute to the mitigation processes through carbon dioxide (CO_2) absorption and carbon sequestration.

FIGURE 5.5 VULNERABILITY OF FORESTS BY END-CENTURY UNDER RCP 8.5



Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al. 2018.* Arab Climate Change Assessment Report – Snapshot of Key Findings. https://riccar.org/sites/default/files/2020-01/RICCAR-Booklet-Snapshot%20of%20Key%20findings.pdf

FIGURE 5.6 ADAPTIVE CAPACITY IN THE FOREST SECTOR



Source: United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a. *Arab Climate Change Assessment Report – Main Report.* www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

Wetlands: Wetland areas in the RICCAR analysis constitute 2 percent of the Arab region, and comprise Ramsar sites,[59] their buffers, coastal wetlands, riverine wetlands, sabkhas and saltpans. Most wetlands project moderate exposure, of around 88 percent (RCP 8.5) for the mid-century. However, 93 percent of all wetlands project moderate vulnerability. Wetlands will primarily see changes in precipitation, runoff and evaporation, resulting in reduction in flows, threat of floods and increased soil erosion. Temperature changes are set to alter evaporation rates, threatening wetland ecosystems and water quality, and produce heat stress for wildlife. ESCWA *et al.* (2017a) indicate that wetlands with the highest exposure include: those on Lake Nasser; coastal wetlands on the western shore of the Red Sea; and the Buhayrat al-Laha and Ammiq wetlands in the Levant.

Sea level rise: Egypt will be among the countries most affected by a 1-m rise in sea level (Dasgupta, *et al.*, 2007). Agricultural productivity and settlements in the coastal zones of Egypt on the Mediterranean, such as the governorates of the Northern Delta, are extremely vulnerable to sea level rise and salt water intrusion (El-Raey, 2009). Pronounced impacts of saltwater intrusion on agricultural lands in the Nile Delta region are expected through adverse effects on soil fertility and quality of groundwater. Models for sea level-rise scenarios have been developed (Solyman and Abdel Monem, 2020), predicting the impacts on different livelihoods of farmers in the Delta.

[59] Linked to the Convention on Wetlands which is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

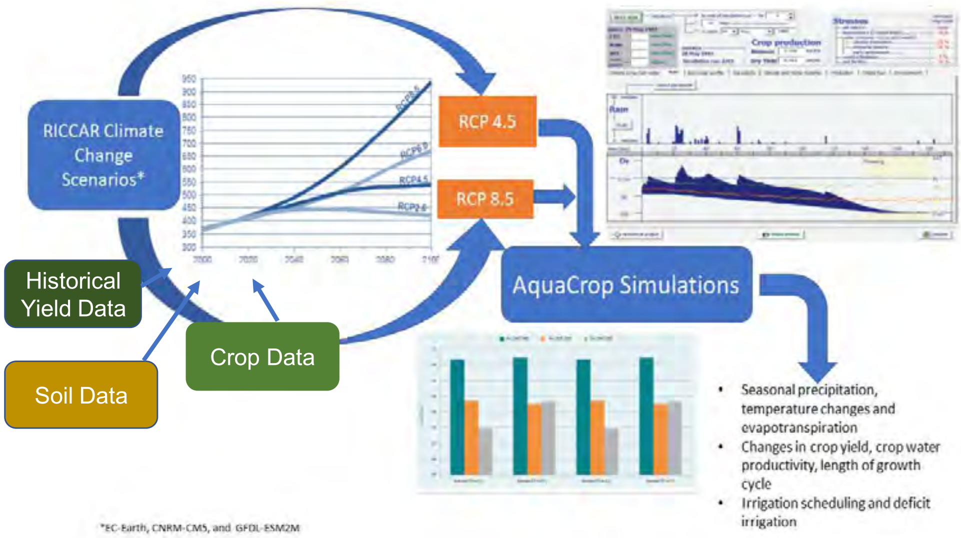
5.2 Impacts on the agriculture sector

This section details climate change impacts on water availability for agriculture; describes the farming systems at risk in the region; and outlines the social and economic dimensions of these impacts.

5.2.1 Impacts on water availability for agriculture

The impacts of climate change on agricultural productivity were analysed using both AquaCrop[60] simulations and applying RICCAR climate change projections, as Figure 5.7 demonstrates.[61] These analyses were conducted for nine countries (Egypt, Jordan, Iraq, Lebanon, Palestine, Morocco, Sudan, Tunisia and Yemen) to project the climate impacts on selected rainfed and irrigated crops.

FIGURE 5.7 PROCESS METHODOLOGY FOR AQUACROP SIMULATIONS USING RICCAR PROJECTIONS



Source: ESCWA. 2020c. *Impacts of climate change on water resources, agriculture and food security in the Arab region. Beirut.* www.unescwa.org/sites/default/files/event/materials/cc_impact_on_water_resources_and_agriculture_in_the_arab_region_27_july_-_rn.pdf

Findings showed that the impact of climate change on precipitation and rainfall patterns alters crop productivity and growth cycle. A decrease in productivity is accompanied by a shortage in the length of crop cycle, leading to negative impacts on crop quantity and quality. Table 5.1 presents the change in yields for selected rainfed and irrigated crops under RCP 4.5 and 8.5 scenarios and fixed CO_2 concentrations, compared with the reference period (1985–2005). The range of change in yield presents the impact of CO_2 concentration in the atmosphere in comparison with fixed CO_2 concentrations under similar scenarios of AquaCrop simulation.[62] Rainfed yields are generally expected to decline, thus affecting

[60] AquaCrop is a crop growth model developed by FAO's Land and Water Division to address food security and assess the effect of the environment and management on crop production. It simulates the yield response of herbaceous crops to water and can be applied to conditions where water is a key limiting factor in crop production. See www.fao.org/aquacrop/en/.

[61] Technical country teams were established and trained by ACSAD, ESCWA and FAO to conduct the crop-specific assessments.

[62] In the absence of other mitigating factors, the effect of rising CO_2 concentration has less significant positive effects on C4 group crops, which react less with an increase in CO_2 concentration yield compared with those of C3 group.

food production. In some cases, such as in Jordan and Palestine, rainfed wheat yield is projected to increase due to the shift in rainfall towards the mid-wheat growing season. Table 5.1 reveals that yield reduction in Moroccan wheat (Marchouch area) is projected to range between -23.0 to -13.0 percent under RCP 4.5 (moderate climate scenario) during the period 2020–2030, compared with the reference period of 1985–2005.

TABLE 5.1 CHANGE IN YIELDS (%) FOR SELECTED CROPS FOR RCP 4.5 AND RCP 8.5 UNDER CHANGING AND FIXED CO_2 CONCENTRATIONS

Country (district) and crop	Percentage change in yield							
	2020–2030		2040–2050		2020–2030		2040–2050	
	RCP 4.5 with fixed CO_2	RCP 4.5 with changing CO_2	RCP 4.5 with fixed CO_2	RCP 4.5 with changing CO_2	RCP 8.5 with fixed CO_2	RCP 8.5 with changing CO_2	RCP 8.5 with fixed CO_2	RCP 8.5 with changing CO_2
Rainfed crops								
Morocco[63] (Marchouch) – Wheat	-23.0	-13.2	-18.0	-1.6	-9.0	-1.9	-26	2.4
Sudan[64] (Gadari) – Sorghum	-0.7	-2	-7.0	-8.0	-7	-5	-11	-8.0
Tunisia[65] (Koudiat) – Wheat	-7.0	5.7	-2.8	17.4	-4.4	4.2	0.2	13.9
Jordan[66] (Madaba) – Wheat	33.77	32.1	48.26	36.5	53.53	42.4	81.59	73.9
Yemen[67] (Dhamar) – Sorghum	-26.4	-21.6	-29.8	-24.3	-3.1	2.64	-10.3	-2.47
Palestine[68] (Jenin) – Wheat	17.8	20.0	30.0	24.0	33.8	38.5	56.2	54.7

[63] ESCWA, 2019a
[64] ESCWA, 2019b
[65] ESCWA, 2019c
[66] ESCWA, 2019d
[67] ESCWA, 2019e
[68] ESCWA, 2019f

Country (district) and crop	Percentage change in yield							
	2020–2030		2040–2050		2020–2030		2040–2050	
	RCP 4.5 with fixed CO_2	RCP 4.5 with changing CO_2	RCP 4.5 with fixed CO_2	RCP 4.5 with changing CO_2	RCP 8.5 with fixed CO_2	RCP 8.5 with changing CO_2	RCP 8.5 with fixed CO_2	RCP 8.5 with changing CO_2
Irrigated Crops								
Egypt[69] (Sakha) – Wheat	-1.7	10.3	-3.9	13.2	-2.9	10.1	-5.7	12.5
Iraq[70] (Al Suwaira) – Tomato	-1.2	11.6	-5.3	12.8	-6.2	6.7	-7.0	11.9
Yemen[71] (Sana'a) – Wheat	-4.2	8.3	-6.1	12.6	-3.81	13.1	-7.6	10.2
Lebanon[72] (central Beqaa Valley) – Wheat	8.3	22.5	13.4	35.8	10.2	26.1	17.4	42.2

Source: Aquacrop simulations using RICCAR projections. [73] RICCAR regional Knowledge Hub [online]. [Cited 15 December 2021]. www.riccar.org

Climate change is also affecting the availability of water for irrigated agriculture. For example, in Egypt (Sakha area), change in irrigated wheat yield is projected to range between -5.7 and -12.5 percent under RCP 8.5 scenario during the period 2040–2050, compared with the reference period of 1985–2005. Elevated CO_2 concentrations in the atmosphere are projected to increase productivity of irrigated crops, as these enhance the photosynthetic rate of plants while reducing transpiration. However, a loss in nutritional value of plants may result from increased CO_2 concentration, which can partially counteract the possible advantage related to increasing quantity. Instability in output jeopardizes the income of the most vulnerable farmers relying on rainfed agriculture. Some examples below from Morocco and Tunisia provide an estimate of the cost of no action, but should be taken with caution due to price volatility in the wheat market.

- In Marchouch, Morocco, under the most pessimistic scenario RCP 8.5 for rainfed wheat, a loss of around USD 3.1 million is estimated (2018 producer price for wheat) (ESCWA, 2020a).

[69] ESCWA, 2019g

[70] ESCWA, 2019h

[71] ESCWA, 2019e

[72] ESCWA, 2019i

[73] Country reports are available in English on the following website: https://www.unescwa.org/publications/climate-resilient-agriculture-translating-data-policy-actions

- In Koudiat, Tunisia, losses could range between USD 2.07 million and USD 3.3 million per year due to wheat production losses (ESCWA, 2020b).

5.2.2 Farming systems at risk

Projections show that agricultural areas dedicated to rainfed and irrigated crops (which cover 22 percent of the region's surface area) or livestock production (practised in 33 percent of the region) will suffer moderate to high vulnerability to climate change (ESCWA, 2021). A FAO-RNE project on the impacts of climate change on farming systems (2018) identified climate-impacted farming systems and the major hotspots of climate change impacts on agriculture. Combining data from RICCAR (2017) with the FAO farming systems approach, farming systems most vulnerable to climate change are highlighted (FAO, 2018g). Compared with irrigated crops, rainfed farming systems are the most sensitive to climate change in the region, due to a reduction in and unpredictable precipitation. The FAO-RNE analysis found that cereals and horticultural and perennial crops will see reduced yields. Wheat (the main staple crop for the region) and barley are projected to suffer yield losses under most farming systems. High-value crops such as olives are projected to decrease by 65 to 90 percent under RCP 4.5 and by more than 90 percent under RCP 8.5 by the end of the century (FAO, 2018g; Ouda *et al.*, 2016). Such high-value crops are seen as a form of productive water use (see Chapter 3), bringing higher returns from export than other crops.

Other NENA farming systems also face the risks of sea level rise, heat stress, and sand and dust storms. For example:

- Oman's agriculture is centred on coastal regions dominated by horticulture, fruits and cereals, which face threats from an increase in evapotranspiration rates, increasing frequency of cyclones and salinization of coastal aquifers and soils due to sea level rise.
- Sand and dust storms are expected to intensify due to land degradation and desertification, threatening soil fertility and potentially limiting agricultural productivity for affected areas in Iraq, Jordan and the Syrian Arab Republic.

The direct risks of reduced productivity will be borne by small-scale farmers who engage in rainfed mixed farming systems, unless options for diversification of livelihoods and incomes are available (FAO, 2018g). Thus, water saving and other adaptation measures are required to offset the climate change effects on crops.

5.2.3 Social and economic dimensions of climate projections

To better understand the economic impacts of climate change and their spatial manifestation in the NENA region, an econometric study (FAO and CMCC, unpublished) using micro household survey data on labour supply and income in agriculture combined with high-resolution climate data was developed, estimating the impacts on household income and labour supply in the agriculture sector. The econometric panel data approach captures data that vary in time and space. Based on an expected increase in drought events by more than 150 percent between 2020 and 2070, it was found that:

- Each additional drought event reduces agricultural income by 0.04 percent and labour supply by 0.002 percent.
- Potential agricultural income is estimated to decline by 6.8 percent under RCP 8.5 and 4.2 percent under RCP 4.5 by 2070.
- In the case of agricultural labour supply, this decline is expected to be 8.4 percent under RCP8.5 and 4.6 percent under RCP 4.5.

- Agricultural income will decline by USD 196 billion to USD 318 billion in 2070 compared with a no-action baseline in RCP 8.5 in the NENA region. Under the more moderate RCP 4.5 warming scenario, the highest declines in agricultural income are expected in: parts of Sudan (River Nile area); Mauritania (Hodh Ech Chargui, Tagant, and Hodh el Gharbi); Iraq (Al-Basrah); Oman (northern Al-Batinah); United Arab Emirates (Abu Dhabi); and Algeria (Adrar).
- Under RCP 8.5, the highest declines in agricultural income by 2070 will be in: Mauritania (-10.4 percent); Sudan (-9.3 percent) and United Arab Emirates (-7.2 percent). Moderate declines are expected in Lebanon and Morocco (FAO and CMCC, unpublished).

Heat stress and frequency of droughts play a significant role in agricultural labour performance. Some predictions with gender differences were noted, indicating that the reduction in work performance, working hours and weekly or monthly earnings for female workers will be more pronounced than that of male workers:

- The highest declines in agricultural labour supply are expected to be in Sudan (-16.7 percent), with the lowest relative decline in Egypt (-7.8 percent).
- Gender differences are evident, with male and female labourers set to experience a labour decline phenomenon disproportionately. Female labour supply in the NENA region will decline by 12.3 percent by 2070 (9.7 percent by 2050). Male labour supply will decline by 7.6 percent by 2070 (5.2 percent by 2050) under RCP 8.5 (FAO and CMCC, unpublished).

The RICCAR project has highlighted that the hardest hit in terms of income losses are LDCs (e.g. Mauritania and Sudan). While large areas in LDCs are projected to witness moderate increases in temperature (e.g. the Horn of Africa) and increases in precipitation, these will be offset by relatively low levels of adaptive capacity that magnify climate risks. Thus, any adaptation interventions should also include areas of poverty and target those with low adaptive capacity. Due also to the low capacities to adapt, water sector vulnerabilities are highest in the upper Nile Valley, the southwestern Arabian Peninsula and the northern Horn of Africa. Conversely, areas with relatively low vulnerability include the Tigris-Euphrates basin and the lower Nile Valley, including the Nile Delta. Low levels of adaptive capacity are correlated with vulnerability hotspots in forest areas described in section 5.2.2. Another point to note is that all hotspots are located in areas with livestock.

5.3 Response options

Policy priorities should move towards reducing the variability of agricultural production and securing a stable income for farmers, especially smallholders and those relying on rainfed agriculture. Although some small-scale farmers already employ integrated crop-livestock systems that increase their adaptation capacity, more climate-resilient farming strategies and climate-smart farming systems, with support options to diversify production and livelihoods, are required. Governments must also consider enhancing national programmes for social protection and establish climate-resilient agricultural insurance coverage to help mitigate climate-related shocks on rural people's livelihoods. This section details national and regional responses in the following areas:

- Climate-smart agricultural practices and adaptation interventions in agricultural-food systems
- Regional institutional and policy responses
- Climate planning mechanisms including commitments to global climate change processes
- The need for climate finance flows.

5.3.1 Climate-smart agricultural practices

Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. The CSA approach aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience; and reducing and/or removing greenhouse gas emissions, where possible (FAO, 2016). Potential CSA responses include on-farm diversification (including crop diversification); adopting heat- and drought-tolerant crop varieties and species; the application of conservation agriculture with minimum tillage, ensuring land cover; modification of crop rotation and planting times; and fertilizer micro-dosing in areas with moisture shortage to secure efficient fertilizer use by plants (Sebnie *et al.*, 2020).

The assessments using AquaCrop simulations and RICCAR projections found that a number of response measures can be appropriate for specific countries. For example, the yield of wheat in Lebanon is projected to increase by 4–17 percent if supplementary irrigation is employed (ESCWA, 2019i); Egypt can generate water savings of up to 40 percent through deficit irrigation for wheat and maize and targeted interventions (ESCWA, 2019g). CSA responses are particularly salient for rainfed systems, such as in Maghreb countries, where citrus and dates are vulnerable to climate change. Wheat, olives and maize are vulnerable in both the rainfed and highland mixed farming systems. Given the importance of wheat, considering new heat-tolerant varieties is imperative. Indeed, a transition to barley, instead of wheat, might be appropriate, as barley requires less water. Adopting and scaling up conservation agriculture practices in rainfed areas was also one of the recommendations of the RICCAR country studies. In rainfed lands in the Nile Valley, millet, potatoes and tomatoes are the most vulnerable crops. Increasing sorghum cultivation could be a helpful CSA approach here, given its lower vulnerability to climate change and shorter growing period. In the irrigated areas, where fruits, vegetables and maize are grown, optimizing irrigation patterns will be inevitable. It will also be imperative to change crop sowing and planting times, or adjust cropping periods in response to shifts in rainfall patterns, thus adjusting to change in crop growth cycle. More specific examples are presented below.

Crop diversification and irrigation: In dryland mixed systems, wheat and vegetables will be vulnerable, especially in Jordan and the Syrian Arab Republic. Continued crop diversification will be important, especially for cucumbers, tomatoes and aubergines. Rainwater harvesting, and the application of supplementary and deficit irrigation, are increasingly being promoted. The introduction of supplemental irrigation (especially drip) is being adopted, such as for olive trees (an important component of the agricultural economy across many NENA countries). The application of deficit irrigation is proving to be a good adaptation measure.[74] This form of irrigation generates higher yields and increases water productivity, as the reduced amount of water is used to irrigate more land, thereby enhancing crop production with the same amount of water.

Water accounting systems: For long-term planning, enhancing water accounting systems is important to ensure that water availability is monitored, and water allocations are sustainable for supplemental irrigation interventions. Water accounting systems are already being initiated. For example, six new RICCAR regional climate projections were developed at a 10-km^2 resolution to support analysis of climate change impacts at the watershed level.[75] These projections are supporting a collaboration between FAO and ESCWA and being used to establish a water accounting system in three watersheds

[74] Deficit irrigation is an optimization strategy in which irrigation is applied during drought-sensitive growth stages of a crop.

[75] The setting up and testing of this new domain was conducted by the Swedish Meteorological and Hydrological Institute, with input from ESCWA and ACSAD and support provided by the Swedish International Development Cooperation Agency. This new Mashreq domain actually goes beyond the Mashreq subregion to include the entire Arabian peninsula and northeastern Africa.

in Algeria and Lebanon. The key aims are to improve the evidence base for basin stakeholders, with interventions to increase water efficiency and productivity.

Landscape-based approaches: Landscape-based approaches such as land restoration and ecosystems-based approaches are gaining traction. One such example is the Great Green Wall initiative. This is an African Union-led 20-country project that aims to address desertification and climate change impacts on Sahelian communities.[76] The plan is to restore 100 million ha of degraded land, create 10 million green jobs and sequester 250 million tonnes of carbon dioxide. NENA countries involved in the initiative are Algeria, Egypt, Mauritania, Sudan and Tunisia. Landscape-based options offer strong potential and more such initiatives should be considered for the NENA region.

Food loss and waste reduction: Value chain actions such as reducing food loss and waste (FLW) are important priorities for the region, and are outlined in Chapter 6. Addressing FLW as part of the climate solution requires an understanding of what drives losses along the value chain and the decision-making behaviour of different actors. With food loss and waste attributed as the cause of at least 8 percent of the GHGs responsible for global warming in 2010–2016 (according to the *IPCC Special Report on Climate Change and Land*), the NENA region is recognizing the need to tackle these issues. However, incentives for farmers and firms to address FLW are required. It was found in one project that farmers often face a trade-off between the costs of reducing losses and enhancing productivity.[77] Evidence from the tomato and grain value chains in Egypt and Tunisia point to the need for clearer and better incentives for value chain actors (both farmers and firms) to adopt loss-reducing equipment and technologies, some of which may only be cost-effective for farms of a certain size.

Diversification: Off-farm diversification is another important consideration. In the pastoral lands of the Maghreb subregion, milk yield relative to feed will decline for both goats and sheep. Adapting traditional management and mobile grazing strategies will be unavoidable in the long run. Diversification in the form of off-farm jobs, especially around urban centres, must be pursued in parallel to on-farm responses.

Other CSA responses: Mobilizing resources for investment in agricultural value chains and promoting investments to modernize irrigation systems are important options to be taken into consideration. Also essential are ongoing efforts to improve data collection and reporting. Unified and reliable databases can be better shared between institutions, ensuring cross-sectoral coordination. With the assistance of the World Bank and partners such as FAO, countries like Egypt and Jordan are already developing CSA investment frameworks to prioritize suitable CSA practices across agro-ecological zones, farming systems or regions. However, more investment is needed for testing CSA practices through effective local governance, including the use of the Farmer Field School approach and extension services.

5.3.2 regional institutional and policy responses

Mainstreaming climate change into national strategies and policies can help to address vulnerability to climate change in advance, rather than responding as impacts unfold (such as disaster risk reduction and immediate or shorter-term response measures). Although national responses to climate change had tentatively begun in some countries, climate change was not articulated under a regional position in the Arab States until 2007.

Arab Centre for Climate Change Policies: During the 19th session of the meeting of the Council of Arab Ministers Responsible for the Environment (CAMRE), the Arab Ministerial Declaration on Climate Change emphasized

[76] See www.greatgreenwall.org/about-great-green-wall

[77] Name of project: EGY and TUN FLW – Smolak and Santos Rocha.

the importance of adaptation.[78] Among the regional priorities were calls for efforts to establish studies and research centres for climate change in the region (ESCWA, 2021). The Arab Summit endorsed its first climate change project in January 2009 in Kuwait, with five initiatives on integrated water resources management tasked to a newly established Arab Ministerial Water Council. Some of the early initiatives included the establishment of the Arab Centre for Climate Change Policies (ACCCP) by ESCWA member states. The ACCCP provides Arab States with support in the areas of climate change assessment, adaptation, mitigation, disaster risk reduction, meteorology, climate finance, negotiations, integrated development planning, technology, and tools for geospatial climate change analysis.

The 2019 Cairo Declaration: Under the auspices of the League of Arab States, the Arab Ministerial Water Council and Ministers of Agriculture that serve as the governing board of the Arab Organization for Agricultural Development (AOAD) established a Joint Ministerial Council (JMC). The first session of the JMC was convened in April 2019 during the 2019 FAO Land and Water Days. During this time, the JMC adopted the 2019 Cairo Declaration and established a High-Level Joint Technical Committee, comprising senior officials from the agriculture and water sectors; it meets on an annual basis. Eighteen Arab countries adopted the declaration. The Declaration itself:

- stresses the importance of establishing a coordination mechanism between the water and agriculture sectors;
- seeks to review the legislation, systems and mechanisms on the use of water and lands; and
- aims to increase investments in the field of agricultural water management.

Regional data and information: regional initiatives are also coalescing around the enhancement of climate information services. The Arab Permanent Committee on Meteorology set up an Arab Climate Outlook Forum (ArabCOF), with the first session held in September 2017 (in Beirut). It brings together Arab meteorological services twice a year to prepare seasonal forecast consensus statements, and serves as a platform for regional exchange, capacity-building, lessons learned and consensus-building on common concerns facing Arab states' meteorological services.[79] The RICCAR project is an example of regional coordinated efforts to downscale and make available data on climate change vulnerabilities, to support national planning efforts. RICCAR's regional Knowledge Hub, jointly developed by FAO and ESCWA, provides access to regional information and knowledge products. It is composed of a website and a data portal, the latter giving access to geospatial data sets and modelling outputs generated for the Arab region, and allows users to visualize maps developed under the initiative. RICCAR country reports have already enhanced the capacities of at least nine member countries to incorporate climate change in their water and agricultural plans.

Other regional collaboration: In 2020, FAO and ESCWA led a discussion with the Arab group of negotiators in partnership with others on the Koronivia Joint Work on Agriculture (see also section 2.4.4) and a work programme developed from a COP22 decision that highlights agricultural issues of relevance for the climate negotiations. Other initiatives in the region support the development, update and implementation of Nationally-Determined Contributions (NDCs) and negotiations at the UNFCCC. These include:

- The bodies of the League of Arab States, such as the ACCP and the Arab Group of Negotiators
- The UN Issue-Based Coalitions on food security, climate and the environment
- The UNFCCC Lima Adaptation Knowledge Initiative.

[78] Council of Arab Ministers Responsible for the Environment, Arab Ministerial Declaration on Climate Change, 19th session, Cairo, December 2007.

[79] The ArabCOF convenes under the Arab Permanent Committee on Meteorology, with the support of the LAS Secretariat, ESCWA and WMO. More information is available at: www.riccar.org/basic-page/arabcof

5.3.3 Implementing national climate commitments

Nationally Determined Contributions: These are the non-binding national plans highlighting climate actions, including targets for greenhouse gas emissions reductions, policies and measures that governments aim to implement in response to climate change and to achieve global targets set out in the Paris Agreement. Governments and other national actors are responsible for accelerating finance for NDC implementation to achieve transformative change in climate change actions. Following COP26, governments are also expected to raise ambitions of what can be achieved, as well as to mobilize society to meet NDC targets. Several Arab countries have established national committees on climate change, involving relevant sectors to support a coordinated response to climate change challenges. For example:

- Palestine established a national climate change committee to pursue policy formulation coherence across sectors.
- Kuwait set up a national coordination committee on climate change under the leadership of the Ministry of Health, which provides a platform for enhanced cross-sectoral collaboration at national level.[80]

Yet more can be done to mainstream climate change into national and sectoral policies and strategies. This includes assessing the gaps and barriers for agriculture sectors to develop and implement climate change mitigation and adaptation actions, in conjunction with efforts to combat land degradation and water scarcity. Studies of the sectoral priorities and climate finance flows to the agriculture, land-use, forestry and water and sanitation sectors highlight that NENA countries were lagging behind some other regions in this regard. All Arab states except for Libya submitted their first-round NDCs. A number of countries have submitted their NDC updates.[81] Out of the 30 National Adaptation Plans (NAPs) communicated by developing countries globally, only Palestine and Sudan in the region have submitted their NAP (UNFCCC, 2021). A FAO 2021-NDC analysis of 18 NENA countries' first round of NDCs to the Paris Agreement (climate change) show that water scarcity, salinization, and productivity losses due to ecosystems impact warrant adaptation action. For example:

- The majority included a GHG target in relation to a business-as-usual scenario, with one-third committing to 'action-only'.
- Over half the countries include agriculture in their general mitigation contribution, although only two countries (Mauritania and Morocco) present a target specific to the sector.
- Almost all countries reference water stress (17 countries or 94 percent).
- Seven countries mention salinization (39 percent).
- Fifteen countries have reported ecosystems impacts (88 percent) and refer to losses in primary production and productivity, followed by the loss of biodiversity, ecosystems and related functions (13 countries or 76 percent) and changes in water availability and quantity (12 countries or 71 percent).
- Most countries prioritize agriculture (9 countries or 64 percent), followed by crops and forestry subsectors (7 countries or 50 percent).
- Among countries with an adaptation component in the agriculture and land-use sectors, 11 countries (65 percent) include land and oil resources-related adaptation policy options. Water resources are prioritized by 12 countries (86 percent).
- Biodiversity, ecosystems and natural resources are prioritized by 6 countries (43 percent).

[80] For more information, see ESCWA and IsDB, 'Expert Group Meeting on Mainstreaming Climate Action into National Development Planning in the Arab region: Report', Amman, 25–27 November 2019, E/ESCWA/SDPD/2019/WG.46/Report.

[81] NDCs were delayed in some countries by the onset of the COVID-19 pandemic.

- Most countries referring to adaptation measures in water resources promote irrigation and drainage (9 countries, 82 percent).

- Two-thirds (7 or 64 percent) promote water storage and harvesting.

5.3.4 Climate finance flows for agriculture, land and water priorities

Climate finance refers to local, national or transnational financing – drawn from public, private and other sources of financing – that seeks to support mitigation and adaptation actions that will address climate change. The Arab region continues to leverage multilateral finance from traditional sources, such as bilateral funds and the Global Environmental Facility (GEF), and increasingly, the Green Climate Fund (GCF). These are important sources for building capacities and infrastructures for mainstreaming and implementing climate change mitigation and adaptation projects. However, on average, GCF national projects are approved for just two NENA states each year. While GCF also provides important readiness support, the limited number of projects funded through the GCF highlights the need for NENA states to diversify efforts to mobilize climate finance. The following sections outline how obtaining climate finance for adaptation in agriculture does not appear to be easy, and it is important to consider how better partnerships can be developed to access financial resources, especially for those countries in the region that urgently require support.

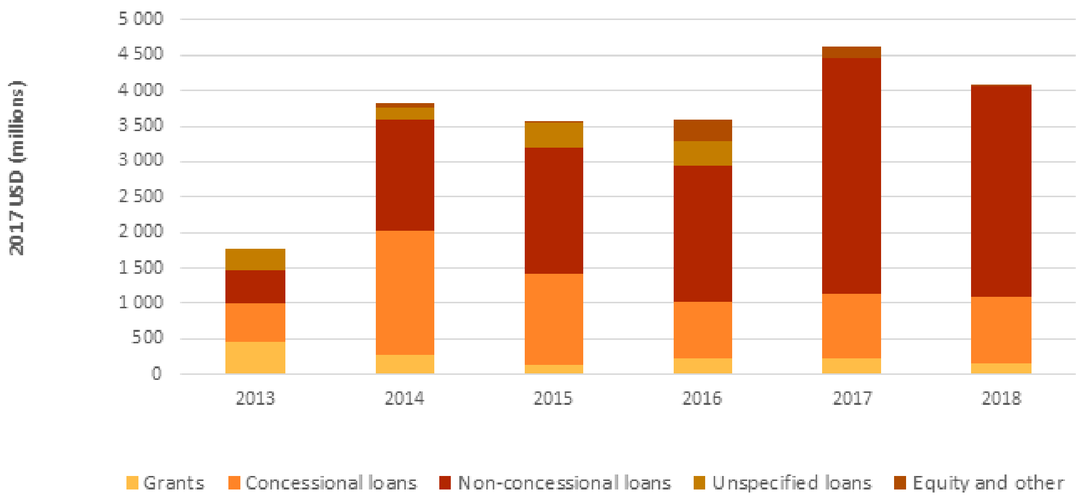
Need for climate financing identified: Eight of the 19 NENA countries identified national climate finance needs in their first NDCs,[82] [83] totaling USD 371 billion, with much of this amount required in the immediate decade. Of these needs, NENA countries have unconditionally committed to implement climate actions with an estimated cost of USD 30 billion, either from national budgets or by mobilizing finance from other sources. However, implementation of the remaining climate actions for which costs estimates are provided, totalling USD 341 billion, is conditional on NENA countries receiving public international support. Despite this large financing need, the NENA region only receives an average of USD 4 billion per year in Public international climate finance support (based on climate finance reporting to the Organisation for Economic Co-operation and Development (OECD),[84] which is far below the needs of the seven NENA countries that provided estimates in their first NDCs (see Figure 5.8). Furthermore, only a handful of NENA countries are accessing bilateral and multilateral climate finance at scale (see Figure 5.8). Egypt and Morocco are the top recipients by volume, mostly in the form of debt finance.

[82] The eight countries are: Egypt, Iraq, Jordan, Mauritania, Morocco, Palestine, Sudan and Tunisia.

[83] Seventeen NENA countries submitted Intended Nationally Determined Contributions (INDCs), which are considered to be the first NDC following the adoption of the Paris Agreement. The data in this chapter are based on NDCs submitted through 31 December 2020. Several Arab States were due to submit updated NDCs in 2021, which are likely to have adjustments.

[84] This refers to bilateral and multilateral climate finance flows to the NENA region based on reporting to the OECD. It includes flows with climate marked as a 'principle' objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a 'significant' objective (Rio Tag) are not included.

FIGURE 5.8 PUBLIC INTERNATIONAL CLIMATE FINANCE COMMITMENTS TO NENA BY TYPE OF FINANCIAL INSTRUMENT



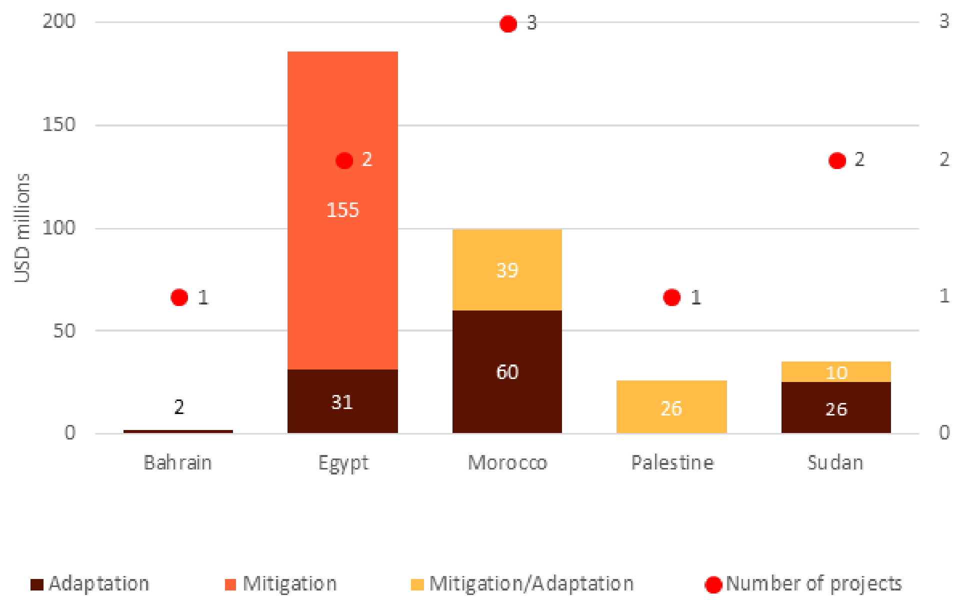
Source: Prepared by ESCWA based on OECD. *Climate-related development finance data, database* [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Note: This chart evaluates bilateral and multilateral climate finance commitments to the NENA region based on reporting to the OECD. It includes commitments with climate marked as a 'principle' objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a 'significant' objective (Rio Tag) are not included.

Finance for adaptation versus mitigation: The region requests more than twice as much finance for adaptation than it does for mitigation, clearly identifying that adaptation is the regional priority.[85] However, NENA receives nearly five times more public international finance for mitigation than it does for adaptation (see Figure 5.9). Furthermore, while the region requests more grant support, particularly for adaptation, grants account for just 6 percent of support received since 2014. In general, the quality of climate finance commitments to the region must be better matched with the priorities of NENA countries, as articulated in their NDCs and climate-related policies or communications.

[85] The region has requested USD 189.3 billion in adaptation finance and USD 93.8 billion in mitigation finance. An additional USD 73.5 billion in requests do not specify the breakdown between adaptation and mitigation.

FIGURE 5.9 GREEN CLIMATE FUND FUNDING COMMITMENTS TO NATIONAL PROJECTS IN THE NENA REGION, BY PURPOSE (2016–SEPTEMBER 2021)



Source: Elaborated by ESCWA.

Note: These figures only include direct GCF funding commitments. Co-financing amounts mobilized by the GCF are not included. GCF reports its commitments to the OECD with a 'significant' Rio Marker.

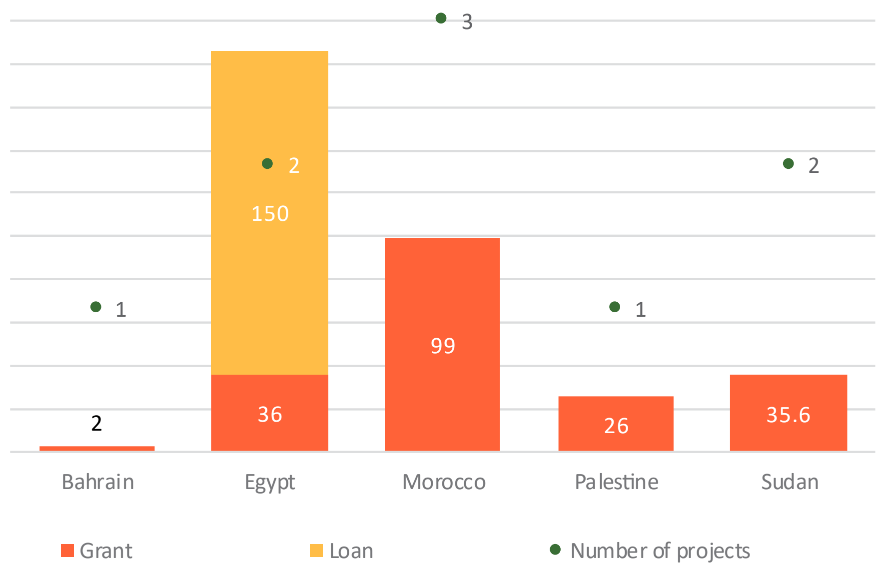
Multilateral climate funds provide a better aggregate balance between adaptation and mitigation finance and between grants and loans (see Figure 5.10). However, access to multilateral resources is limited in NENA. While most states in the region have been able to secure support through the GCF Readiness Programme, the GCF has approved funding in only six NENA countries (as of October 2021) for national projects to implement specific climate actions. An additional four NENA states have accessed GCF funding through multicountry projects that also include recipient countries from outside the NENA region.[86] [87] The GCF allocated a total of USD 390 million in direct commitments (excluding those co-financed) to 10 national projects in the NENA region between November 2015 and December 2020, an average of just 2 projects per year, providing less than USD 100 million in annual commitments to the region.[88]

[86] Jordan, Lebanon, Mauritania and Tunisia.

[87] For example, 5 NENA countries (Jordan, Lebanon, Mauritania, Morocco and Tunisia) are among the 42 countries eligible for financing from the Global Subnational Climate Fund, which has received USD 750 million in committed equity and USD 28 million in grant commitments from the GCF and others.

[88] The amount of finance provided by the GCF is reported separately because the GCF reports its commitments to the OECD with a 'significant' Rio Marker. Thus, GCF commitments are not included in the OECD climate finance flows reported in this section. However, the providers of GCF co-finance typically report to the OECD with a 'principal' or 'climate components' tag. Thus, most co-finance 'mobilized' by the GCF is likely to be included in the OECD climate finance flows reported in this section. That is why only the direct GCF contribution is presented in Figure 5.10.

FIGURE 5.10 GREEN CLIMATE FUND FUNDING COMMITMENTS TO NATIONAL PROJECTS IN THE NENA REGION, BY TYPE OF FINANCIAL INSTRUMENT



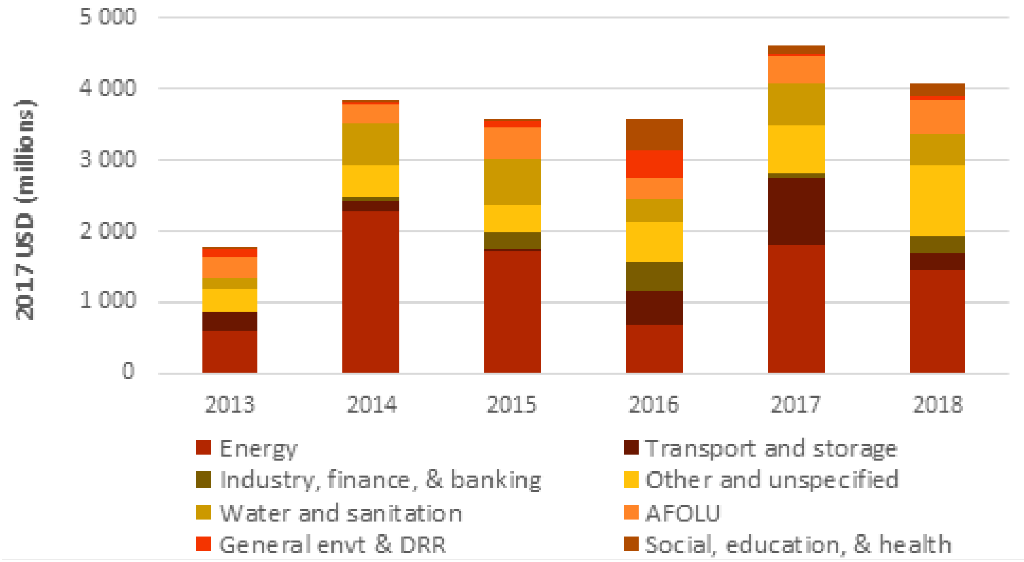
Source: Elaborated by ESCWA.

Note: These figures only include direct GCF funding commitments. Co-financing amounts mobilized by the GCF are not included. GCF reports its commitments to the OECD with a 'significant' Rio Marker.

Climate finance by sector: The NENA region presents strong interlinkages across the nexus of water, energy and food security for climate-resilient development in the region. Commitments to the WATSAN (water and sanitation) and AFOLU (Agriculture, Forestry, and Other Land Uses) sectors accounts for just 13 and 10 percent of Public international climate finance commitments to the NENA region, respectively. Conversely, climate finance flows to energy, transport, storage, industry, finance, banking and other sectors outnumber flows to WATSAN and AFOLU by a factor of five and seven, respectively (see Figure 5.11).[89] This anomaly is despite the critical importance of these two sectors for addressing climate change and is particularly notable given that AFOLU and WATSAN are the only sectors in which most flows are intended to support adaptation. In fact, WATSAN is also the sector with the highest share of investments with a cross-cutting mitigation and adaptation purpose. There is potential for a higher share of funding for AFOLU projects with cross-cutting purposes, given the strong potential for achieving adaptation and mitigation co-benefits in this sector.

[89] 95 percent of flows to other or unspecified sectors are for mitigation.

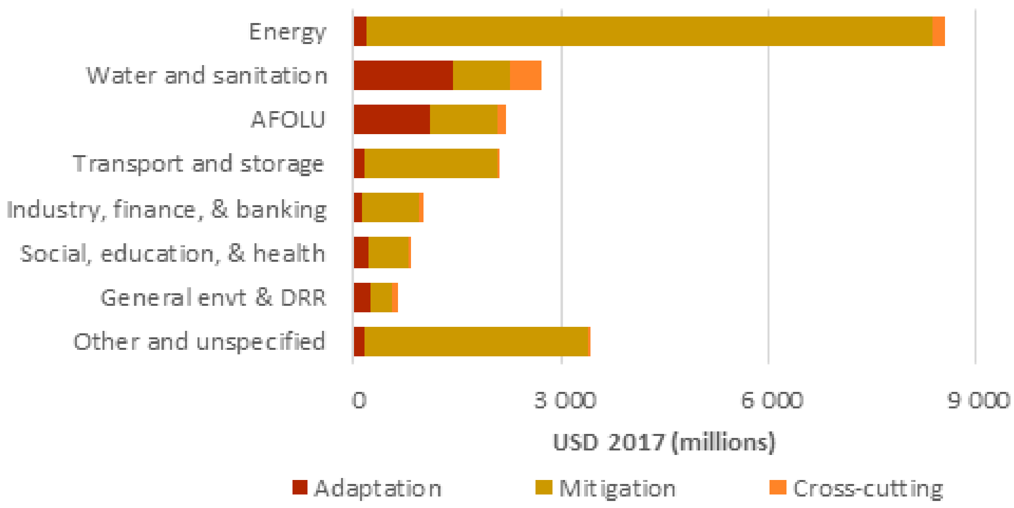
FIGURE 5.11 PUBLIC INTERNATIONAL CLIMATE FINANCE FLOWS TO NENA BY SECTOR



Source: Prepared by ESCWA based on OECD. *Climate-related development finance data, database* [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Note: This chart evaluates bilateral and multilateral climate finance flows to the NENA region based on reporting to the OECD. It includes flows with climate marked as a 'principle' objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a 'significant' 'objective (Rio Tag) are not included.

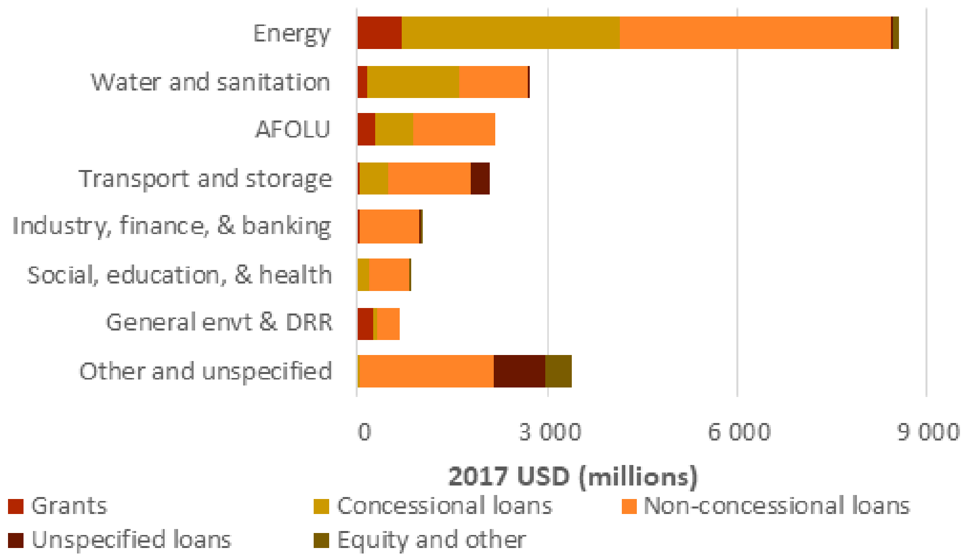
FIGURE 5.12 PUBLIC INTERNATIONAL CLIMATE FINANCE FLOWS TO THE NENA REGION, BY SECTOR AND PURPOSE (2013–2018)



Source: Prepared by ESCWA based on OECD. *Climate-related development finance data, database* [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Note: This chart evaluates bilateral and multilateral climate finance flows to the NENA region based on reporting to the OECD. It includes flows with climate marked as a 'principle' objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a 'significant' 'objective (Rio Tag) are not included.

FIGURE 5.13 PUBLIC INTERNATIONAL CLIMATE FINANCE FLOWS TO THE NENA REGION, BY SECTOR AND PURPOSE (2013–2018)



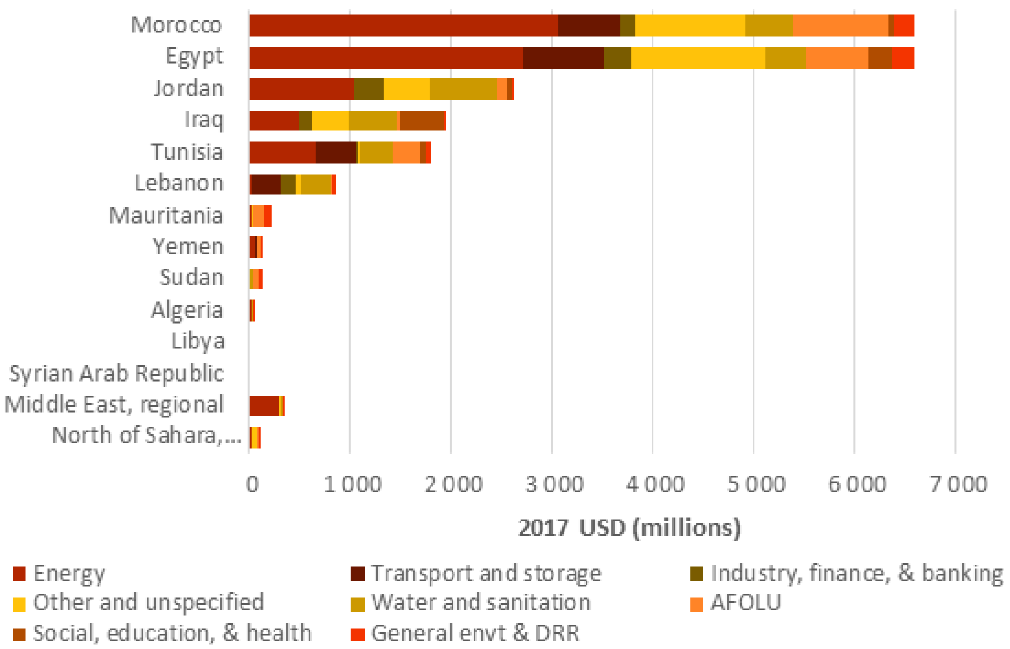
Source: Prepared by ESCWA based on OECD. *Climate-related development finance data, database* [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Note: This chart evaluates bilateral and multilateral climate finance flows to the NENA region based on reporting to the OECD (OECD, 2021). It includes flows with climate marked as a 'principle' objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a 'significant' objective (Rio Tag) are not included.

Despite the importance of AFOLU and WATSAN sectors for adaptation and the urgent need for concessional and grant finance, these sectors receive very little grant finance and rely to an important degree on non-concessional finance. This is in comparison with the energy sector, where there are greater opportunities to recover costs. regionally, the quantity of Public international climate finance commitments to AFOLU and WATSAN varies by country, as shown in Figure 5.14. Some salient points from Figure 5.14 include the following:

- Egypt and Morocco are the highest recipients of Public international climate finance flows.
- Jordan, Lebanon, Iraq and Tunisia are also attracting climate finance, albeit on a more moderate scale than Egypt and Morocco.
- NENA's LDCs and countries affected by conflict face more difficulties in accessing funding, despite SDG 13 calling for increased dedicated financing for the world's LDCs and small island states. NENA's LDCs receive very little climate finance support compared with the middle-income countries.
- Countries facing ongoing conflicts or under international sanctions receive almost no climate finance support. However, the little that they receive tends to be for WATSAN and AFOLU rather than for energy and transportation.
- Jordan, Lebanon, Iraq and Palestine have received little climate finance support for AFOLU.
- Sudan and Mauritania predominantly receive climate finance support for AFOLU, with little to no support for WATSAN.
- Algeria, Libya, the Syrian Arab Republic and Yemen receive almost no support for AFOLU or WATSAN, despite the great need to strengthen water and food security.
- Egypt receives the most climate finance focused on land use within the region.
- Morocco receives the most climate finance support for agriculture.

FIGURE 5.14 PUBLIC INTERNATIONAL CLIMATE FINANCE FLOWS TO THE NENA REGION BY SECTOR AND RECIPIENT (2013–2018)



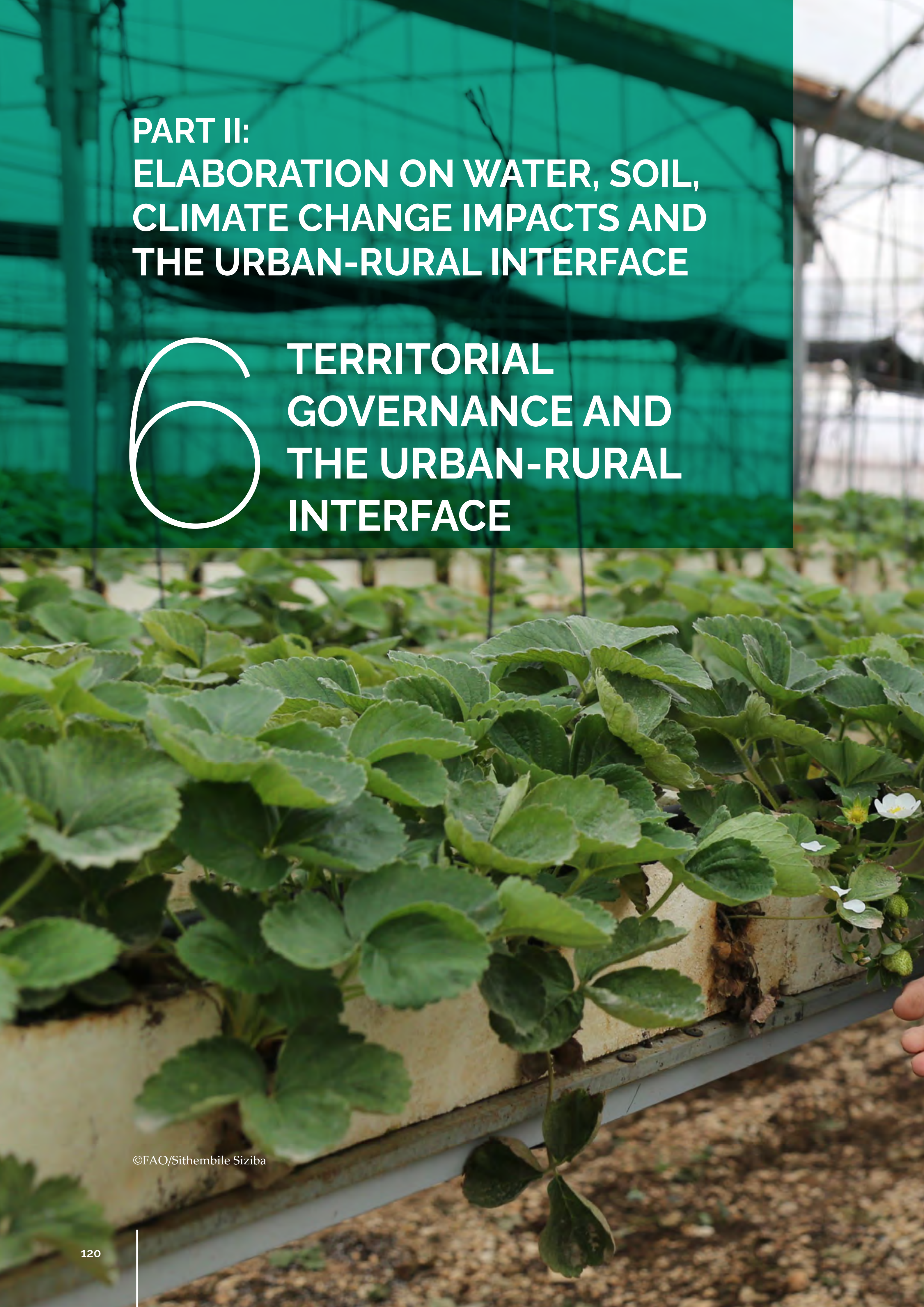
Source: Prepared by ESCWA based on OECD. *Climate-related development finance data, database* [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Note: This chart evaluates bilateral and multilateral climate finance flows to the NENA region based on reporting to the OECD. It includes flows with climate marked as a principal objective (Rio Tag). It also includes 'climate components' reported by multilateral development banks. Flows with climate marked as a significant objective (Rio Tag) are not included.

The distribution of climate finance support to the AFOLU and WATSAN sectors varies significantly by state, as shown in Figure 5.13 and Figure 5.14. regional crises and conflicts have affected the ability of countries to access climate finance for adaptation. Clearly, more efforts to galvanize and earmark climate finance is required so that countries in the NENA region can respond to the adaptation challenges and put in place adaptation measures that build upon improved land and water management practices. Such efforts must have at their core transformative food systems and a focus on boosting overall resilience to climate change for the most vulnerable.

PART II:
ELABORATION ON WATER, SOIL, CLIMATE CHANGE IMPACTS AND THE URBAN-RURAL INTERFACE

6 TERRITORIAL GOVERNANCE AND THE URBAN-RURAL INTERFACE



©FAO/Sithembile Siziba

KEY MESSAGES

- **Urbanization is a growing phenomenon in NENA.** The number of people living in urban areas rose from around 146 million to 250 million in the past 20 years. Although currently at almost 60 percent, the urban population is projected to grow to almost three-quarters of the rural population by 2050.
- **Peri-urban and rural farmlands are under constant pressure from urbanization and degradation.** Infrastructure development is often at the expense of agricultural land, leading to land fragmentation.
- **Making available food and water resources for a growing urban population is a challenge.** With limited land and water resources, and to avoid being over-reliant on food imports, agrifood systems will have to transform and adapt, addressing food security, climate change and natural resource scarcity. Without action, water availability, including the quality and quantity, will further deteriorate, severely affecting the resilience of urban communities.
- **Urban waste is often not properly collected and treated, resulting in pollution.** Landfill for waste results in loss of resources that could be recycled. Eleven percent of food was lost or wasted in 2016 in the region. Wastewater recycling, although practised by several countries, is low overall. A circular economy model aims to keep products, materials, equipment and infrastructure in use for longer periods.
- **Cities should reconnect with their rural territories, ensuring supply and demand for locally supplied fresh foods.** Efficient urban-rural linkages are important for inclusive and resilient territorial development. Urban agriculture also facilitates shorter supply chains.
- **Digital technologies can facilitate connections between rural and urban areas and help smallholder farmers to better access local markets.** Use of transformation and innovative digital technologies improved during the COVID-19 pandemic, but can be better directed at zero percent waste and carbon neutrality.
- **Greener cities improve the quality of life and standard of living.** Multiple environmental benefits such as flood control, reduction of stormwater runoff and soil sealing, as well as biodiversity, are benefits of green planning in cities. Green infrastructure and urban agriculture can be integrated in planning.
- **Land and water management must be more effectively integrated within city watersheds.** A functional multilevel governance system is ideally required for territorial governance. Accurate data, more effective, inclusive and participatory planning mechanisms, along with tenure policies, are important inputs for better decision-making and planning. The restoration of existing natural resources while leaving no one behind is the ultimate goal.

Introduction

Since 1970, the NENA region has been urbanizing faster than the global average. Urbanization and growing city sprawl challenge rural, urban and peri-urban landscapes. Although people living in cities may have better access to employment, and cities have advantages in terms of economies of scale, high densities of population and infrastructure in urbanized areas have major implications for energy consumption, water use, pollution and housing.

This chapter examines the increasingly connected urban-rural worlds in NENA, highlighting the pressure of urban population growth on land and water resources. Section 6.1 examines how cities are interacting with rural areas for food production, distribution and consumption. Section 6.2 focuses on responses to urban challenges, drawing examples from the region, looking at planning strategies and the role of a ‘circular bioeconomy’ and digital technologies to strengthen food systems. The final section discusses how territorial governance can enhance urban-rural linkages to foster sustainable management.

6.1 Urban-rural interface issues

The flows of people, services, goods, finance and refuse occur daily across the urban-rural continuum. This section examines types of challenge within the urban-rural interface and explores issues of equitable rural and urban development.

6.1.1 Urbanization and footprint increase

Population growth and urbanization: The population in the NENA region has been growing rapidly, as can be seen in Table 6.1 and Figures 2.1 to 2.4 in Chapter 2. People and activities are concentrated on a limited land area along the coast or around water sources, resulting in high population densities on limited territory, increasing competition for scarce water and land resources. For many countries in the region, urbanization and coastalization are the dominant development dynamics. Although the extent and rate vary, the overall trend is towards coastal and low land expansion in areas with impervious soil. This has resulted in a gradual merging of urban and rural landscapes, but with large contrasts between wealthier coastal zones and neglected hinterlands. Although the definition varies as to what is considered urban, 59 percent of the region’s population is considered to be living in urban areas.[90] A very rapid urbanization growth of 72 percent occurred between 2000 and 2020 (UNDESA, 2018). By 2050, the urban population share is projected to grow to about 73 percent, totalling more than 450 million people (FAO, 2020g).

[90] UN-Habitat, in collaboration with New York University, the European Commission’s Joint Research Centre and other partners, is working on the actual definition of cities, whether it concerns the level of built-up and urbanized open space, or whether the area is defined by the degree of urbanization (density clusters).

TABLE 6.1 POPULATION GROWTH 2000–2020

	2000	2010	2020	% growth 2000–2010	% growth 2010–2020	% growth 2000–2020
Urban population	146 499 777	195 382 586	252 185 468	33%	29%	72%
Rural population	127 361 675	147 787 988	168 738 943	16%	14%	33%
Total population	273 861 452	343 170 574	420 924 411	25%	23%	54%

Adapted from source: UNDESA 2018 revision, online edition, 2021.

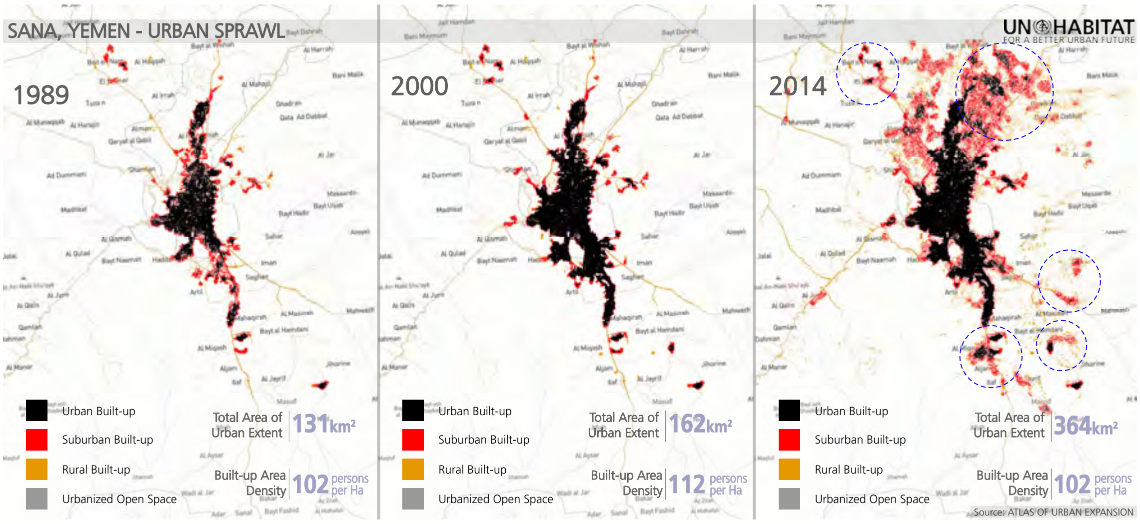
Note: The growth rates are calculated as simple percentage changes between the ending and the beginning years.

Many cities are built on impervious soils that do not allow local infiltration of water, increasing flood risks and reducing natural groundwater recharge.[91] Coastal cities are particularly exposed to risks of rising sea levels and extreme coastal events.

Urban sprawl and changes in land use: Rapid urban sprawl around small, medium and large cities threatens limited agricultural land resources. Although informal settlements often occupy already degraded or more vulnerable areas in cities, urban expansion frequently expands onto nearby peri-urban and rural land, overtaking agricultural lands, orchards and ecological areas, and claiming nearby water sources. This expansion comes with needs for roads and infrastructure, which in turn claim more land and water. A 2020 UN report on the state of the environment and development in the Mediterranean indicates that most urban expansion "is linked to the establishment of informal settlements, defined as residential areas where inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit" (UNEP-MAP and Plan Bleu, 2020). Living modalities range from squatting to informal rental housing. The impacts of urban sprawl on agricultural land were highlighted by a study conducted in two locations in Jordan and Lebanon, which aimed to explore the relation between food security and peri-urban agriculture. In the town of Bebnine (Lebanon), infringement on field crops accounted for 176 855 m^2 (or 3 percent of total area), while in Wadi el Seer (Jordan), urban settings expanded over field and permanent crops, generating losses of 332 098 m^2 and 153 904 m^2, respectively (Babar and Mirgani, 2014). The case of Sanaa in Yemen (see Figure 6.1) illustrates the evolution of urban sprawl from 1989 to 2014.

[91] Infiltration is the process by which water on the ground surface enters the soil.

FIGURE 6.1 EVOLUTION OF URBAN SPRAWL IN SANA'A, YEMEN FROM 1989–2014



Source: Based on information provided by FAO/UN-Habitat, 2021 (unpublished).

Studies on the impact of urban sprawl confirm alarming land-use changes. In Morocco, urbanization could cause losses of 70 000 ha of agricultural land by the end of 2025 (Royaume du Maroc, 2015). In Algeria, 250 000 ha of agricultural land has been lost since 1962, and in Tunisia, 4 000 ha are being lost every year due to urban expansion (FAO, 2012a).

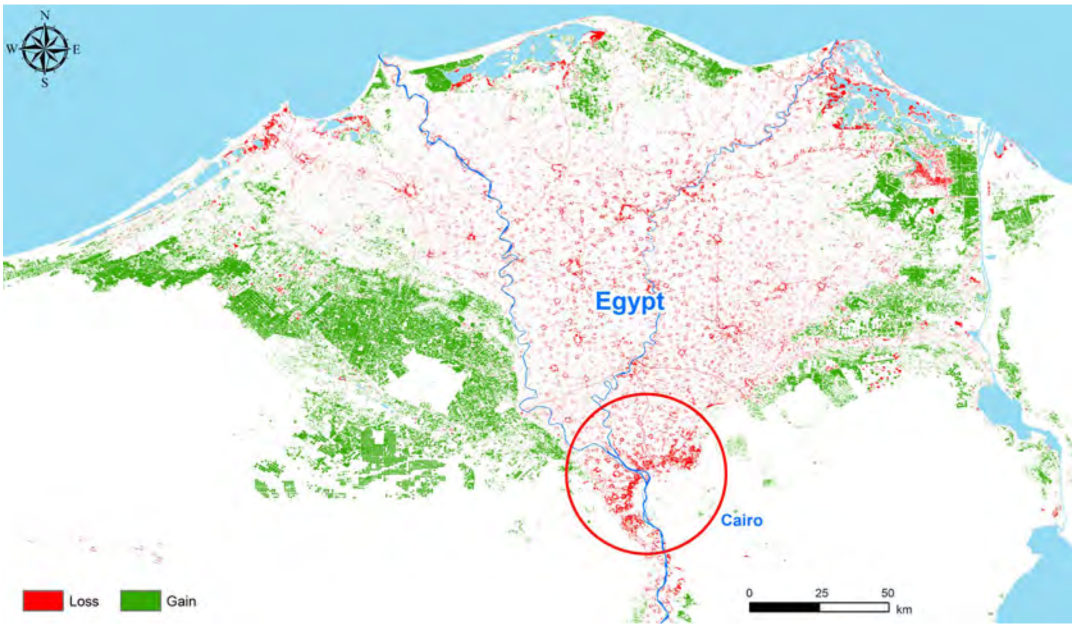
On the other hand, an emerging phenomenon is new lands in the NENA region being developed for agriculture. FAO statistics show some examples of cropland gains between 1962 and 2018 (FAOSTAT, 2021). For example, Morocco has gained about 2.1 million ha of cropland; Algeria has gained 1.6 million ha; and Tunisia has gained 743 000 ha. However, even with new lands being developed, the same type of agricultural land is not interchanged. Urbanization often replaces the more fertile agricultural lands, whereas new lands for agriculture expand on marginal land (former deserts in Algeria or Egypt), using modern technologies involving irrigation for high-value crops. The gained lands will not exactly replace the land lost. Some of the functions traditionally implemented through agriculture are also lost (such as staple crop production, flood buffering, landscape and food culture).

BOX 6.1 EGYPT – THE FERTILE DELTA SLOWLY OVERTAKEN BY URBAN SPRAWL

According to Radwan *et al.*, within 23 years (1992–2015) 74 600 ha of productive agricultural land in the Nile Delta was lost (at an average rate of 3.108 ha per year), due to expanding urban sprawl. However, desert lands outside the Delta (new lands) have been reclaimed to compensate these losses. Although 206 100 ha of bare land are used for agricultural production (Radwan *et al.*, 2019), the area of land lost was greater than that of the land gained. The figure below shows the losses and gains in vegetation cover in the Nile Delta during the period 1990–2019 due to urban settlement expansion and land reclamation efforts.

Source: Radwan *et al.* 2019. *Dramatic loss of agricultural land due to urban expansion threatens food security in the Nile Delta*, Egypt. Remote sensing, 11(3): 332. https://doi.org/10.3390/rs11030332

FIGURE 6.2 LOSS AND GAIN IN VEGETATION COVER IN THE NILE DELTA IN 2019 COMPARED TO 1990



Source: Prepared by FAORNE based Landsat Data on Google Earth Engine Platform. https://explorer.earthengine.google.com/#search/tag:landsat

6.1.2 Urban-rural continuum

Production and urban consumption patterns: Globalization processes enable low-cost food imports and exports. While farmers and firms along a value chain exporting from and importing into the NENA region benefit financially, low-cost imports can change the share of domestic agriculture, thereby altering national incomes from food production. The mild winters of the NENA region can produce high demand for off-season products on international markets, and this has influenced production shifts to high-value export crops (such as citrus, avocado, apple, tomato and strawberries). Expanding cities in the region and beyond represent a significant market for rural products if they match urban demands and are well connected to these markets. On the other hand, scarce land and water resources must be reallocated to satisfy these newer demands. For example, In Morocco, avocado was an unknown fruit in 2000, imported at high cost. Today, it is in high demand from the urban Moroccan consumer and the country's European neighbours. Avocado production in Morocco has increased by more than 85 percent in 10 years, with about 1 300 ha planted (Agridigitale, 2020). Its production, however, relies heavily on water, requiring irrigation.

Population growth, along with consumer demand for different types of food, evidently influence supply and land use. Increased consumer demand for fish means more capture fishery and the development of aquaculture along the coast, or inland. Increased demand for meat pushes traditional pastoral agriculture towards industrial livestock rearing (for example, battery chicken farming) to reduce costs. Farmers invest in milking cows and fodder production when there is increased demand in urban areas. Urban dwellers' diet choices can also place an increased reliance on imports, with dependence on processed food, even if traditional diets prevail in rural areas. Re-establishing stronger relations between rural and urban settings is important, particularly for assessing the transformation process that is needed in territories that enclose cities, to encourage a sustainable food systems approach. Land and water policies, land-use planning, tenure issues and incentive structures for value chains must be assessed to understand how food systems are organized and can improve.

Food waste: When diets are dependent on fresh but perishable products, food waste along the supply chain and at consumer level can be significant. Table 6.2 presents household level food waste estimated by the Food Waste Index.[92] An estimated 11 percent of food produced for human consumption in 2016 was lost from the farm up to, but excluding, the retail stage in the NENA region.[93] This compares with almost 14 percent globally (FAO, 2019i).[94] Over 360 million ha of land are used to produce food that is lost or wasted in the NENA region. Section 6.2.3 contains more information on food waste.

Infrastructure challenges: Urban-rural linkages are both visible and invisible. Limited access to infrastructure results in some rural areas not engaging in new value chains. Roads, bridges, pipes (above ground or underground), canals, cables and rivers can connect or fragment landscapes. Connection is increased through air, water and road transport, facilitating international trade.

Infrastructure investments help to incentivize exports (such as fruit and vegetable packaging hubs), and also enable imports. Physical connections require land as trade increases, which frequently occurs on unbuilt natural or agricultural land. This is well illustrated in Tunisia, where the traditional Gabès Oasis is slowly being absorbed by the fast growing urban-industrial area connected to the harbour (see Box 6.2).

Water supply: There is intense competition for water resources in the NENA region. Urban water demand, although small (accounting for about 10 percent of water demand in the region), is prioritized by the authorities. Due to a shortage of public water supplies (and inadequate infrastructure), urban dwellers often have to buy water from private vendors (Alderwish, 2011). The need to supply water over long distance can connect cities to distant rural settings, although resources upstream in some catchments can be vulnerable. For example, in the Souss Massa (Morocco), the Aoulouz dam was initially conceived for flood control and provided water for irrigation when excess water was discharged. Today, a share of the water stored is now directed through pipelines to downstream cities and for irrigation.

[92] It should be noted that, with the exception of Saudi Arabia, there is low confidence in these estimates due to lack of data.

[93] Defined in the 2019 FAO State of Food and Agriculture report as Western Asia and Northern Africa.

[94] FLW across food commodity groups in the NENA region is estimated to be around 30 percent of cereals; 26 percent of fish and seafood; 13 percent of meat; and 45 percent of fruits and vegetables (FAO, 2015a).

TABLE 6.2 HOUSEHOLD FOOD WASTE ESTIMATES IN NENA COUNTRIES

Country	Kg/capita/year	Tonnes/year
Algeria	91	3 918 529
Bahrain	132	216 161
Egypt	91	9 136 941
Iraq	120	4 734 434
Jordan	93	939 897
Kuwait	95	397 727
Lebanon	105	717 491
Libya	76	513 146
Morocco	91	3 319 524
Oman	95	470 322
Palestine	101	501 602
Qatar	95	267 739
Saudi Arabia	105	3 594 080
Sudan	97	4 162 396
Syrian Arab Republic	104	1 771 842
Tunisia	91	1 064 407
United Arab Emirates	95	923 675
Yemen	104	3 026 946

Source: Compiled from United Nations Environment Programme (UNEP). 2021. *Food Waste Index Report 2021*.

BOX 6.2 TUNISIA – THE SOUTHERN OASIS OF GABÈS IN RAPID TRANSFORMATION

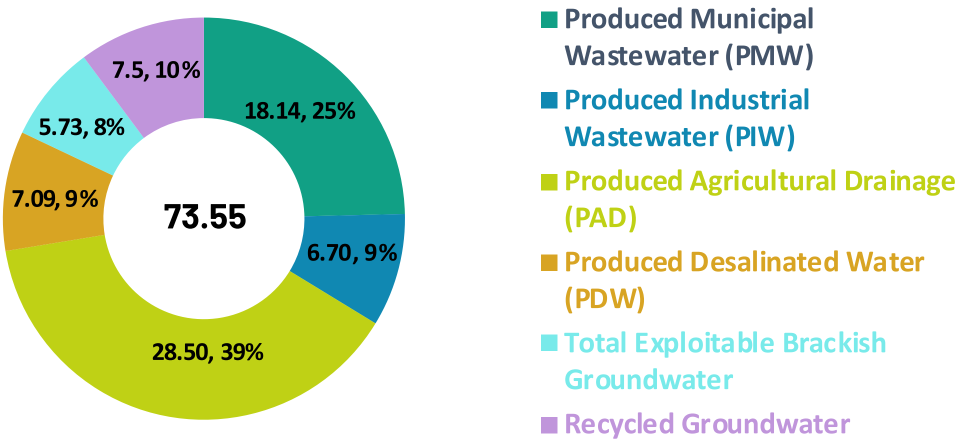
In Tunisia, the transformation of the Gabès traditional oasis system began in the 1970s, with the creation of an industrial zone next to the commercial port, as well as a cement plant in the interior. Irrigated areas were developed in the plain to the south and west. These dramatic changes in the oasis systems have resulted in land fragmentation and transformation of territorial management. Since the 1980s, the oasis has been losing 10 ha of productive land per year to urbanization. Industrial and service activities (including leisure activities and tourism) compete for water resources, land and markets. Since the 1990s, natural water sources have been drying up, and the remaining oasis and new irrigated lands must be watered from deep wells that depend on non-renewable aquifers. Many farms consist of highly fragmented land, with smallholders representing 63 percent of the farmers in almost half the area. Farmers have diversified cropping systems, with fruit trees, vegetables and fodder production combined with small livestock. Although answering to urban needs, these smallholder farming systems remain fragile in a context of political instability and uncertainty over traditional access rights.

Source: Diversité des dynamiques locales dans les oasis du Sud de la Tunisie. *Cahiers Agricultures*, 26(3): 35001.

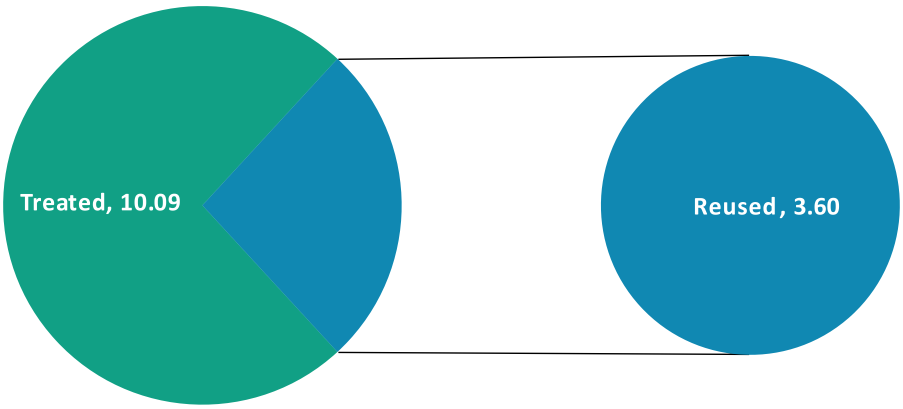
Water pollution: Water pollution comes from various sources of contaminants. For example, industries frequently discharge contaminants without pre-treatment, either to urban sewage networks or directly into river systems or the sea. Agriculture also pollutes, releasing high concentrations of nitrates and phosphates that affect the functioning of freshwater and seawater systems and contaminate urban water supplies downstream. Nitrate pollution creates algal bloom when it reaches shallow groundwater. A large share of the wastewater produced in the NENA region remains untreated before being discharged and only a small part is reused. In the Arab region, agricultural drainage water accounts for almost 40 percent of non-conventional water resources. Figure 6.3 provides data on wastewater.

FIGURE 6.3 A) TOTAL NON-CONVENTIONAL WATER RESOURCES WITH 25% OF PRODUCED WASTEWATER AND B) TREATMENT AND REUSE IN THE ARAB REGION

A) TOTAL NON-CONVENTIONAL WATER RESOURCES WITH 25% OF PRODUCED WASTEWATER



B) TREATMENT AND REUSE IN THE ARAB REGION



Source: AbuZeid, K., Wagdy, A. & Ibrahim, M. 2019. 3[rd] *State of the Water Report for the Arab region – 2015*, Cairo.

FIGURE 6.4 POLLUTION HOTSPOTS IN THE SOUTH MEDITERRANEAN

Source: UNEP-MAP, 2012 cited in UNEP-MAP and Plan Bleu, 2020. *State of the Environment and Development in the Mediterranean.* Nairobi. https://planbleu.org/wp-content/uploads/2021/04/SoED_full-report.pdf

Figure 6.4 illustrates concentrated pollution hotspots at the discharge point of watersheds and coastal cities. The accumulation of pollution in water systems restricts the use of certain sources for drinking purposes, but also affects its use for irrigation, as it can be dangerous for health. The Hemiz scheme in Algeria provides a country-specific example in Box 6.3.

BOX 6.3: AN IRRIGATION SCHEME BECOMES URBANIZED WITH POLLUTION CONSEQUENCES

In Algeria, the Hemiz irrigation scheme is one of the oldest, having been set up in the 1930s, in a fertile coastal area within the Mididja basin. The irrigation scheme is fed by both surface water through the Hemiz dam and groundwater from coastal aquifers. The scheme was conceived to irrigate more than 10 000 ha, but now irrigates only one-quarter of that area. Some sections of the scheme had to be abandoned due to water supply difficulties and pollution risks when fields are close to industrial areas. Industrial water demand is expected to reach 710 000 m^3/year by 2030 (doubling since 2008). With an estimated urban population of 650 000 living within the irrigation scheme, drinking water demand has increased, requiring additional water to be supplied from outside the scheme. Wastewater discharged after use is mainly untreated and flows into the streams within the basin. With better treatment plans, wastewater could be reused for agriculture and fill some of the gap in water demand. The Regalia Lake, downstream of the basin, is now polluted and its water can no longer be used for agriculture, due to the excess in accumulated heavy metals coming from the upstream cities and industries. Although polluted water now flows into the sea, the Government has an ambitious plan to improve and increase the number of treatment plants for urban and industrial water.

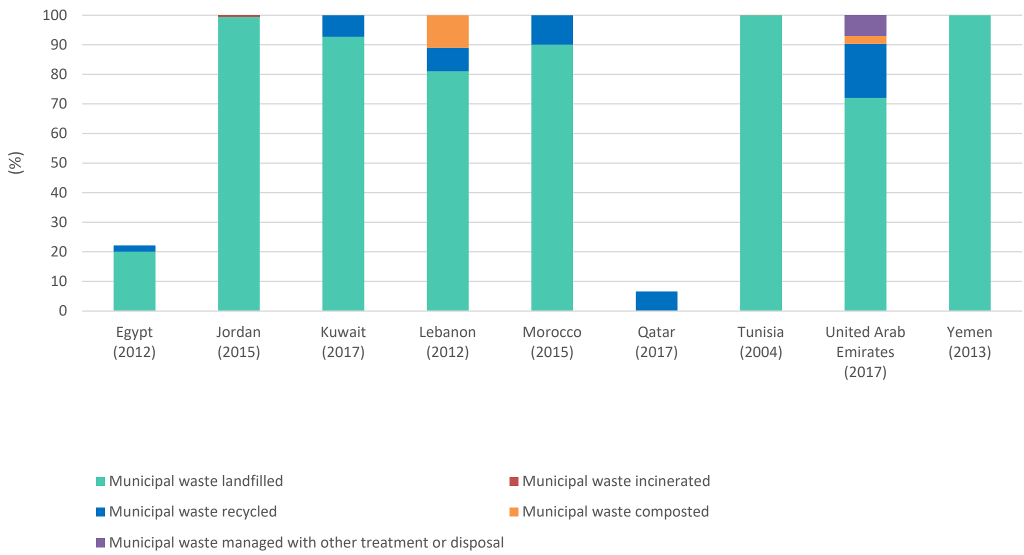
Source: Republique Algerienne Démocratique et Populaire, Ministere des ressources en eau, 2021.

Apart from environmental damage, the disposal of waste fluids in open surface water bodies also threatens peoples' livelihoods and ecosystem sustainability. The city of Alexandria in Egypt is a case in point, where two-thirds of urban industries dispose of their waste fluids in a nearby lake, endangering lake fisheries, which produce 52 percent of Egypt's total fish production and provide employment to 53 000 fishers (FAO, 2002a).

Waste management: Urban waste has become a major concern in NENA.[95] Non-degradable waste (for example, plastics) is found in streams, canals and on roads, ultimately reaching the sea. Most urban waste ends up in unspecified landfills or open dumps (see Figure 6.5), with inadequate collection systems in small and medium-sized cities.

[95] Waste management is a key urban-related challenge and inadequate integrated systems for solid waste and wastewater collection, treatment and safe disposal in cities can lead to health and environmental problems, with clear implications for water security and hence food security. Food waste and its packaging often ends up in landfill, emitting harmful methane gas and contaminating water and soils.

FIGURE 6.5 PERCENTAGE OF MUNICIPAL WASTE MANAGED BY TYPE OF TREATMENT, NENA, LATEST AVAILABLE YEAR*



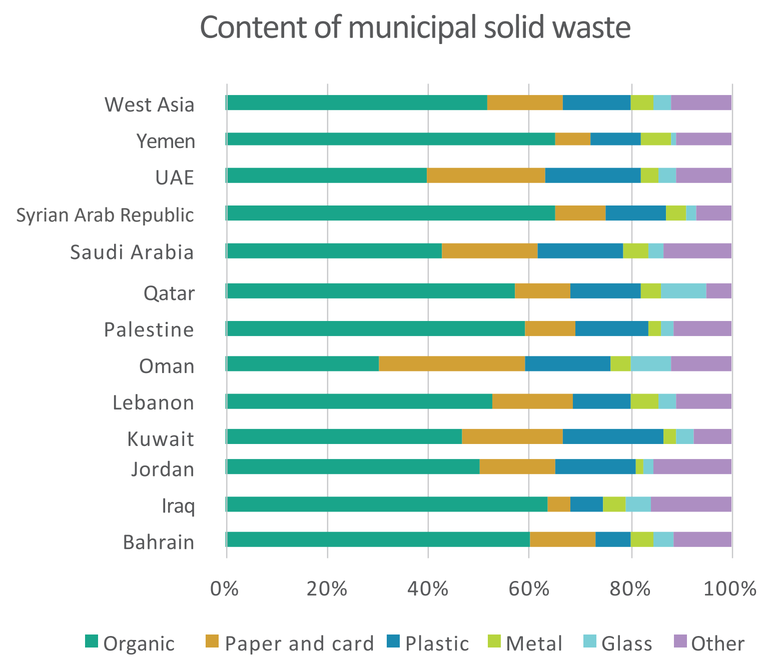
Source: United Nations Statistical Division. 2021. *Environmental Indicators.* https://unstats.un.org/unsd/envstats/qindicators

The percentages shown reflect only the data available. Therefore, the categories for waste treatment shown do not necessarily sum to 100 percent.

Reducing the demand for landfills and incineration requires raising recycling rates. UNEP (2019) examined the contents of municipal solid waste in certain NENA countries, and found on average more than 50 percent organic municipal solid waste.[96] It reported that the figure for Cairo is 55 percent, and up to 65 percent in the case of Sousse (Tunisia) (UNEP, 2018). In Morocco, household waste in urban areas was estimated to reach almost 70 percent of organic waste (UNEP, 2018).

[96] Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, the Syrian Arab Republic, United Arab Emirates and Yemen.

FIGURE 6.6 MUNICIPAL SOLID WASTE CHARACTERIZATION FOR WEST ASIAN COUNTRIES



Source: United Nations Environment Programme (UNEP). 2019. *Waste Management Outlook for West Asia.*

Climate and human related risks: Chapter 5 outlined how climate change impacts are affecting the NENA region. Experts agree that there is a major risk of increased heat and variability in rainfall, with episodes of extreme events. Heavy rainfall on a degraded landscape weakened by desertification increases the risks of floods and landslides threatening downstream lowlands and valleys, where many cities are located. The rapid increase of groundwater abstraction for agriculture and urban needs has resulted in the overexploitation of shallow aquifers, which are an important source of urban water. As coastal aquifers empty, the risk of two phenomena increases: i) soil subsidence; and ii) seawater intrusion (Custodio, 2018). Groundwater also plays a role in maintaining the base flow needed for wetlands, buffering floods, and feeding coastal springs. Coastal wetlands are losing their buffering capacity as they are partially altered with the change in groundwater volumes, patterns or chemistry, or fully altered when drained for agriculture or built upon.

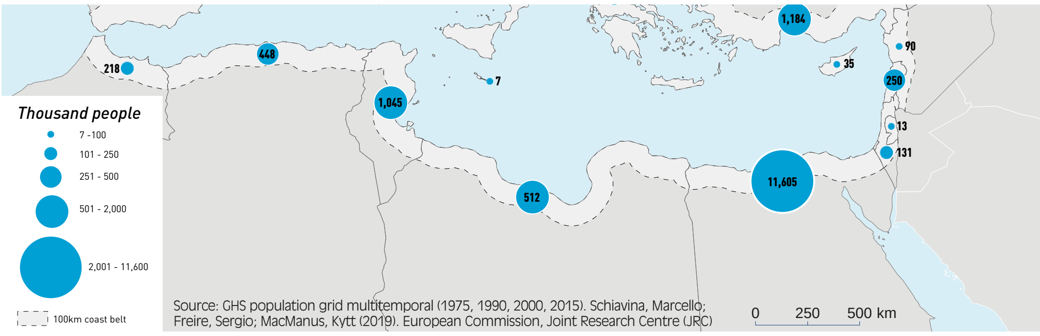
In 2015, the United Nations Environment Programme Mediterranean Action Plan (UNEP-MAP) and the UNESCO International Hydrological Programme (UNESCO-IHP) carried out a review of the status of coastal aquifers for a range of countries (Algeria, Egypt, Lebanon, Libya, Palestine and Tunisia).[97] This analysis confirmed that salinization is a growing risk for coastal water sources, indicating that it is increasing in three-quarters of all aquifers, due to seawater intrusion, and an influx of deeper saline groundwater. This alarming phenomenon is caused by the overexploitation of freshwater aquifers (extractions exceeding recharge) and compounded by high human dependency on water from coastal aquifers.

Rising sea levels represent a significant risk for urban populations. Figure 6.7 pinpoints the number of people living lower than 5 m above sea level within the 100 km coastal belt. The change of flow from rivers (exacerbated when dams are set on their course) and natural runoff from coastal landscapes also

[97] Based on the analysis of aquifer questionnaires carried out by UNEP-MAP and UNESCO-IHP, 2015.

affect erosion of rocks on land and inputs of sediment that are key to the existence of beaches and dune systems (UNEP-MAP and Plan Bleu, 2020). This can add to the risks faced by coastal populations as the coast becomes unstable.

FIGURE 6.7 POPULATION LIVING AT LESS THAN 5 M ABOVE SEA LEVEL WITHIN THE 100 KM MEDITERRANEAN BELT/PER COUNTRY



Source: Cited in UNEP-MAP and Plan Bleu, 2020. *State of the Environment and Development in the Mediterranean.* Nairobi. https://planbleu.org/wp-content/uploads/2021/04/SoED_full-report.pdf

The challenges outlined in sections 6.1 and 6.2 demonstrate the need to consider urban development within its broader landscape and waterscape, such as the water systems-catchment and aquifers in relation to a city's location. The next section examines some responses to urban-rural interface challenges.

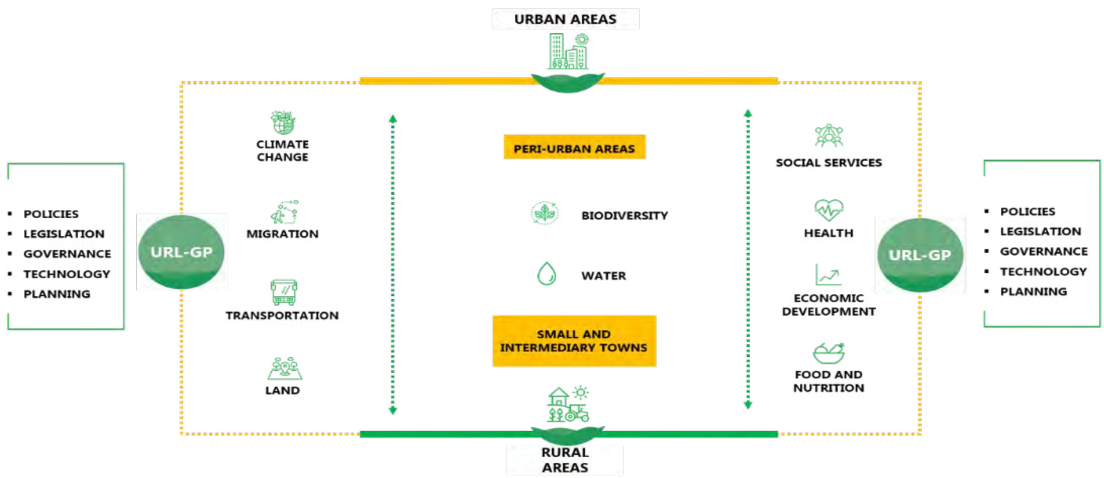
6.2 Response options

To achieve the objectives of the 2030 Sustainable Development Agenda, an important focus must be on strengthening urban-rural linkages. The way in which cities interact with rural areas for food production, distribution and consumption provides a lens for better planning, and such an interface can help to focus attention on the implications of land and water use at a broader level (territorial). This section puts the case for 'territorial approaches' in the NENA region, which build on the region's strengths, and can help to build resilient food systems.

6.2.1 Urban-rural linkages guiding principles

UN-Habitat defines urban-rural linkages as non-linear, diverse urban-rural interactions and linkages across space within an urban-rural continuum, including flows of people, goods, capital and information, but also between sectors and activities such as agriculture, services and manufacturing. In general, they can be defined as a complex web of connections between rural and urban dimensions (see Figure 6.8). UN-Habitat (2019) presents ten guiding principles for urban-rural linkages as a framework to advance territorial development, which could be usefully discussed and used to guide changes in the NENA region. These include fostering partnerships, creating spaces for interaction, alliances and networks to link urban and rural actors and different sectors, and embedding human rights in actions across the urban-rural continuum. Being data driven and evidence-based to establish and improve knowledge systems is another principle.

FIGURE 6.8 URBAN-RURAL INTERACTIONS



Source: UN-Habitat. 2020b. Mainstreaming urban-rural linkages in national urban policies: National urban policy guide. https://unhabitat.org/sites/default/files/2020/06/mainstreaming-url-in-nup-guide-_web.pdf

6.2.2 Integrated planning across the urban-rural continuum

Bringing together spatially sensitive policies and programmes to support economic, social and environmental change is important at many levels, but can be difficult to set in motion. Some planning points to consider in a well-structured land-use planning framework include:

- Systemically evaluate land potential, demands, access and tenure.
- Ensure there are measures in place to protect natural resources and take into consideration all elements of the food system.
- Put effective planning mechanisms and zoning policies in place to prevent further agricultural land loss due to informal urban expansion.
- Include a cross-sectoral focus in deciding land-use priorities and ideally consult with many actors, especially local users, to balance different needs.
- Include tenure security of both land and water in planning.

Taking the last point, informal or customary forms of land tenure are rarely recognized in NENA, and the region is characterized by a complex system of land tenure with customary law (Urf) coexisting. In addition, water tenure is also often ignored.[98] Without policy frameworks to secure land and water tenure, social and economic instability, which frequently relates to conflict over natural resources, will continue to exist and possibly escalate. The VGGT Guidelines (FAO, 2012b) provide a framework for the development of policies and legislation for improved governance of tenure and rural development. This tool could be very useful for the NENA region, starting with recognition of existing water tenure, using a methodology on water tenure assessment available to support such a process.

[98] Water tenure is defined as the relationships, whether legally or customarily defined, between people, as individuals or groups, with respect to water resources. See www.fao.org/in-action/knowat/wt-assessment/concept/en/

Taking the first three points from the above list, there is a need to have planning systems in place that optimize land use and enable regional development in a sustainable way. However, this requires information, data and resources. Currently, the region faces a deficit of comparable data to assess, plan, implement and evaluate development at territorial level. As such, existing information systems are not disaggregated at territorial level, but developed on a sectoral basis. There are some examples to build from, such as in Morocco where the authorities have made use of well-established land resource assessment tools to identify land degradation issues at subnational and local levels (see Box 6.4).

BOX 6.4: TERRITORIAL PLANNING TO ADDRESS LAND DEGRADATION – SOUSS MASSA, MOROCCO

With support from FAO, Morocco has developed a territorial development pact at provincial level and a three-year action plan to implement and scale out sustainable land management in the Prefecture of Agadir Ida-Outanane communes.

Following the LADA methodology, a participatory process was used to identify hotspots of land degradation using a subnational assessment of Land Degradation in Drylands (FAO, 2019k), with several regional maps providing information on land cover, land use and the main types of degradation. Three pilot sites were selected (Ameskroud, Tamri and Aziar), where assessments identified the land-use systems, the socioeconomic context, water resources, rangelands and biodiversity status, as well as the spatial distribution of existing good agricultural practices. Using these findings, representatives of local communities and actors agreed on the implementation of specific sustainable land and water management practices in areas with good potential. The negotiations between stakeholders led to the development of a Territorial Development Pact for the Prefecture of Agadir-Ida-Outanane and an Action Plan to scale out to other areas of the province, which has been integrated in the broader Souss Massa agricultural regional plan (2020–2030).

Source: FAO (unpublished). Participatory land resources planning to promote the scaling out and mainstreaming of sustainable land management in Morocco.

Incorporating food systems in urban planning: Feeding a growing and more urbanized population using increasingly scarce land and water resources demands new thinking around the structure and efficiency of existing food systems. Given the land scarcity in urban environments, land use-planning must be comprehensive, covering all potential uses, including agriculture and urban green spaces. With the FAO Framework for the Urban Food Agenda, FAO is calling for concerted actions and participatory decision-making processes to include food systems in urban planning (FAO, 2019j). The basis of this agenda takes into consideration urban-rural linkages and territorial development approaches. The first step is to recognize planning challenges and potential green solutions, so that they can be considered in a systematic way. The online FAO region City Food System Toolkit provides guidance on how to analyse and build sustainable city region food systems.[99] This tool can be useful for the NENA region in terms of integrated planning and policies.

[99] See www.fao.org/in-action/food-for-cities-programme/toolkit/introduction/en/

Urban agriculture: The integration of agriculture into urban planning receives poor recognition from planners and policy-makers, with limited information available on its status in the NENA region. Even if small-scale activities cannot entirely meet urban food demands, urban agriculture can still play a role in local production and consumption. In short, urban agriculture can complement rural food production, facilitate local economic growth by proximity to urban markets, offer a space for recycling and reusing water and nutrient from waste, and contribute to the greening and cooling of cities. Some initiatives do exist, however. The RUAF Foundation supported cities in the NENA region in 2005–2006 to establish the Arab Network of Cities for Urban Agriculture.[100] Pilot activities were launched in five cities – Baalbeck (Lebanon), Ariana (Tunisia), Amman (Jordan), and Gaza and Jericho (Palestine). Two examples of the benefits of urban agriculture are given below.

BOX 6.5 PROTECTING THE FOOD SECURITY AND MENTAL HEALTH OF ELDERLY PEOPLE IN PALESTINE VIA HOME GARDENS

The COVID-19 pandemic has greatly affected dense urban areas in Palestine, with 77 percent of the population in urban cities and towns. During 2021, the UN-Habitat Palestine Office, in partnership with the municipalities of Bethlehem, Beit Sahour and Beit Jala, and the Applied Research Institute – Jerusalem, implemented a project targeting elderly groups in dense areas of Bethlehem, Beit Jala and Beit Sahour cities as a COVID-19 response. Five percent of the population in Palestine is aged 60 years and above, with a sex ratio of 92 males to 100 females. This intervention aimed to enhance the coping capacity of this target group, through the provision of plants and equipment for home farming spots, utilizing front and backyards, balconies or roofs. Home gardens and self-sufficient food production (vegetables and greens) are maintained by the elderly people with family support. The project reached 60 families (over one-third were female-headed households) and built their resilience by contributing to daily food needs. An evaluation indicated that the project has promoted social engagement and physical activity for the elderly, also enhancing also mental health.

Source: UN-Habitat Palestine. 2021. Final Technical progress report, alleviating quarantine effects among the elderly. Home garden interventions, 2020–21 (unpublished).

[100] The RUAF Global Partnership on Sustainable Urban Agriculture and Food Systems is a consortium of institutions and individuals (cities, research institutes and NGOs), with a track record in urban and peri-urban food systems.

BOX 6.6 A DEDICATED OFFICE FOR URBAN AGRICULTURE IN AMMAN, JORDAN

In Amman, since 2007, the City Strategic Agenda has facilitated a range of initiatives embracing urban agriculture and food security. The importance of urban agriculture has been highlighted by the establishment of a dedicated bureau to deal with such initiatives and facilitate its integration into policies. In 2014, Amman launched its Resilience Strategy as part of the 100 Resilient Cities network. Urban green spaces are scarce, but the city launched a green infrastructure project in 2017. The aim is to improve mobility, preserve biodiversity, and adapt to extreme weather events, including floods (GIZ, 2018). Amman has continued to support urban food production by incorporating a Green Amman 2020 Initiative, which acknowledges the economic and ecological benefits of urban agriculture and green areas. The Green City Action Plan was drawn up following a two-year multistakeholder process, with strong involvement of the public. In 2020, it was synthesized in a strategic document, the Agriculture Sector Green Growth National Action Plan 2021–2025. It includes sectoral action plans for agriculture, energy, tourism, transport, water and waste sectors, with implementation since May 2021.

Source: Ministry of the Environment, Jordan, 2020. Agriculture Sector Green Growth National Action Plan 2021–2025. Amman.

6.2.3 Incorporating the water dimension in territorial and urban planning

Urban planning that incorporates water dimensions is crucial to promote resilience to drought and floods. Headwaters of watersheds are frequently upstream of large cities. Mountains play an essential role as water towers and regulators of the water cycle. When left unprotected, headwaters are not able to retain and infiltrate excess water gained during extreme events. When there is no storage capacity or buffer, the result is flooding, as observed in some cities in the NENA region. A 'source to sea' approach can be helpful both for disaster risk reduction and sustainable water supply.

Drought management: Effective drought management rests on preparedness, response, monitoring and early warning, combined with vulnerability and impact assessment. The creation of reservoirs and retention basins could help to secure drinking water supply for urban and rural populations, particularly during the dry seasons. The NENA region is highly dependent on the use of groundwater (see Chapter 3) for supplying drinking water. Groundwater aquifers have a much larger storage capacity than surface reservoirs and are therefore an important safety net against drought. However, many aquifers are overexploited. Replenishing water storage and aquifers will require capturing more water from storms. Good management of rainwater and storage is necessary to capture any rainfall excess. Developing community-based watershed-level plans for managing water before, during and after droughts is essential to drought preparedness. Such plans should be aligned with flood management strategies (see next section) and integrated in an overall watershed plan. Yemen (see Box 6.7) provides an example of drought management with a gender focus.

BOX 6.7 WOMEN ENGAGING IN WATER USERS' ASSOCIATIONS

In Yemen, water infrastructure has been severely damaged due to conflict. Up to 93 percent of surface and groundwater is for agricultural use (World Bank, 2010). Overexploitation in Sanaa's basin is causing a water table drawdown of about 4–8 m/year (Taher, 2016). FAO implemented a project in the area which encouraged community participation and established 38 water users' associations to regulate consumption of water, with 30 percent women representation on the management board. Enhancing the role of women in water users' associations can play a key role in identifying priorities for investments for improved water access. The female unit of these associations sought further support for the construction of shallow wells connected to the Sanaa dam. This was realized through cash-for-work social protection interventions.

Source: FAO, 2017e. *FAO support provides water sustainability for farmers while empowering women.* www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1045903/

Flood management: Flood management must be a priority in both urban and rural settings, where different actors need to engage in collaborative planning, tapping into local knowledge and experience. It should be closely connected to drought management, as outlined above. The sponge city model for flood management strengthens drainage systems, and if adopted for urban construction, can alleviate a city's waterlogging problems and water resource shortage, and improve the ecological environment by capturing rainwater and repurposing it for irrigation and home use. Originating in China, this may be an interesting model to consider. An example from Saudi Arabia in the Jeddah Municipality described in Box 6.8 showcases how public-private partnerships can work towards economic development and sustainable water management.

BOX 6.8 MANAGING FLOOD RISKS IN JEDDAH, SAUDI ARABIA

Jeddah has consistently faced water disasters. During a catastrophic disaster in 2009, the area received 90 mm of rain in four hours, whereas Jeddah normally receives 45 mm per year (Azzam and Ali, 2019). In 2012, Jeddah Municipality launched several permanent flood and rainwater drainage projects, including new dams, drainage channels and a new floodwater drainage system at the airport. A rainwater drainage project was completed in 2019. An agreement to build the Jeddah II Independent Sewage Treatment Plant was signed by the Minister of Environment, Water and Agriculture, forming part of a national plan targeting water production and sewage treatment projects. The plan is being implemented through public-private partnerships. For example, the Jeddah Airport 2 Independent Sewage Treatment Plant will be developed under a 25-year PPP model. However, such interventions are only part of the solution; storage structures (water harvesting, including dams of various types and forms – surface and subsurface) are proposed for the main valleys or tributaries to reduce upstream runoff in the valleys.

Sources: Azzam, A., & Ali A.B. 2019. Urban sprawl in Wadi Goss Watershed (Jeddah City/Western Saudi Arabia) and its impact on vulnerability and flood hazard, Journal of Geographic Information System, Vol.11 No.3 and **Daoudi, M. & Niang A.J.** 2018. Flood risk and vulnerability of Jeddah City, Saudi Arabia. www.intechopen.com/chapters/64449

Managing floods requires an integrated approach that considers the basin or watershed in which the cities are set, as well as climate variability (including drought risks). For this reason, investment in improvements in the headwaters' landscape are required. Intervention may include watershed treatment (including *in-situ* and *ex-situ* water harvesting), reforestation, and good pasture and crop management. These interventions require planning and cooperation with local populations, fully recognizing their role as guardians of the headwater's status. A focus on incentives for flood protection services is also important. FAO has produced an online toolkit on Incentives for Ecosystem Services, which may be useful for NENA countries to guide a process of setting in place ecosystem services.[101]

Green infrastructure: Investing in green infrastructure and innovative solutions for urban settings is another option to increase infiltration and reduce heat hotspots and stormwater runoff. Green infrastructure can be part of a remediation strategy offering additional environmental benefits, such as reducing water surface runoff created by urban soil sealing, and increasing biodiversity protection. So-called nature-based solutions (for example green roofs, rain gardens, urban trees, rainwater harvesting with permeable surface and dedicated infrastructures, and land conservation) provide many environmental services and benefits.

Wastewater and waste treatment: An integrated system for solid waste and wastewater collection, treatment and safe disposal is an aspiration in many cities. If treated, wastewater can support freshwater systems needed for fisheries, but also can provide the water needed for irrigating, reducing the pressure on freshwater resources. Similarly, solid waste, when sorted, can provide a source of organic waste for composting that can help to maintain soil fertility. A broader perspective with the use of territorial planning is required to locate sources of production and dumping points, as well as the opportunities for reuse. Careful assessment of prior use is important, as untreated waste and wastewater may already be used informally.

Including a citizen-focused and gender perspective: Cooperation among sectors with a broad range of stakeholders across the urban-rural continuum is essential, to ensure buy-in for both consumers and producers. A gender perspective highlights how differentiated gender roles affect and are affected by water resource interventions. Experience has shown that initiatives that include the views, input and participation of both men and women generally work better. Results from understanding gender roles and relations can guide landscape and watershed planning and increase sustainability and resource-use efficiency.

6.2.4 The circular bioeconomy

A global movement is under way towards more sustainable production and consumption patterns that are climate- and nature-positive, eliminate food loss and waste, reuse and recycle, and build circular food economies while producing healthy and safe diets. The transition to a circular bioeconomy presents a solution to recycle and reuse biomass as feed, bioenergy, compost or other biological resources. Cities can play a leading role in promoting a circular bioeconomy by managing waste and recycling it into the agriculture sector (MacArthur Foundation, 2019). A 'blue water footprint' concerns water that has been sourced from surface or groundwater resources and has either evaporated, been incorporated into a product, or taken from a body of water and returned to another or returned at a different time.[102] Entry-points to reducing the water (and land) footprints are found at the production level, in value chains, and in areas where evidence shows that food losses are greatest, although blue water footprint reductions can also be at

[101] See www.fao.org/in-action/incentives-for-ecosystem-services/toolkit/en/

[102] The estimated blue water footprint in NENA is 42 km^3/year, about 17 percent of the global footprint of 250 km^3/year. GHG produced by FLW in the NENA region reach 200 million tonnes of CO_2, or about 500 kg CO_2/capita (FAO, 2019a).

post-harvest and processing levels. However, although food waste reduction efforts at retail and consumer levels are closely connected to urban agrifood systems, these usually cannot be traced back to the territory where food is produced, for several reasons, such as: the length of the value chain and lack of systems of traceability; the presence of food imports; and the handling and processing of food components into end products and meals. Nonetheless, reducing food waste offers many benefits (Cattaneo, 2021) and opportunities for income generation. Several municipalities in the NENA region have launched initiatives to tackle food loss and waste. The Dubai Municipality launched the United Arab Emirates Food Bank initiative in 2017. This is a platform for safe food redistribution and works to reduce food import loss at ports of entry by diverting to the food bank.

BOX 6.9 FOOD WASTE REDUCTION IN TUNISIA

The municipality of Tunis is working with FAO to assess food waste. In collaboration with national institutes, studies were carried out among households, retailers and restaurants in specified districts of greater Tunis to document levels of food waste across food groups, disaggregated by age and sex. Within households:

- Waste was highest for bread (over 10 percent), followed by other grain products and vegetables, corresponding to about USD 6 per household per month.
- Most respondents were of the opinion that food waste is a major problem.

Findings from more than 800 retailers surveyed included the following:

- Loss levels were highest for fruits and vegetables (over 14 percent each), followed by red meat, and fish and seafood products.
- Restaurants (including fast food, food carts and traditional eateries) reported over 90 kg of waste per month (on average), mainly due to inedible parts and trimmings.

Research results can help authorities to consider access to green space and how to reduce food waste at local level, manage waste management and consider other aspects of urban food governance. In other cities, the MED 3-R project focuses on technical capacity-building and multilevel governance to promote an efficient waste management system (e.g. in Aqaba, Byblos, Sfax and Sousse).

Source: Unpublished reports from FAO Tunis.

Urban waste and water management for recycling and reuse: Social, cultural and economic transactions that operationalize better linkages between rural and urban areas should be viewed in a circular way. Water, food and fibre produced in rural areas can be processed, distributed and consumed in urban areas. Food, non-food organic waste and wastewater generated across the urban-rural space can be cycled back as productive materials and resources for use within or outside food systems (MacArthur Foundation, 2019). Cities hold potential as engines for this process, but it must be conceived as part of a single system, with rural areas linked by infrastructure and a mutual exchange of products and services. This requires creative thinking and cross-sectoral planning. As already outlined, there is significant potential to use wastewater for agriculture, urban farming and trees, but water testing and legislation need to be appropriately developed to fully tap into this prospective. Some promising examples include the following:

- Jordan has the highest percentage of wastewater reuse (93 percent) in NENA countries, followed by Qatar and United Arab Emirates, with 65 and 55 percent respectively. Most of the effluents generated from the country's 31 wastewater treatment plants are used for irrigation in the Jordan Valley (Qdais *et al.*, 2019).
- Egypt has the highest annual amount of waste and drainage water reuse in absolute numbers, at 700 million m^3. The United Arab Emirates is ranked second, with 248 million m^3 (Qdais *et al.*, 2019).
- Aside from the use of wastewater in agriculture, there has been increased interest from NENA countries (especially Egypt, Jordan, Kuwait and Yemen) in irrigating forest plantations and greenbelts with wastewater (FAO/Near East Forestry Commission, 2002).

BOX 6.10 WASTEWATER GOVERNANCE IN MOROCCO

Morocco's annual water withdrawal is equivalent to 60 percent of its available freshwater resources. Lack of an effective sanitation and wastewater treatment system results in scarce water resources being contaminated and unsuitable for use. Wastewater discharge volumes have increased sharply over the past three decades (from 48 million m^3 in 1960 to 700 million m^3 in 2012). Projections for 2030 are 900 million m^3. Currently, only about 42 percent of treated wastewater is reused in Morocco, representing 10 percent of the total wastewater produced (FAO-AQUASTAT, 2015). Launched in 2019, the National Liquid Sanitation and Wastewater Treatment Program aims to improve connections to the liquid wastewater network via 154 sanitation projects to achieve a connection rate of 90 percent and a depollution rate of 80 percent, including outlets by 2040. The initiative expects to complete 1 207 sanitation projects in towns to achieve a connection rate of 50 percent by 2030 and 80 percent by 2040 and a depollution rate of 40 percent by 2030 and 60 percent by 2040. Overall, the plan is to reuse of 474 million m^3 of wastewater (treated annually) by 2030 and 573 million m^3 by 2040.

Source: Diaco *et al.*, 2020. Circular economy in the Africa-EU cooperation – Country report for Morocco. Trinomics B.V., ACEN, Adelphi Consult GmbH and Cambridge Econometrics Ltd.

Circular bioeconomy approaches require robust waste and wastewater management solutions at municipal level, starting with source-segregated collection. Further components are sorting and composting plants, anaerobic digestion, waste-to-energy technologies, and recycling facilities for source-segregated waste. All require investment, integral multisectoral planning, and unique public-private business models (UNEP, 2019). There has been considerable progress in implementing these ideas across the world. Some good initiatives for collecting and transforming urban waste already exist in the NENA region, although more could be done. A Lebanese example is presented in Box 6.11.

BOX 6.11 PRODUCING GOLD FROM GARBAGE IN LEBANON

In the absence of state intervention for waste management in Lebanon, many local initiatives and enterprises are coming forward to transform waste into a resource. Compost Baladi is one such example, converting biowaste into a bio-resource. The scheme involves working with agro-industrialists and municipalities to recover organic waste and process it in stations, operating with community partners to produce compost and other mixes. Compost Baladi has also built a chicken manure composting facility in the south of Lebanon, producing 200 metric tonnes of compost per year, which is sold to more than 1 900 end-users for agricultural purposes. Compost Baladi works with a range of partners to raise awareness on organic waste management.[103]

Taking one example, Manara in the Bekaa region has 3 000+ residents, producing 3 metric tonnes of waste per day. Door-to-door campaigns took place to encourage a reduction in waste dumped. Eighty percent recycling has occurred, with more than 200 metric tonnes of compost sold each year to farmers. More than 2 800 metric tonnes of waste has been diverted from dumpsites and open burning. Schools are now running a recycling scheme, spreading the word about environmental awareness to youth.

Source: Leyla Zeidan from Compost Baladi.

The NENA region is only beginning a transition to circularity. However, there are already some promising initiatives, such as these from United Arab Emirates, Lebanon, Morocco and Abu Dhabi:

- United Arab Emirates is the first country to adopt a Circular Economy Policy, focused on promoting environmental health and private sector innovation. United Arab Emirates participates in the World Economic Forum's Scale 360° initiative that aims to leverage a fourth industrial revolution innovation to achieve circularity.
- Initiatives are emerging from entrepreneurship ecosystems to drive a transition using innovative business models, while interlinking food and circular bioeconomy value chains. BQ Whey in Lebanon collects waste from whey (a cheese by-product), to produce low-cost, high-quality material for poultry feed producers.
- Morocco's Ecofertil produces compost, potting soil and other products from manure, grain waste and wood chips through biofermentation.
- Tadweer, Abu Dhabi's waste management centre, is a model para-public entity with projects in fertilizer production, municipal and agricultural waste-to-energy and recycled food oils, as well as non-organic waste recycling.

6.2.5 Digital technologies and innovation

Information and communication technologies can support urban-rural food systems using digital tools to connect rural producers with urban consumers. For example, data from ICTs can facilitate the exchange of information, demand and transactions by informing decisions to reuse, recycle and redistribute.

[103] For example, it works with Mercy Corps, the Lebanese Reforestation Initiative, Green Track and Action Against Hunger. Compost Baladi has been able to divert 2 700+ metric tonnes of solid biowaste from landfills, avoided 2 300+ metric tonnes of carbon dioxide, eliminated 540 m^3 of leachate from freshwater bodies and avoided the use of 136 000+ plastic bags. Compost production has reached 1 000+ metric tonnes – enough to fertilize 3 600 000 m^2 of agricultural land, while sequestrating 120 metric tonnes of CO_2 per year through application.

The Agrimasr.com platform and Mozare3 are two examples from Egypt of digital platforms connecting smallholder farmers to local markets through e-commerce, as well as providing digital finance. The COVID-19 crisis has disrupted the agrifood sector in many respects, but in some ways it has encouraged greater emphasis on local products and shorter value chains. An acceleration of digital agriculture tools to facilitate local food production, distribution, marketing and flows into a circular bioeconomy is now occurring. The example from Oman (see Box 6.12) was in response to COVID-19.

BOX 6.12 FISH AND E-COMMERCE IN OMAN

Oman is a major producer and consumer of fish, and fisheries provide an important livelihood for coastal communities. Bustling fish markets in Muscat were brought to a standstill by the COVID-19 pandemic and the subsequent social distancing requirements. Within a week of lockdown, Oman's Ministry of Agriculture and Fisheries, in cooperation with the Oman Technology Fund, responded by launching the Behar e-commerce platform for the wholesale auction of fresh fish and seafood, thereby linking producers and wholesalers with traders and companies across the country. Behar allows sellers to upload photos and details of the catch, buyers to place electronic bids, and transactions to take place via e-invoicing and electronic payments. Originally piloted in the Al Fulaij central wholesale market, plans have emerged to expand to other national and international markets, along with efforts for further digitalization of the fisheries value chain.

Source: FAO, 2020e. From bustling Omani fish markets to online auctions. www.fao.org/fao-stories/article/en/c/1278611/

ICTs also provide opportunities to develop early warning systems for floods, protecting people and infrastructure, as well as remote sensing and modelling to strategically locate waste sources (e.g. wastewater treatment plants) in relation to the agricultural reuse areas. The capacity of cities and rural communities to use ICTs needs to be promoted, with training to overcome digital gaps among smallholders and cooperatives, and a particular focus on women's participation (who may lose out on some opportunities if not targeted).

6.3 Governance for 'territory'- focused urban-rural linkages

Territorial governance hinges upon decentralized authority, horizontal coordination across actors and sectors, adequate data, and knowledge sharing. These factors are explored in more detail in the next section.

6.3.1 Decentralization and local capacities

Enhancing urban-rural linkages requires local authorities to have greater power and capacity to coordinate planning and implementation of territorial strategies. For this, NENA countries need to develop decentralized and more inclusive decision-making processes. The roles of central and local governments must be articulated, with legislation enacted that allows for sustainable territorial planning at different scales. There is a diversity of local governance forms (municipalities, governorates, communes, etc.), which relate to the political economy and history of each country. Although each requires a slightly different approach, a common aim should be to create institutional and regulatory structures for better rural-urban linkages within their territories. In most NENA countries, budgeting and finance of local services, such as waste management, water infrastructure and land regulation, takes place at centralized national institutions. Typically, local authorities do not have the power to manage these resources in a way that responds to local needs. Although decentralization allows for governance structures closer to those responsible for its administration, it relies on the capacity of local authorities to manage public services and often requires local authorities to take on additional statutory duties, sometimes without an equivalent increase in human resources. Capacity-building is required at municipal levels so that local authorities can plan and implement sustainable resource management strategies that promote integrated territorial development. Leadership is also necessary, to instil cultural and social changes required to replace unsustainable ways of doing things. Several countries have already started strengthening national/local collaboration on planning and development, creating subnational/governorate-level planning agencies and empowering local administrations to draft and implement their own plans. Smaller cities also have a role to play in connecting rural and urban areas, as evidenced by the Charter of Intermediary Cities of the World.[104] A variety of tools and approaches can be adapted to complement existing initiatives in the NENA region.[105]

6.3.2 Horizontal coordination across actors and sectors

To implement urban and rural planning successfully and manage increasingly large and complex territorial systems, much better participation and coordination between different ministries, institutions and stakeholders relevant to urban and rural development (at central and local levels) are required. Implementation requires partnerships, including with businesses and citizens. Municipalities and local governments can also partner with international organizations, local universities, civil society, microcredit institutions and other concerned actors. Civic engagement initiatives can be carried out by municipal authorities, local civil society organizations, activist groups,

[104] See the Chefchaouen Declaration-Charter of Intermediary Cities of the World at the 2018 UCLG Forum on Intermediary Cities in Morocco adopted by 250 participants from 40 different countries.

105 UN-Habitat has developed guidelines and tools to help governments at different levels to develop and refine urban and territorial policy and planning. Among these tools are the following:
- International Guidelines for Integrated Urban and Territorial Planning
- the Urban-Rural Linkages Guiding Principles
- the Framework for Action to Advance Integrated Territorial Development, guides, and manuals
- with FAO, the City region Food System toolkit provides guidance on how to assess and build sustainable city region food systems.

and urban communities themselves. Changing the way that urban planning is undertaken requires an understanding of individual and societal incentives for change, as well as of the transaction costs for such change. There is a need to come together to respond to urbanization trends in NENA and set up pilots and programmes that:

- encourage local agricultural production for local markets;
- pilot small-scale processing (such as cleaning, packaging and processing vegetables);
- set up urban and peri-urban agriculture and roof gardening;
- establish wastewater and solid waste management reuse; and
- encourage local marketing and catering and retrieve traditional foods and food practices.

The 2030 Agenda for Sustainable Development calls for leaving no one behind. Funding must be allocated to programmes that support vulnerable people (unemployed women and youth, migrants, refugees and IDPs). The establishment of a regional territorial body, and related governance observatories – with indicators to monitor and assess country-level decentralization reforms – could help to bring together these different processes. Regardless of who leads these initiatives, the role of local government is crucial in facilitating an inclusive citizen culture.

6.3.3. Adequate data and information

Sufficient data and information must be available for territorial planning discussions on the realities of specific territories and identify vulnerable areas, such as productive land that is water scarce, and prone to subsidence, flooding, or drought. Data disaggregated by age and sex can further ensure that gender and generational gaps are reflected and addressed in territorial plans. Data collection requires financial and human resources and can be expensive at smaller scales. Fortunately, there is already a growing range of digital products and services that can help to facilitate data management at local scales. Data management systems and social registries scan and collate data from different sources (demographic, geospatial, economic and environmental) to facilitate integrated and cross-sectoral planning. Monitoring progress is also part of planning and implementation, bearing in mind the complexity of policy implementation and the often unmeasurable effects of social change.

6.3.4 Vertical integration for knowledge sharing

Vertical coordination is about linking people and units at various levels, and is helpful to encourage regional experience sharing and consolidate knowledge from countries tackling similar challenges. Exchanges can be conducted across cities and regions in the same country or across NENA countries, as well as internationally. In some NENA countries, ministries of environment and municipal and local governments are already engaging with platforms and processes for knowledge sharing. Useful networks to be built upon or linked to include:

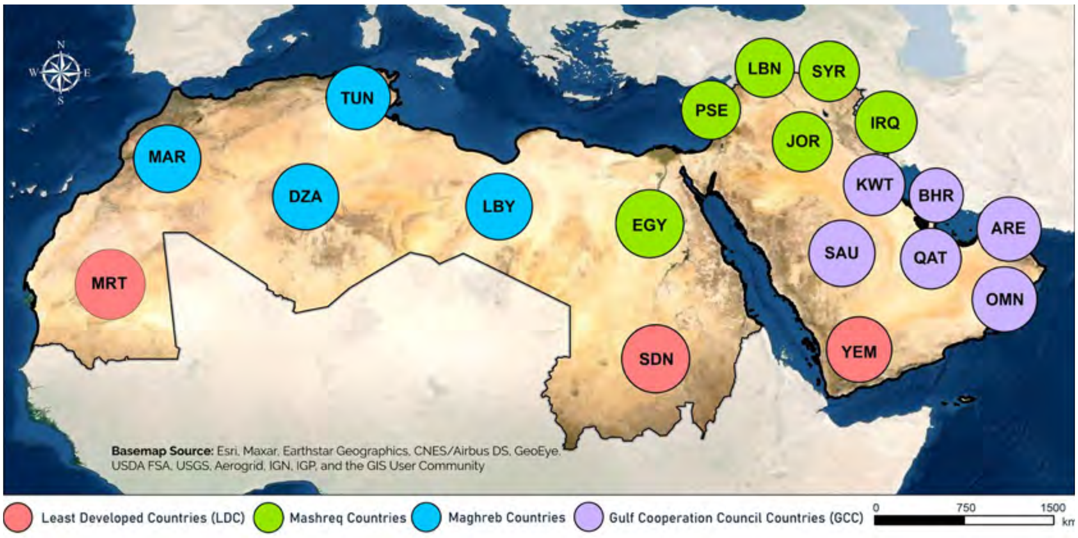
- The Global Covenant of Mayors for Climate and Energy, a global alliance, builds on the commitment of more than 10 000 cities and local governments (including 142 in the NENA region) to implement Sustainable Energy and Climate Action Plans.
- The Clima-Med project (and Covenant of Mayors Mediterranean) attempts to translate initiatives into concrete, bankable, low-carbon projects at local level.
- The Milan Urban Food Policy Pact promotes sustainable urban food systems, bringing together mayors. Signatories in the NENA region include Tunis, Bethlehem and Hebron.

- CES-MED (Cleaner Energy Saving Mediterranean Cities) is an EU-funded initiative that provides local and national governments in the European Neighbourhood and Partnership Instrument (ENPI) South region with training and technical assistance to address sustainable policy challenges. It promotes knowledge sharing and partnerships between local authorities in the EU and the ENPI South region.
- The Resilience City Network is a global initiative that aims to change the way that cities think about and manage urban spaces. Luxor in Egypt is involved in this network.

ANNEXES

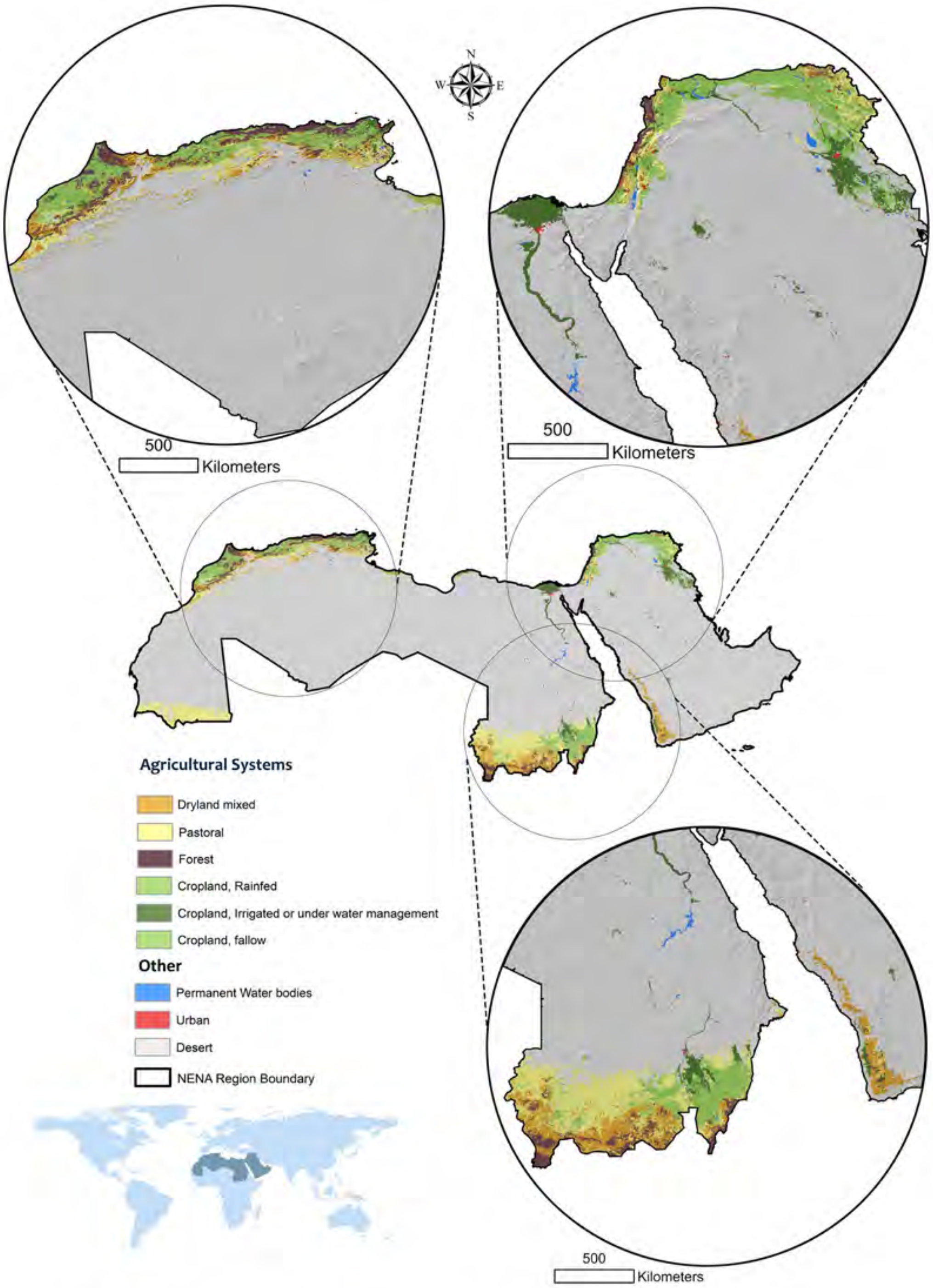
Annex 1: Maps

FIGURE A.1 OVERVIEW OF COUNTRY GROUPINGS USED IN THIS REPORT



Source: Prepared by FAO. 2021.

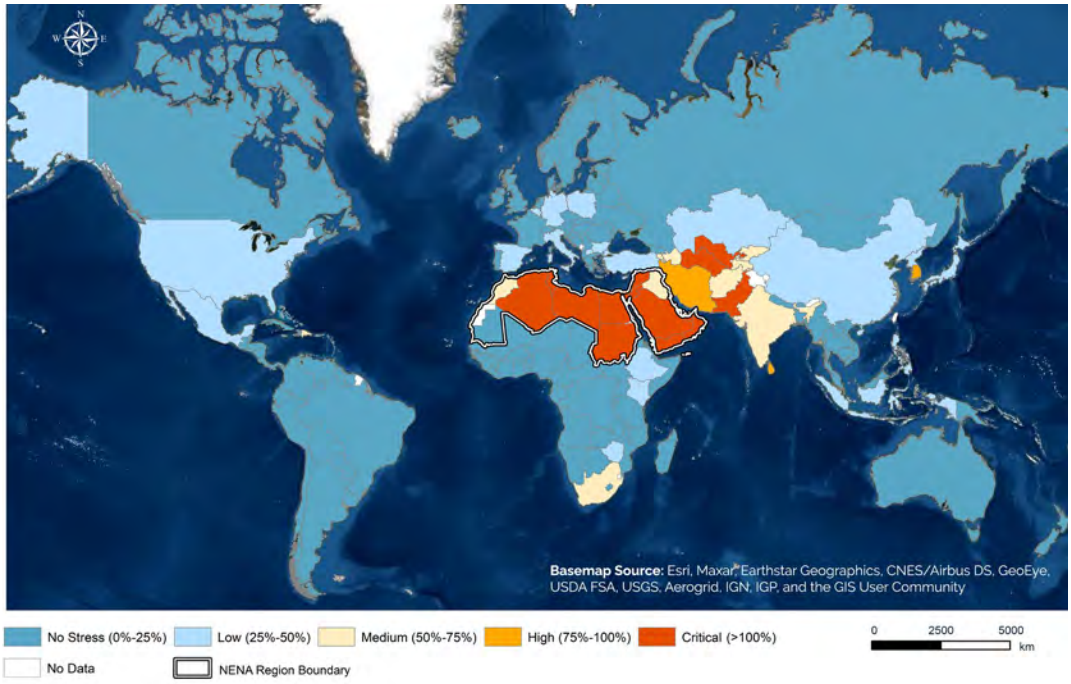
FIGURE A.2 AGRICULTURAL SYSTEMS IN THE NENA REGION



Basemap Source: Esri, Maxar, Earthstar Geographics, CNES/Airbus DS, GeoEye, USDA FSA, USGS, Aerogrid, IGN, IGP, and the GIS User Community

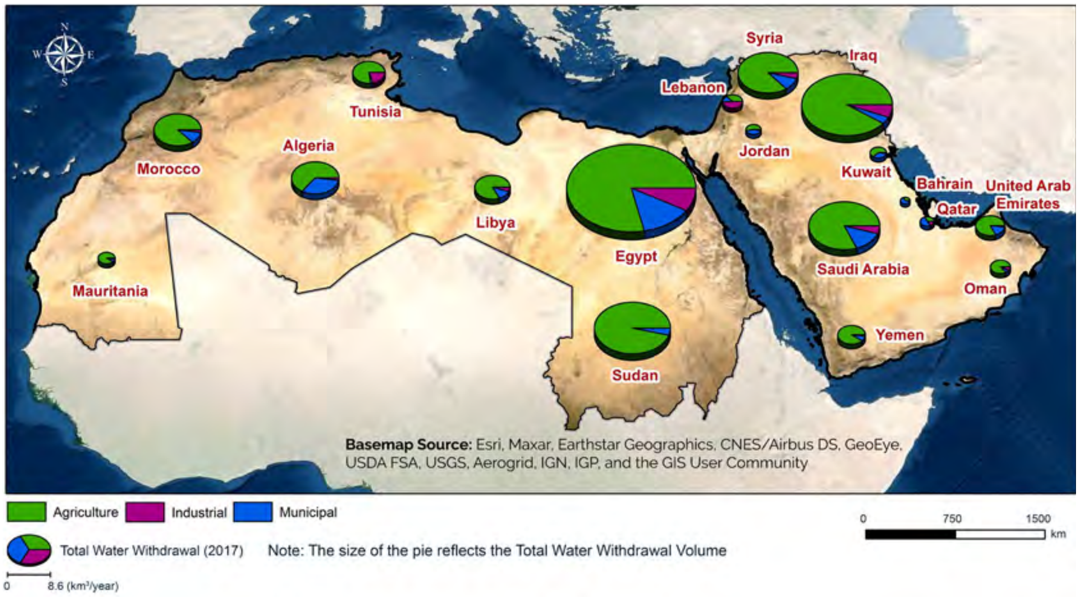
Source: Based on FAO WaPOR. FAO's portal to monitor Water Productivity through Open access of Remotely sensed derived data [online]. Rome. [Cited 15 December 2021] https://wapor.apps.fao.org/catalog/WAPOR_2/1/L1_LCC_A

FIGURE A.3 WATER STRESS IN NENA - SDG INDICATOR 6.4.2



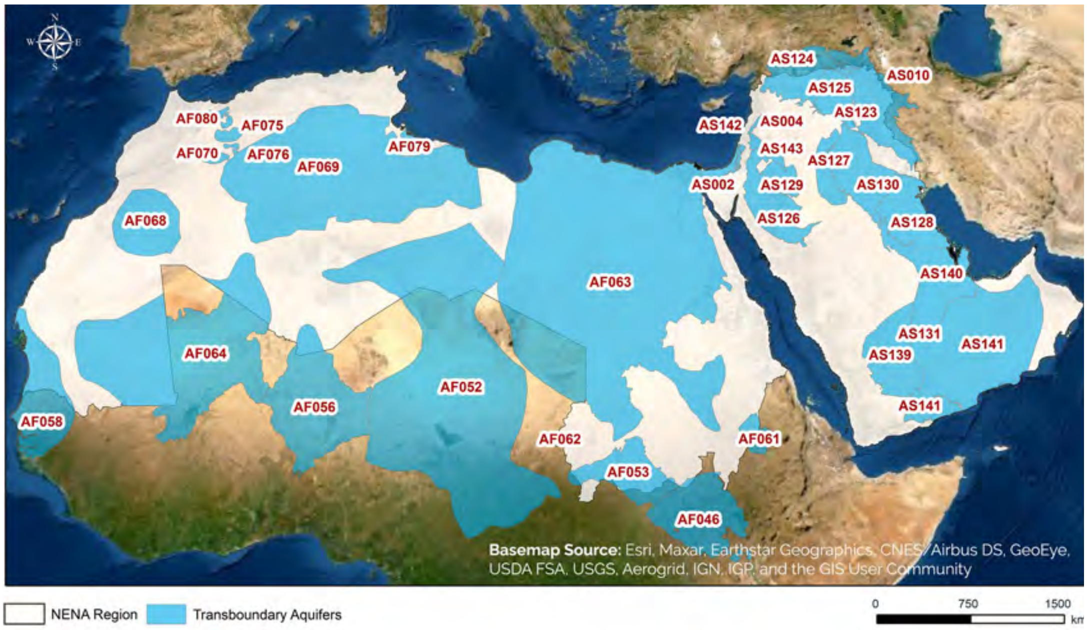
Source: AQUASTAT, 2021. www.fao.org/aquastat/en/

FIGURE A.4 PERCENTAGE OF VOLUME OF WATER WITHDRAWAL BY SECTOR FOR THE PERIOD 2013–2017*



Source: AQUASTAT, 2021. www.fao.org/aquastat/en/

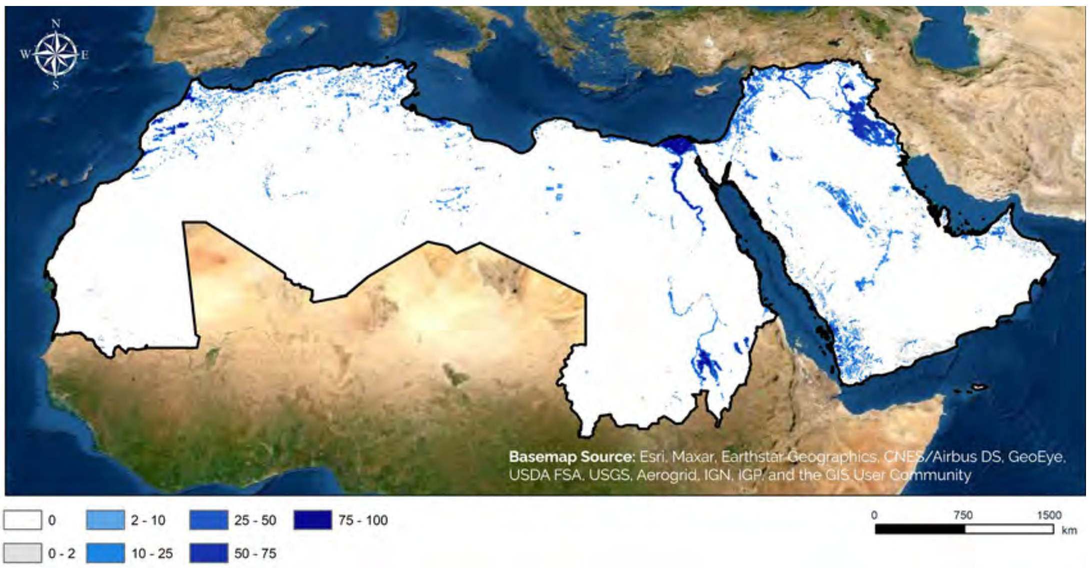
FIGURE A.5 TRANSBOUNDARY AQUIFERS IN THE NENA REGION*



Source: International Groundwater Resources Assessment Center. Transboundary Aquifers of the World GIS data layer [online]. [Cited 15 December 2021] www.un-igrac.org/ggis/transboundary-aquifers-world-map

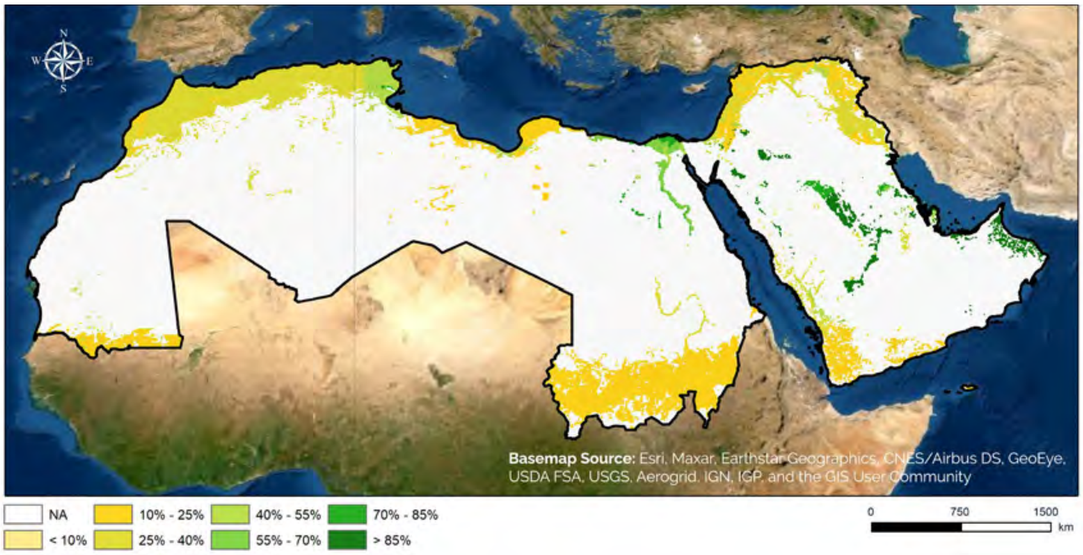
*The names of transboundary aquifers corresponding to codes are provided in Table A10.

FIGURE A.6 AREA EQUIPPED FOR IRRIGATION IN PERCENTAGE OF LAND AREA



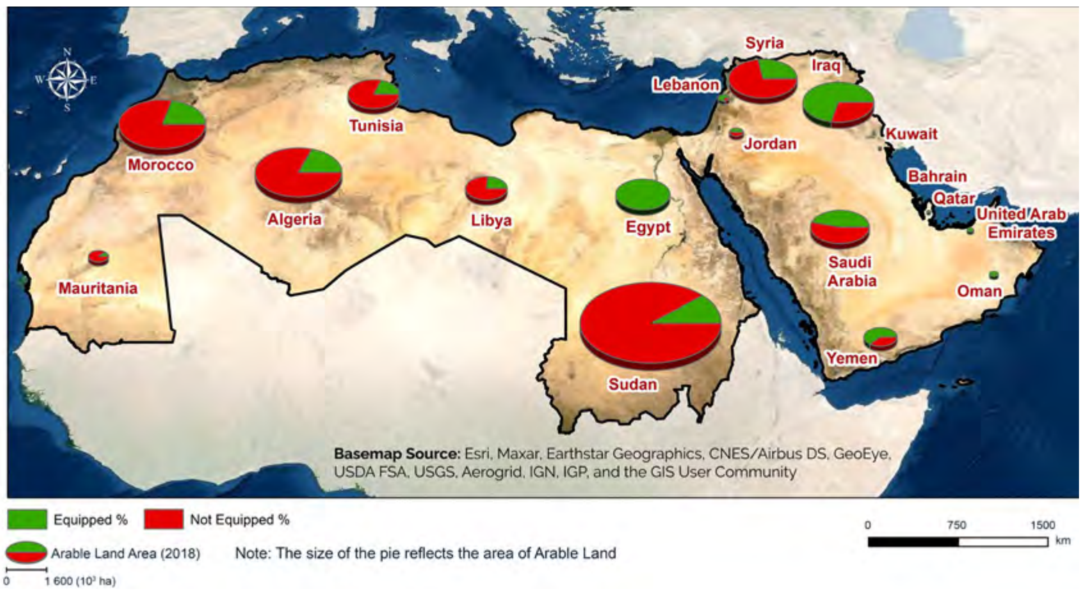
Source: Siebert *et al.*, 2013. *Update of the digital global map of irrigation areas to version 5*. Bonn, Germany, Rheinische Friedrich-Wilhelms-Universität and Rome, FAO. www.fao.org/3/I9261EN/i9261en.pdf).

FIGURE A.7 AGGREGATE YIELD ACHIEVEMENT RATIO FOR THE YEAR 2010 FOR CEREALS UNDER TOTAL (IRRIGATED AND RAINFED) WATER SUPPLY CONDITIONS



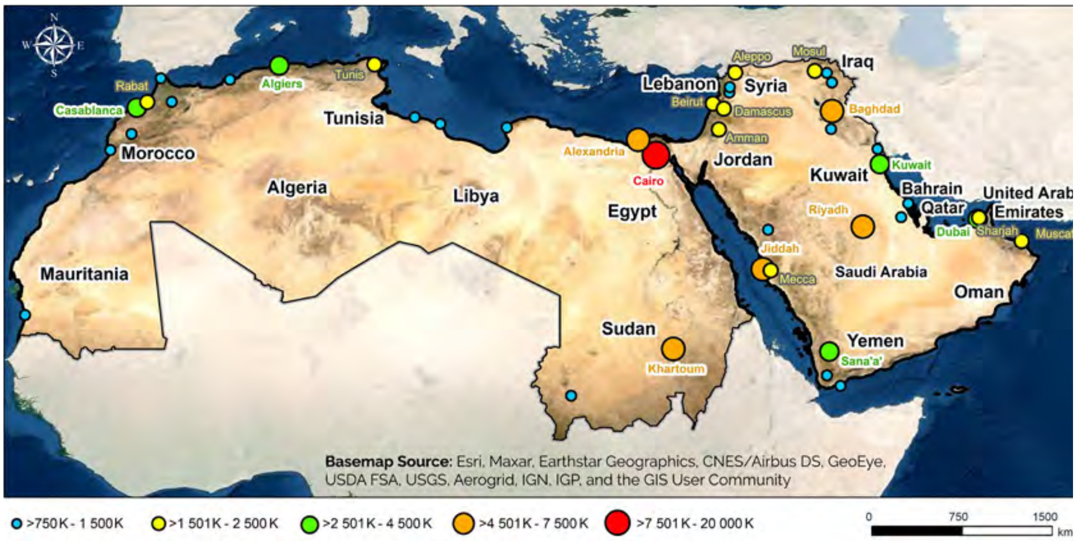
Source: GAEZ V4, Global Agro-Ecological Zoning Version 4 Data Portal [online]. [Cited 15 December 2021]. https://gaez.fao.org/pages/data-viewer

FIGURE A.8 PERCENT OF ARABLE LAND EQUIPPED FOR IRRIGATION (3-YEAR AVERAGE 2015–2017)*



Source: FAOSTAT, 2021. https://www.fao.org/faostat/en/#data/RL

FIGURE A.9 CITIES OF POPULATION GREATER THAN 750 000 INHABITANTS IN 2020



Source: United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2018. *World Urbanization Prospects: The 2018 revision, online edition.* https://population.un.org/wup/Download/

Annex 2: Tables

TABLE A.1 CROPLAND AS A PERCENTAGE OF TOTAL LAND AREA, 2000–2018, NENA (%)

Area/Year	2000	2005	2010	2015	2018
Algeria	3.44	3.51	3.53	3.55	3.58
Bahrain	7.32	6.35	6.04	5.91	5.90
Egypt	3.31	3.54	3.69	3.81	3.85
Iraq	9.83	12.32	9.72	12.09	12.09
Jordan	3.15	3.07	2.93	3.54	3.15
Kuwait	0.67	0.79	0.90	0.75	0.79
Lebanon	26.39	27.66	23.46	25.22	25.22
Libya	1.22	1.18	1.17	1.17	1.17
Mauritania	0.49	0.40	0.45	0.40	0.40
Morocco	21.63	20.14	20.14	20.27	20.32
Oman	0.24	0.21	0.23	0.27	0.35
Palestine	36.88	35.51	16.26	24.41	30.90
Qatar	1.38	1.22	1.42	1.55	1.48
Saudi Arabia	1.76	1.73	1.58	1.69	1.69
Sudan				10.81	10.81
Syrian Arab Republic	29.12	30.30	31.02	31.22	31.22
Tunisia	32.12	31.51	33.38	31.65	32.14
United Arab Emirates	3.48	3.62	1.30	1.17	1.15
Yemen	3.16	2.88	2.99	2.71	2.63
NENA	4.25	4.31	4.20	5.28	5.30
World	11.47	11.61	11.68	11.91	12.03

Source: FAOSTAT, 2021.

** Data for Sudan is only available from its creation in 2011.

TABLE A.2 ARABLE LAND AS A PERCENTAGE OF CROPLAND, 2000–2018, NENA (%)

Area/Year	2000	2005	2010	2015	2018
Algeria	93.53	89.81	89.19	88.18	88.12
Bahrain	38.46	31.91	34.78	34.78	34.78
Egypt	85.11	72.75	78.26	75.62	75.89
Iraq	95.35	96.47	94.79	95.24	95.24
Jordan	68.35	68.27	68.23	72.51	71.84
Kuwait	83.33	78.57	62.50	57.46	57.14
Lebanon	47.78	50.07	47.50	51.16	51.16
Libya	84.42	83.93	83.67	83.90	83.90
Mauritania	97.60	97.32	97.61	97.32	97.32
Morocco	90.83	90.35	85.99	82.87	82.45
Oman	42.47	43.08	47.25	62.84	70.40
Palestine	45.95	46.30	44.64	34.59	46.77
Qatar	81.25	81.69	83.21	85.96	82.35
Saudi Arabia	94.90	94.16	93.36	96.00	94.71
Sudan¨	Not avail.	Not avail.	Not avail.	99.16	99.16
Syrian Arab Republic	84.87	84.05	82.29	81.32	81.32
Tunisia	57.39	55.76	54.44	52.27	52.21
United Arab Emirates	24.29	26.46	54.82	53.26	51.74
Yemen	92.57	84.50	81.76	79.41	79.10
NENA	86.02	83.99	82.52	87.08	86.91
World	91.05	90.36	89.57	89.17	88.98

Source: FAOSTAT, 2021.

¨ data for Sudan is only available from its creation in 2011.

TABLE A.3 LAND UNDER PERMANENT CROPS AS A PERCENTAGE OF CROPLAND, 2000–2018, NENA (%)

Area/Year	2000	2005	2010	2015	2018
Algeria	6.47	10.19	10.81	11.82	11.88
Bahrain	61.54	68.09	65.22	65.22	65.22
Egypt	14.89	27.25	21.74	24.38	24.11
Iraq	4.65	3.53	5.21	4.76	4.76
Jordan	31.65	31.73	31.77	27.49	28.16
Kuwait	16.67	21.43	37.50	42.54	42.86
Lebanon	52.22	49.93	52.50	48.84	48.84
Libya	15.58	16.07	16.33	16.10	16.10
Mauritania	2.40	2.68	2.39	2.68	2.68
Morocco	9.17	9.65	14.01	17.13	17.55
Oman	57.53	56.92	52.75	37.16	29.60
Palestine	54.05	53.70	55.36	65.41	53.23
Qatar	18.75	18.31	16.79	14.04	17.65
Saudi Arabia	5.10	5.84	6.64	4.00	5.29
Sudan**	Not avail.	Not avail.	Not avail.	0.84	0.84
Syrian Arab Republic	15.13	15.95	17.71	18.68	18.68
Tunisia	42.61	44.24	45.56	47.73	47.79
United Arab Emirates	75.71	73.54	45.18	46.74	48.20
Yemen	7.43	15.50	18.24	20.59	20.90
NENA	13.98	16.01	17.48	12.92	13.09
World	8.95	9.64	10.43	10.66	10.84

Source: FAOSTAT, 2021.

** data for Sudan is only available from its creation in 2011.

TABLE A.4 FOREST AREA (000 HA) AS A PROPORTION OF TOTAL LAND AREA, NENA, (2000–2020)

Area/Year	2000	2010	2015	2016	2017	2018	2019	2020
Algeria	0.66	0.81	0.82	0.82	0.82	0.81	0.81	0.82
Bahrain	0.48	0.67	0.77	0.80	0.82	0.85	0.87	0.90
Egypt	0.06	0.07	0.05	0.05	0.05	0.05	0.05	0.05
Iraq	1.88	1.90	1.90	1.90	1.90	1.90	1.90	1.90
Jordan	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Kuwait	0.27	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lebanon	13.51	13.43	13.72	13.78	13.83	13.89	13.95	14.01
Libya	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Mauritania	0.41	0.36	0.33	0.32	0.32	0.31	0.31	0.30
Morocco	12.34	12.71	12.74	12.77	12.80	12.82	12.84	12.87
Oman	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Palestine	1.51	1.65	1.68	1.68	1.68	1.68	1.68	1.68
Qatar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saudi Arabia	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Sudan	11.69	10.76	10.29	10.20	10.11	10.02	9.93	9.84
Syrian Arab Republic	2.35	2.68	2.84	2.84	2.84	2.84	2.84	2.84
Tunisia	4.30	4.42	4.47	4.48	4.49	4.50	4.51	4.52
United Arab Emirates	4.36	4.47	4.47	4.47	4.47	4.47	4.47	4.47
Yemen	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
World	31.93	31.53	31.36	31.34	31.28	31.25	31.21	31.17

Source: FAO, Sustainable Development Goals, Indicator 15.1.1 – Forest area as a percentage of total land area, 2021. www.fao.org/sustainable-development-goals/overview/en/

TABLE A.5 TOTAL ARABLE LAND IN NENA, 2000–2018 (000 HA)

Area/Year	2000	2005	2010	2015	2018
Algeria	7 662.0	7 511.0	7 502.0	7 462.1	7 505.0
Bahrain	2.0	1.5	1.6	1.6	1.6
Egypt	2 801.0	2 563.0	2 873.0	2 865.9	2 911.0
Iraq	4 100.0	5 200.0	4 000.0	5 000.0	5 000.0
Jordan	190.0	185.0	177.6	227.9	201.0
Kuwait	10.0	11.0	10.0	7.7	8.0
Lebanon	129.0	141.7	114.0	132.0	132.0
Libya	1 815.0	1 750.0	1 716.0	1 720.0	1 720.0
Mauritania	488.0	400.0	450.0	400.0	400.0
Morocco	8 767.0	8 122.0	7 729.3	7 497.3	7 477.6
Oman	31.0	28.0	34.3	52.2	76.7
Palestine	102.0	99.0	43.7	50.8	87.0
Qatar	13.0	11.6	13.7	15.3	14.0
Saudi Arabia	3 592.0	3 500.0	3 180.0	3 490.0	3 437.0
Sudan*	Not avail.	Not avail.	Not avail.	19 823.2	19 823.2
Syrian Arab Republic	4 542.0	4 675.0	4 687.0	4 662.0	4 662.0
Tunisia	2 864.0	2 730.0	2 823.0	2 570.0	2 607.0
United Arab Emirates	60.0	68.0	50.6	44.1	42.3
Yemen	1 545.0	1 287.0	1 291.0	1 137.6	1 097.7
NENA	38 713.0	38 283.8	36 696.8	57 159.6	57 203.0
World	1 359 610.5	1 365 737.8	1 361 129.8	1 383 225.5	1 394 979.1

Source: FAOSTAT, 2021.

*data for Sudan is only available from its creation in 2011.

TABLE A.6 PRODUCTION VALUE, QUANTITY AND YIELD OF THE TOP 5 CROPS IN PRODUCTION VALUE BY COUNTRY, NENA*, 2018

Country (Area)/Crop	Value (current 000 USD)	Quantity (tonnes)	Yield (hg/ha)
Algeria			
Dates	3 689 880	1 094 700	64 831
Potatoes	1 756 064	4 653 322	310 916
Wheat	1 536 573	3 981 219	19 076
Oranges	1 225 695	1 134 194	223 104
Apples	899 522	487 808	124 970
Bahrain			
Dates	9 435	12 900	52 653
Tomatoes	8 644	6 500	730 337
Cucumbers and gherkins	3 525	2 651	1 019 615
Pumpkins, squash and gourds	2 979	2 800	651 163
Cauliflowers and broccoli	1 489	1 120	350 000
Egypt			
Wheat	1 771 945	8 348 629	62 942
Groundnuts, with shell	861 267	209 843	35 267
Maize	843 755	5 111 236	75 162
Tomatoes	664 908	6 777 754	387 739
Sugar cane	641 214	15 823 103	1 150 169
Iraq			
Wheat	797 315	2 177 885	27 789
Dates	248 577	646 163	17 070
Tomatoes	185 411	467 579	268 662
Maize	105 961	225 000	45 000
Grapes	104 689	123 083	159 043
Jordan			
Cucumbers and gherkins	221 746	208 226	1 070 021
Olives	177 519	125 150	22 112
Tomatoes	119 914	717 865	710 054
Peaches and nectarines	88 374	83 077	224 472
Potatoes	66 501	153 199	403 155

Country (Area)/Crop	Value (current 000 USD)	Quantity (tonnes)	Yield (hg/ha)
Kuwait			
Dates	80 013	96 656	288 267
Tomatoes	48 671	97 991	1 353 467
Cucumbers and gherkins	36 861	58 590	1 203 080
Potatoes	15 588	36 212	623 270
Pumpkins, squash and gourds	9 749	18 401	391 511
Lebanon			
Potatoes	326 914	645 901	275 684
Apples	266 825	239 001	172 863
Olives	239 791	145 000	21 993
Tomatoes	190 903	248 735	381 261
Oranges	101 188	138 547	255 480
Morocco			
Wheat	1 858 603	7 320 620	25 752
Olives	893 017	1 561 465	14 940
Barley	575 605	2 851 022	18 224
Potatoes	428 151	1 869 149	301 315
Tomatoes	305 730	1 409 437	883 383
Oman			
Tomatoes	65 506	199 232	786 856
Chillies and peppers, green	42 185	64 663	608 307
Cucumbers and gherkins	33 009	73 267	1 134 164
Mangoes, mangosteens, guavas	27 090	15 847	105 226
Cauliflowers and broccoli	17 489	28 031	223 355
Palestine			
Olives	180 826	89 723	15 899
Tomatoes	100 109	130 230	1 260 697
Cucumbers and gherkins	81 473	113 866	490 802
Pumpkins, squash and gourds	57 644	47 107	192 117
Grapes	55 724	35 943	105 870

Country (Area)/Crop	Value (current 000 USD)	Quantity (tonnes)	Yield (hg/ha)
Qatar			
Dates	27 099	29 012	120 033
Tomatoes	20 102	26 133	403 287
Pumpkins, squash and gourds	4 326	7 873	181 406
Vegetables, fresh nes	3 594	4 361	124 957
Eggplants (aubergines)	2 153	2 902	250 172
Saudi Arabia			
Dates	3 755 833	1 427 506	122 928
Watermelons	391 914	489 432	170 350
Tomatoes	318 766	274 194	230 048
Potatoes	269 248	425 250	235 491
Wheat	225 683	517 910	54 640
Tunisia			
Dates	441 428	305 000	46 565
Olives	394 663	827 563	5 394
Wheat	293 981	1 075 400	17 373
Chillies and peppers, green	150 137	430 000	215 994
Tomatoes	142 638	1 193 000	559 464
Yemen			
Mangoes, mangosteens, guavas	201 182	290 793	128 892
Oranges	199 768	103 431	135 932
Grapes	198 315	122 751	105 158
Coffee, green	187 361	18 642	5 652
Potatoes	179 855	229 777	143 584

Source: FAOSTAT, 2021.

`No production value data for crops is available for Libya, Mauritania, Sudan, the Syrian Arab Republic or the United Arab Emirates in 2018.

TABLE A.7 LEVEL OF WATER STRESS, NENA (2000–2018)

Variable	Level of water stress					
Unit	(%)					
Area / Year	2000	2005	2010	2015	2017	2018
Algeria	79.3	92.5	104.9	126.0	137.9	137.9
Bahrain	248.9	196.4	173.1	137.2	133.7	133.7
Egypt	103.9	112.3	120.7	110.6	141.2	141.2
Iraq	92.7	79.6	66.6	49.0	60.5	47.1
Jordan	82.6	95.9	98.9	96.2	100.1	100.1
Kuwait	1912.0	2075.0	2075.0	3399.0	3850.5	3850.5
Lebanon	41.1	35.6	47.2	58.8	58.8	58.8
Libya	615.4	698.1	783.1	817.1	817.1	817.1
Mauritania	15.7	13.2	13.2	13.2	13.2	13.2
Morocco	60.5	63.5	50.8	50.8	50.8	50.8
Oman	91.8	91.1	107.1	116.7	116.7	116.7
Palestine	40.1	58.7	55.3	51.3	41.1	42.7
Qatar	282.6	374.1	409.9	431.0	431.0	431.0
Saudi Arabia	819.8	894.8	914.5	948.9	883.3	1000.0
Sudan**	Not avail.*	Not avail.	Not avail.	118.7	118.7	118.7
Syrian Arab Republic	134.2	126.0	126.0	124.4	124.4	124.4
Tunisia	66.0	72.8	79.1	107.9	89.5	96.0
United Arab Emirates	1 556.0	1 490.0	1 612.4	1 769.1	1 708.0	1 667.3
Yemen	161.1	169.8	169.8	169.8	169.8	169.8
World	Not avail.	Not avail.	Not avail.	18.2	18.4	18.4

Source: FAO, Sustainable Development Goals, 2021. www.fao.org/sustainable-development-goals/overview/en/ and AQUASTAT, 2021.

*Not avail. refers to unavailable data.

**Data on FAOSTAT are reported for former Sudan, South Sudan, and Sudan; that is why Sudan only appears from 2011.

TABLE A.8 WATER-USE EFFICIENCY, NENA (2000–2018)

Variable	Water-use efficiency					
Unit	(USD per cubic metre)					
Area / Year	2000	2005	2010	2015	2017	2018
Algeria	Not avail.*	16.5	16.2	15.2	14.1	14.5
Bahrain	43.8	53.0	63.9	71.8	76.3	78.1
Egypt	2.4	2.7	3.4	4.4	4.4	4.6
Iraq	1.4	1.8	2.5	4.7	4.2	5.4
Jordan	19.6	24.9	34.2	34.6	34.9	35.4
Kuwait	75.5	93.1	100.4	113.6	100.2	101.6
Lebanon	17.5	21.3	25.9	24.9	25.8	25.8
Libya	21.5	26.7	27.8	2.4	3.8	4.3
Mauritania	1.0	1.7	2.3	3.5	3.8	3.9
Morocco	3.1	3.8	6.3	7.7	8.4	8.7
Oman	30.6	30.6	34.0	36.3	45.0	46.6
Palestine	20.2	16.4	23.1	32.3	34.4	34.1
Qatar	124.2	121.0	194.5	206.4	205.0	200.8
Saudi Arabia	17.6	19.4	23.4	26.3	28.3	28.1
Sudan**	Not avail.	Not avail.	Not avail.	2.3	2.6	2.8
Syrian Arab Republic	1.5	1.7	2.2	1.0	0.9	1.0
Tunisia	8.0	8.9	10.6	8.5	10.6	10.2
United Arab Emirates	63.5	60.9	69.4	73.9	73.7	74.2
Yemen	Not avail.	10.4	12.5	6.8	6.1	6.0
World	Not avail.	Not avail.	Not avail.	17.3	18.2	19.0

Source: FAO, Sustainable Development Goals, 2021. www.fao.org/sustainable-development-goals/overview/en/ and AQUASTAT.

*Not avail. refers to unavailable data.

** Data on FAOSTAT are reported for former Sudan, South Sudan, and Sudan; that is why Sudan only appears from 2011.

TABLE A.9 ESTIMATED AREA OF FORESTS AND OWL (000 HA) IN NENA REGION FOR EACH FRA SINCE 1990

Year	Area of forests (000 ha)	Area of other wooded land (000 ha)	Total area of forest & other wooded land (000 ha)	% of forests & other wooded land from total land area
1990	35 303.5	35 431.8	70 735.2	5.7
2000	33 615.9	33 588.7	67 204.5	5.4
2010	32 426.0	31 463.5	63 889.5	5.1
2015	31 599.4	30 520.7	62 120.1	5.0
2016	31 445.8	30 309.5	61 755.3	5.0
2017	31 269.1	30 101.0	61 370.1	4.9
2018	31 090.5	29 893.8	60 984.2	4.9
2019	30 934.5	29 664.6	60 599.0	4.9
2020	30 779.4	29 434.6	60 213.9	4.8

Source: FAO, 2021a. Forest Resources Assessment for Near East and North Africa 2020 in the global context. www.fao.org/3/cb6781en/cb6781en.pdf.

TABLE A.10 TRANSBOUNDARY AQUIFERS IN THE NENA REGION

#	Code_2017	Aquifer name	Geographical coverage
1	AF075	Ain Beni Mathar	Morocco, Algeria
2	AF076	Chott Tigri-Lahouita	Morocco, Algeria
3	AF077	Figuig	Morocco, Algeria
4	AF070	SystBme Aquifrre d'Errachidia	Morocco, Algeria
5	AF080	Triffa	Morocco, Algeria
6	AF078	Jbel El Hamra	Morocco, Algeria
7	AF074	Angad	Morocco, Algeria
8	AF079	SystBme Aquifrre de la Djeffara	Tunisia, Libya
9	AS001	Western Aquifer Basin	Egypt, Israel, Palestine
10	AS123	Taurus-Zagros	Iran, Iraq, Turkey
11	AS142	Basalt Aquifer System (West): Yarmouk Basin	Jordan, Syrian Arab Republic
12	AS143	Basalt Aquifer System (South): Azraq-Dhuleil Basin	Jordan, Syrian Arab Republic
13	Palestine	Palestine	Palestine
14	AS003	Northeastern Aquifer	Israel, Palestine
15	AS010	Upper Jezira	Iraq, Syrian Arab Republic, Turkey
16	AS004	Anti-Lebanon	Lebanon, Syrian Arab Republic
17	AS125	Neogene Aquifer System (North-West): Upper and Lower Fars	Syrian Arab Republic, Iraq
18	AF062	Disa	Chad, Sudan
19	AF052	Lake Chad Basin	Chad, Niger, Nigeria, Cameroon, Central African Republic, Algeria
20	AF056	Irhazer-Illuemeden Basin	Algeria, Benin, Mali, Niger, Nigeria
21	AF058	Senegalo-Mauretanian Basin	Gambia, Guinea-Bissau, Mauritania, Senegal, Western Sahara
22	AF068	Systeme Aquifere de Tindouf	Morocco, Western Sahara, Mauritania, Algeria
23	AS139	Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands	Saudi Arabia, Yemen
24	AS131	Wajid Aquifer System	Saudi Arabia, Yemen

25	AS141	Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali	Oman, Saudi Arabia, United Arab Emirates, Yemen
26	AS140	Umm er Radhuma-Dammam Aquifer System (Centre): Gulf	Saudi Arabia, United Arab Emirates, Bahrain, Qatar
27	AF061	Gedaref	Ethiopia, Sudan
28	AS127	Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba	Saudi Arabia, Iraq
29	AS130	Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman	Iraq, Kuwait, Saudi Arabia
30	AS128	Neogene Aquifer System (South-East): Dibdibba-Kuwait Group	Iraq, Kuwait, Saudi Arabia
31	AS129	Tawil Quaternary Aquifer System: Wadi Sirhan Basin	Jordan, Saudi Arabia
32	AS126	Saq-Ram Aquifer System (West)	Jordan, Saudi Arabia
33	AF053	Baggara Basin	Central African Republic, South Sudan, Sudan
34	AF046	Sudd Basin	Ethiopia, Kenya, South Sudan
35	AF064	Taoudeni Basin	Algeria, Mali, Mauritania
36	AS002	Coastal Aquifer Basin	Egypt, Israel, Palestine
37	AF063	Nubian Sandstone Aquifer System (NSAS)	Chad, Egypt, Libya, Sudan
38	AF069	Northwest Sahara Aquifer System (NWSAS)	Algeria, Libya

Source: International Groundwater Resources Assessment Center. *Transboundary Aquifers of the World GIS data layer* [online]. [Cited 15 December 2021] www.un-igrac.org/ggis/transboundary-aquifers-world-map

TABLE A.11 POPULATION AND CULTIVATED AREA AS A PERCENTAGE OF THE TOTAL COUNTRY AREA, 2018

Area	Total population (inhabitants)	Percentage of cultivated area/total area of the country (expressed in %)
Algeria	42 228 408	4
Bahrain	1 569 446	6
Egypt	98 423 598	4
Iraq	38 433 600	12
Jordan	9 965 318	3
Kuwait	4 137 312	1
Lebanon	6 859 408	25
Libya	6 678 559	1
Mauritania	4 403 313	0
Morocco	36 029 093	21
Oman	4 829 473	0
Palestine	4 862 979	31
Qatar	2 781 682	1
Saudi Arabia	33 702 756	2
Sudan	41 801 533	11
Syrian Arab Republic	16 945 057	31
Tunisia	11 565 201	31
United Arab Emirates	9 630 959	1
Yemen	28 498 683	3

Source: AQUASTAT, 2021

TABLE A.12 PERCENTAGE OF THE AREA EQUIPPED FOR IRRIGATION ACTUALLY IRRIGATED, 2018

Area	(%)
Algeria	78
Bahrain	109
Egypt	90
Iraq	55
Jordan	93
Kuwait	69
Lebanon	100
Libya	79
Mauritania	51
Morocco	95
Oman	100
Palestine	
Qatar	100
Saudi Arabia	36
Sudan	
Syrian Arab Republic	90
Tunisia	83
United Arab Emirates	139
Yemen	

Source: AQUASTAT, 2021

TABLE A.13 WATER WITHDRAWAL BY SOURCE, 2018

	Surface and groundwater		Reused agricultural drainage (%)		Desalinated water		Treated wastewater		Total (10^6 m³/yr)	
	in 10^9 m³/yr	(%)	in 10^9 m³/yr	(%)	in 10^9 m³/yr	(%)	in 10^9 m³/yr	(%)	in 10^9 m³/yr	(%)
Algeria	9,802	94			0,631	6	0,050	0	10,483	100
Bahrain	0,155	36			0,242	55	0,039	9	0,436	100
Egypt	77,500	85	12	13	0,200	0	1,200	1	90,800	100
Iraq	33,564	100	0	0	0,006	0	0,005	0	33,575	100
Jordan	0,904	87	0	0	0,136	13	0,004	0	1,044	100
Kuwait	0,770	61			0,420	33	0,078	6	1,268	100
Lebanon	1,812	96	0,028	1	0,047	3	0,002	0	1,889	100
Libya	5,720	99			0,070	1			5,790	100
Mauritania	1,348	100			0,002	0			1,350	100
Morocco	10,573	99			0,007	0	0,070	1	10,650	100
Oman	1,634	81	0	0	0,330	16	0,061	3	2,025	100
Palestine	0,300	60	0,182	36	0,004	1	0,013	3	0,499	100
Qatar	0,250	23	0,050	5	0,634	59	0,133	13	1,067	100
Saudi Arabia	24,000	91			2,180	8	0,254	1	26,434	100
Sudan	26,935	100							26,935	100
Syrian Arab Republic	13,964	83	2,246	13			0,550	3	16,760	100
Tunisia	3,781	98	0	0	0,043	1	0,021	1	3,845	100
United Arab Emirates	2,501	49	0	0	2,011	40	0,543	11	5,055	100
Yemen	3,565	99			0,025	1	0,006	0	3,596	100

Source: AQUASTAT, 2021

TABLE A.14 WATER USE BY SECTOR, 2018

	Agriculture		Municipalities		Industry		Total	
	in 10^9 m^3/yr	%	in 10^9 m^3/yr	%	in 10^9 m^3/yr	%	in 10^9 m^3/yr	%
Algeria	6,671	64	3,600	34	0,191	2	10,462	100
Bahrain	0,145	33	0,276	63	0,014	3	0,434	100
Egypt	61,350	79	10,750	14	5,400	7	77,500	100
Iraq	30,710	91	1,070	3	1,790	5	33,570	100
Jordan	0,555	53	0,457	44	0,033	3	1,044	100
Kuwait	0,778	62	0,448	36	0,023	2	1,250	100
Lebanon	0,700	38	0,240	13	0,900	49	1,840	100
Libya	4,850	83	0,700	12	0,280	5	5,830	100
Mauritania	1,223	91	0,095	7	0,032	2	1,350	100
Morocco	9,156	88	1,063	10	0,212	2	10,431	100
Oman	1,547	83	0,088	5	0,238	13	1,873	100
Palestine	0,176	45	0,182	47	0,032	8	0,390	100
Qatar	0,230	26	0,616	70	0,035	4	0,881	100
Saudi Arabia	19,000	80	3,428	14	1,400	6	23,828	100
Sudan	25,910	96	0,950	4	0,075	0	26,935	100
Syrian Arab Republic	14,670	88	1,475	9	0,615	4	16,760	100
Tunisia	2,933	76	0,866	23	0,046	1	3,845	100
United Arab Emirates	3,000	59	2,000	40	0,104	2	5,055	100
Yemen	3,235	91	0,265	7	0,065	2	3,565	100

Source: AQUASTAT, 2021

TABLE A.15 IRRIGATED LAND AS A PERCENTAGE OF TOTAL CULTIVATED LAND, 2018

	Irrigated land (ha)	% of irrigated land/Total cultivated land
Egypt	3 861 000	98
Iraq	3 810 000	71.8
Jordan	85 040	40
Lebanon	141 211	60.9
Libya	1 328 000	63
Oman	108 900	100
Bahrain	3 729	73
Yemen	455 173	100
Syrian Arab Republic	973 648	100
Sudan	1 896 635	9.5
Tunisia	486 570	9.3
Algeria	1 430 633	3.5
Morocco	1 825 430	19
Mauritania	302 203	58.9
Palestine	35 863	22.7

Source: AQUASTAT, 2021

TABLE A.16 IRRIGATED WATER FROM GROUND WATER AND SURFACE, 2018

	Irrigation with groundwater (%)	Irrigation with surface water (%)	Irrigation using mix surface and groundwater (%)	Irrigation with direct use of treated municipal wastewater (%)	Irrigation with direct use of non-treated municipal wastewater (%)
Algeria	62	27	1	0	
Bahrain	98	0	14	34	
Egypt	6	74	0	1	
Iraq	6	94			
Jordan	49	43	6	4	1
Kuwait	46	0	39	53	
Lebanon	60	55			
Libya	116	1		1	
Mauritania	11	89	0		
Morocco	28	67	0		1
Oman	54	0	0		
Palestine	19				
Qatar	91	0	6	6	
Saudi Arabia	51	0	1	2	0
Sudan	4	96			0
Syrian Arab Republic	54	0	46	1	3
Tunisia	74	30	103	2	
United Arab Emirates	100	0	0	31	
Yemen	67	100	0		

Source: AQUASTAT, 2021

TABLE A.17 IRRIGATION BY METHOD, 2018

	Surface		Sprinkler		Drip		Total	
	in 1 000 ha	%	in 1 000 ha	%	in 1 000 ha	%	in 1 000 ha	%
Algeria	596,000	45	409,000	31	307,000	23	1 312,000	100
Bahrain	3,149	84	0,149	4	0,432	12	3,730	100
Egypt	2 891,078	76	434,191	11	497,731	13	3 823,000	100
Iraq								
Jordan	15,186	17	1,687	2	73,733	81	90,606	100
Kuwait	10,750	63	2,136	13	4,094	24	16,980	100
Lebanon	57,223	64	25,129	28	7,648	8	90,000	100
Libya							400,000	
Mauritania							45,010	
Morocco	1 044,000	72	125,800	9	288,200	20	1 458,000	100
Oman	51,400	47	33,400	31	24,100	22	108,900	100
Palestine		0	24,000	19	100,000	81	124,000	100
Qatar	9,908	75	1,851	14	1,444	11	13,203	100
Saudi Arabia	1 428,961	44	1 449,201	44	400,757	12	3 278,919	100
Sudan							1726,000	
Syrian Arab Republic	1 043,000	78	187,100	14	110,900	8	1 341,000	100
Tunisia	107,030	23	130,290	28	228,010	49	465,330	100
United Arab Emirates	6,446	12	3,415	6	44,704	82	54,565	100
Yemen	453,800	100	0,354	0	0,485	0	454,639	100

Source: AQUASTAT, 2021

REFERENCES

Abahussain, A.A., Abdu, A.Sh., Al-Zubari, W.K., El-Deen, N.A. & Abdul Raheem, M. 2002. Desertification in the Arab region: Analysis of current status and trends. *J. Arid Environ.*, 51: 521–545.

Abdel Magid, T. D. & Siddig, A. J. 2012. *Development strategy of the traditional rain-fed agriculture: Forestry sector.*

AbuZeid, K., Wagdy, A. & Ibrahim, M. 2019. *3rd State of the Water Report for the Arab region – 2015*. Water Resources Management Program - CEDARE and Arab Water Council.

Agridigitale. 2020. Remarkable Growth for Avocado in Morocco. https://agridigitale.net/art-remarkable_growth_for_avocado_in_morocco.html.

Akhtar-Schuster, M., Stringer, L.C., Erlewein, A., Metternicht, G., Minelli, S., Safriel, U. & Sommer, S. 2017. Unpacking the concept of land degradation neutrality and addressing its operation through the Rio Conventions. *Journal of Environmental Management*, 195: 4–15.

Alderwish, A.M. & Alderwish, F.A. 2011. Environmental aspects of the accelerated urbanization in Sana'a, Yemen. *Sultan Qaboos University Journal for Science,* 16(2011): 1-12.

Al-Sarihi, A. & Luomi, M. 2019. *Climate change governance and cooperation in the Arab region*.

Al-Zyoud, S., Rühaak, W., Forootan, E. & Sass, I. 2015. Over exploitation of groundwater in the centre of Amman Zarqa Basin—Jordan: evaluation of well data and GRACE satellite observations. *Resources*, 4(4): 819–830.

Al-Mudaffar Fawzi, N., Goodwin, K. P., Mahdi, B. A. & Stevens, M. L. 2016. Effects of Mesopotamian Marsh (Iraq) desiccation on the cultural knowledge and livelihood of Marsh Arab women*. Ecosyst. Heal. Sustain.*, 2(3): e01207.

Alklaibi, A.M. & Lior, N. 2005. Membrane distillation desalination: Status and potential. *Desalination* 171(2): 111–131.

Alonso, A., Feltz, N., Gaspart, F., Sbaa, M. & Vanclooster, M. 2019. Comparative assessment of irrigation systems' performance: Case study in the Triffa agricultural district, NE Morocco. *Agric. Water Manag.*, 212: 338–348.

Anseeuw, W., Alden Wily, L., Cotula, L. & Taylor, M. 2012. *Land rights and the rush for land*. Findings of the Global Commercial Pressures on Land Research Project. ILC, Rome.

Antonelli, M. & Tamea, S. 2015. Food-water security and virtual water trade in the Middle East and North Africa. *International Journal of Water Resources Development*, 31(3): 326–342.

Antonelli, M., Laio, F. & Tamea, S. 2017. Water resources, food security and the role of virtual water trade in the MENA region, in *Environmental change and human security in Africa and the Middle East*, pp. 199–217, Springer.

Arab Forum for Environment and Development (AFED). 2014. *Food security, Annual report*. Sadik, M. El-Solh & Saab, N., eds. Beirut.

Azzam, A., & Ali, A.B. 2019. Urban sprawl in wadi goss watershed (Jeddah City/ Western Saudi Arabia) and Its Impact on Vulnerability and Flood Hazard, Journal of Geographic Information System > Vol.11 No.3, June 2019.

Babar, Z., & Mirgani, S. 2014. *Food security in the Middle East.* Oxford, UK, Oxford University Press. DOI: 10.1093/acprof:oso/9780199361786.001.0001

Bailey, R. 2011. *Growing a better future: Food justice in a resource-constrained world*. Oxfam, UK. www-cdn.oxfam.org/s3fs-public/file_attachments/cr-growing-better-future-170611-en_0.pdf.

Balaghi, R. 2012. *Climate change impacts and adaptation in mountain regions in the MENA region.* Rome, FAO. www.fao.org/fileadmin/templates/mountain_partnership/doc/MENA_background_En.pdf.

Barnes, J. 2014. *Cultivating the Nile: The everyday politics of water in Egypt.* Duke University Press.

Bashir, E. M. F. 2020. *Strategies to cope with risks of uncertain water supply in spate irrigation systems: Case study – Gash agricultural scheme in Sudan.* CRC Press.

Basso, B., Shuai, G., Zhang, J. & Robertson, P.G. 2019. Yield stability analysis reveals sources of large-scale nitrogen loss from the US Midwest. *Scientific Reports* 9: 5774. https://doi.org/10.1038/s41598-019-42271-1

Bazza, M. 2003. Wastewater recycling and reuse in the Near East region: Experience and issues. *Water Sci. Technol. Water Supply*, 3(4): 33–50.

Borgomeo, E. & Santos, N. 2019. *Toward a new generation of policies and investments in agricultural water in the Arab region: Fertile ground for innovation*. Rome, FAO; Colombo, Sri Lanka, International Water Management Institute (IWMI), 124 pp. doi: 10.5337/2019.207

Borgomeo, E., Fawzi, N. A. M., Hall, J. W., Jägerskog, A., Nicol, A., Sadoff, C. W., Salman, M., Santos, N. & Talhami, M. 2020. Tackling the trickle: Ensuring sustainable water management in the Arab region. *Earth's Futur.*, 8(5): doi:10.1029/2020EF001495

Breisinger, C., Ecker, O., Al-Riffai, P. & Yu., B. 2012. *Beyond the Arab awakening: Policies and investments for poverty reduction and food security*. Intl Food Policy Res Inst.

Brookings. 2019. *Youth employment in the Middle East and North Africa: Revisiting and reframing the challenge*. Nader Kabbani, February 26, 2019.

Bucchignani, E., Mercogliano, P., Panitz, H.-J. & Montesarchio, M. 2018. Climate change projections for the Middle East–North Africa domain with COSMO-CLM at different spatial resolutions. *Adv. Clim. Chang. Res.*, 9(1): 66–80.

Bucx, T., Marchand, M., Makaske, B., van de Guchte, C. 2010. Synthesis report: comparative assessment of the vulnerability and resilience of 10 deltas. Delft-Wageningen. The Netherlands.

Carpentier, I. 2017. Diversité des dynamiques locales dans les oasis du Sud de la Tunisie. *Cahiers Agricultures*, 26(3): 35001.

Cattaneo, A., Federighi, G. & Vaz., S. 2021. The environmental impact of reducing food loss and waste: A critical assessment. *Food Loss and Waste: Evidence for effective policies*, special issue of *Food Policy*, 28.

CFS & FAO. 2014. *Principles for responsible investments in agriculture and food systems*. Rome, FAO. www.fao.org/3/a-au866e.pdf.

Charara, R. 2008. *Nitrate accumulation in the soil/groundwater system as affected by land use and agricultural practices in an area of Central Bekaa in Lebanon*. Master thesis, CIHEAM Bari, Italy.

Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). 2021. [online]. [Cited 15 December 2021]. https://chc.ucsb.edu/data/chirps/

Closas, A. & Villholth, K. G. 2016. *Aquifer contracts: A means to solving groundwater over-exploitation in Morocco?* Colombo, Sri Lanka, International Water Management Institute (IWMI). 20p. (Groundwater Solutions Initiative for Policy and Practice (GRIPP) Case Profle Series 01). doi: 10.5337/2016.211

Cook, B. I., Mankin, J. S. & Anchukaitis, K. J. 2018. Climate change and drought: From past to future. *Curr. Clim. Chang. Reports*, 4(2): 164–179.

Crumpler, K., Gagliardi, G., Wong, T., Abdel Monem, M., Federici, S., Dasgupta, S., Meybeck, A., Buto, O., Toepper, J., Salvatore, M., Wolf, J. and Bernoux, M. 2022. *regional analysis of the nationally determined contributions in the Near East and North Africa – Opportunities and gaps in the agriculture,* water and land use sectors. Environment and natural resources management working paper, No. 93. Rome, FAO. https://doi.org/10.4060/cb8662en

Costantini, E.A.C., Branquinho, C., Nunes, A., Schwilch, G., Stavi, I., Valdecantos, A. & Zucca, C. 2016. Soil indicators to assess the effectiveness of restoration strategies in dryland ecosystems. *Solid Earth,* 7: 397-414. doi:10.5194/se-7-397-2016

Custodio, E. 2018. Consequences of seawater intrusion in Mediterranean Spain. Project SASMIE. In: M. Calvache, C. Duque & D. Pulido-Velazquez, eds. *Groundwater and global change in the Western Mediterranean area,* Environmental Earth Sciences, Springer.

Council of Arab Ministers Responsible for the Environment. 2007. *Arab Ministerial Declaration on Climate Change,* 19th session, Cairo, December 2007.

Darfoui, E. 2018. *First Unified Arab Report on Land Degradation Neutrality* (Arabic). Khartoum, Sudan, Arab Organization for Agricultural Development.

Daoudi, M. & Niang A.J. 2018. Flood risk and vulnerability of Jeddah City, Saudi Arabia. www.intechopen.com/chapters/64449

Darwish, T. & Fadel, A. 2017. Mapping of soil organic carbon stock in the Arab countries to mitigate land degradation. *Arab J Geosci*, 10:474. Springer. https://doi.org/10.1007/s12517-017-3267-7.

Dasgupta, S., Laplante, B., Meisner, C., Wheeler, D. & Yan, J. 2009. The impact of sea level rise on developing countries: A comparative analysis. *Climatic change*, 93(3): 379–388.

Demattê, J.A.M., Safanelli, J.L., Poppiel, R.R. *et al.* 2020. Bare Earth's surface spectra as a proxy for soil resource monitoring. *Sci Rep,* 10: 4461. https://doi.org/10.1038/s41598-020-61408-1

Derak, M., Cortina, J., Taiqui, L. & Aledo, A. 2018. A proposed framework for participatory forest restoration in semiarid areas of North Africa. *Restoration Ecology*, 26: S18–S25, https://doi.org/10.1111/rec.12486

Dhehibi, B., Zucca, C., Frija, A. & Kassam, S.N. 2018. Biophysical and econometric analysis of adoption of soil and water conservation techniques in the semiarid region of Sidi Bouzid (central Tunisia). *New Medit,* 2: 15–28. DOI: 10.30682/nm1802b

Diaco, M., Alami Merrouni, M. & Bougarrani, S. 2020. Circular economy in the Africa-EU cooperation – Country report for Morocco. Country report under EC Contract ENV.F.2./ETU/2018/004 Project: "Circular Economy in Africa-EU cooperation", Trinomics B.V., ACEN, Adelphi Consult GmbH and Cambridge Econometrics Ltd.

Dixon, J., Gulliver, A. & Gibbon, D. 2001. *Farming Systems and Poverty: Improving farmers' livelihoods in a changing world.* FAO and World Bank.

Dixon, J., Garrity, D.P., Boffa, J.-M., Williams, T.O., Amede, T., Auricht, C., Lott, R., & Mburathi, G. (Eds.). 2019. Farming Systems and Food Security in Africa: Priorities for Science and Policy under Global Change (1st ed.). Routledge. https://doi.org/10.4324/9781315658841

Djoundourian, S. S. 2021. Response of the Arab world to climate change challenges and the Paris Agreement. *Int. Environ. Agreements Polit. Law Econ.*, 1–23.

Dogar, M. M. & Sato, T. 2018. Analysis of climate trends and leading modes of climate variability for MENA region, *J. Geophys. Res. Atmos.*, 123(23): 13–74.

Desert Research Center. 2018. *Final Country Report of the Land Degradation Target Setting Programme*. Cairo, Ministry of Agriculture and Land Reclamation. https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-02/Egypt%20LDN%20TSP%20Country%20Report.pdf.

Driouech, F., ElRhaz, K., Moufouma-Okia, W., Arjdal, K. & Balhane, S. 2020. Assessing future changes of climate extreme events in the CORDEX-MENA region using regional climate model ALADIN-climate. *Earth Syst. Environ.*, 4(3): 477–492.

Droogers, P., Immerzeel, W. W., Terink, W., Hoogeveen, J., Bierkens, M. F. P., Van Beek, L. P. H. & Debele, B. 2012. Water resources trends in Middle East and North Africa towards 2050. *Hydrol. Earth Syst. Sci.*, 16(9): 3101–3114.

Dubbeling, M., De Zeeuw, H. & van Veenhuizen, R. 2010. *Cities, poverty and food multi-stakeholder policy and planning in urban agriculture*. RUAF Foundation.

Dutilly-Diane, C. 2006. Review of the literature on pastoral economics and marketing: North Africa. Report prepared for the World Initiative for Sustainable Pastoralism, IUCN EARO. www.iucn.org/sites/dev/files/import/downloads/north_africa_reports.pdf

El Sakka, H. 2009. *Investigating the risk of nitrate pollution in the soil/groundwater system resulting from intensive horticulture practices in the Bekaa Valley in Lebanon*. Master thesis CIHEAM-Bari, Italy.

El-Raey, M. 2009. "The Cost of Coastal Vulnerability to Climate Change", Conference on climate change and coastal cities, beaches and the Delta, Cairo.

El-Shinnawy, I. 2008*. Coastal vulnerability to climate changes and adaptation assessment for coastal zones of Egypt, Final report*. Ministry of Water Resources and Irrigation (MWRI), National Water Research Center (NWRC), Coastal Research Institute (CoRI).

Economics of Land Degradation (ELD) & United Nations Environment Programme (UNEP). 2018. *The economics of land degradation neutrality in Asia and Africa*. www.eld-initiative.org/fileadmin/pdf/Asia_Report_EN.pdf and www.eld-initiative.org/fileadmin/pdf/ELD-unep-report_07_spec_72dpi.pdf

European Commission. 2020. Proposed mission *Caring for soil is caring for life. Report of the Mission Board for Soil health and food*. Independent expert report. doi: 10.2777/821504

European Commission, Joint Research Centre & FAO. forthcoming. *Soil Atlas of Asia*.

FAO. 2002a. *Agricultural drainage water management in arid and semi-arid areas*. Rome. www.fao.org/3/y4263e/y4263e00.html.

FAO. 2002b. *Farming systems and poverty*. Rome.

FAO. 2010a. *Fighting sand encroachment – Lessons from Mauritania.* Rome. FAO Forestry Paper 158. ISBN 978-92-5-106531-0.

FAO. 2010b. *Water resources in the Near East: Facts and figures*. Cairo, Egypt.

FAO. 2010c. *Forests and climate change in the Near East region*. Forests and climate change working paper 9. Rome 2010. www.fao.org/3/k9769e/k9769e00.pdf.

FAO. 2011a. *Forests and rangelands in the Near East region*. Facts and figures. Cairo. www.fao.org/3/i12557e/i12557e.pdf.

FAO. 2011b. *The State of Food and Agriculture 2010–2011: Women in agriculture: closing the gender gap for development*. Rome.

FAO. 2011c. *Land degradation assessment in drylands (LADA).* www.fao.org/3/i3240e/i3240e.pdf.

FAO. 2011d. *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk.* Food and Agriculture Organization of the United Nations, Rome and Earthscan, London. https://www.fao.org/3/i1688e/i1688e.pdf

FAO. 2012a. *Growing greener cities in Africa*. First status report on urban and peri-urban horticulture in Africa. Rome.

FAO. 2012b. *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*. www.fao.org/3/i2801e/i2801e.pdf.

FAO. 2014. Coping with water scarcity in the Near East and North Africa. Factsheet. regional Conference for the Near East (NERC-32). www.fao.org/3/as215e/as215e.pdf.

FAO. 2015a. *regional Strategic Framework: Reducing food losses and waste in the Near East & North Africa region*. Cairo.

FAO. 2015b. *World Soil Charter*. Rome. ww.fao.org/3/a-i4965e.pdf.

FAO. 2015c. World Programme for the Census of Agriculture 2020: Volume 1-Programme, concepts and definitions. Rome. www.fao.org/3/i4913e/i4913e.pdf.

FAO. 2016. *Climate-smart agriculture: A sourcebook*. Rome.

FAO. 2017a. *Near East and North Africa regional overview of food insecurity 2016*. Cairo.www.fao.org/3/a-i6860e.pdf.

FAO. 2017b. *Arab Horizon 2030: Prospects for enhancing food security in the Arab region*. Technical summary.

FAO. 2017c. *Country fact sheet on food and agriculture policy trends*.

FAO. 2017d*. Intended National Contributions: Global analyses and key findings*. Rome. www.fao.org/3/a-i6573e.pdf.

FAO. 2017e. *FAO support provides water sustainability for farmers while empowering women* [online]. Rome. [Cited 15 December 2021]. www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1045903/

FAO. 2018a. *Drought characteristics and management in North Africa and the Near East*. FAO Water reports 45. Rome. www.fao.org/3/ca0034en/CA0034EN.pdf.

FAO. 2018b. *The future of food and agriculture – Alternative pathways to 2050*. Summary version. Rome. www.fao.org/3/CA1553EN/ca1553en.pdf.

FAO. 2018c. *Agricultural transformation in the Near East and North Africa region and the challenges of youth employment and migration*. Paper (NERC/18/5) presented at FAO regional Conference for the Near East. 7–11 May 2018. Rome. www.fao.org/3/mw318en/mw318en.pdf.

FAO. 2018d. *Supporting efficient irrigation systems in the West Bank.* [online]. Rome. [Cited 15 December 2021]. www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1148985/

FAO. 2018e. *regional analyses of the Nationally Determined Contributions of countries in Southern-Eastern Europe and Central Asia: Gaps and opportunities in the agriculture sectors.* Rome. www.fao.org/3/CA2518EN/ca2518en.pdf.

FAO. 2018f. *Iraq: Restoration of agriculture and water systems sub-programme 2018–2020.* Rome.

FAO. 2018g. *Impacts of climate change on farming systems and livelihoods in the Near East and North Africa*. Rome. www.fao.org/3/ca1439en/CA1439EN.pdf.

FAO. 2019a. *Combating land degradation to promote sustainability, resilience and food security*. Thematic background paper on land degradation and restoration prepared for the 2nd NENA Land and Water Days, Cairo, 31 March–4 April 2019. www.fao.org/3/ca3990en/ca3990en.pdf. Also *Desalinated water – a water shortage solution for agriculture*, FAO Land and Water Case Study Series. Rome.

FAO. 2019b. *Land and water governance to achieve the SDGs in fragile systems*. Background paper prepared for the plenary session on land and water governance. Cairo, 3 April 2019. www.fao.org/3/ca5172en/CA5172EN.pdf.

FAO. 2019c. *Ensuring environmental sustainability in the context of water scarcity and climate change.* Paper prepared for the 35th FAO regional Conference for the Near East. Muscat, Oman, 3–5 March 2020. www.fao.org/3/nc215e/nc215e.pdf.

FAO. 2019d. *Rural transformation – Key for sustainable development in the Near East and North Africa*. Overview of Food Security and Nutrition 2018. Cairo.

FAO. 2019e. *Desalinated water – A water shortage solution for agriculture*, FAO Land and Water Case Study Series. Rome.

FAO. 2019f. *Proceedings from the regional Workshop on Climate-Smart Agriculture in the Near East and North Africa.* Cairo.

FAO. 2019g. *The international Code of Conduct for the sustainable use and management of fertilizers*. Rome. www.fao.org/documents/card/en/c/ca5253en).

FAO. 2019h. *Sudanese soil information system and digital soil mapping*. Rome. www.fao.org/3/ca8828en/CA8828EN.pdf.

FAO. 2019i. *The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction.* Rome.

FAO. 2019j. *FAO Framework for the Urban Food Agenda.* Rome. www.fao.org/documents/card/en/c/ca3151en.

FAO. 2019k. *Guidelines for the national assessment and mapping of land degradation and conservation*. Rome. www.fao.org/3/ca3999en/ca3999en.pdf.

FAO. 2020a. *Global Forest Resources Assessment 2020: Main report*. Rome.

FAO. 2020b. Final evaluation of the project "Adaptive management and monitoring of the Maghreb's oases systems". Rome.

FAO. 2020c. *The State of Food and Agriculture 2020: Overcoming water challenges in agriculture*.

FAO. 2020d. *The Near East and North Africa regional Forest Resources Assessment*. www.fao.org/documents/card/en/c/cb7174en.

FAO. 2020e. *From bustling Omani fish markets to online auctions* [online]. Rome. [Cited 15 December 2021]. www.fao.org/fao-stories/article/en/c/1278611/

FAO. 2020f. *The Impact of COVID-19 in the Near East and North Africa region and FAO's Response Plan*. : http://www.fao.org/3/nd678en/nd678en.pdf.

FAO. 2020g. *NERC 35 Paper on Adapting food systems to respond to an increasingly urban population.* www.fao.org/3/nc213en/nc213en.pdf

FAO. 2021a. *Forest Resources Assessment for Near East and North Africa 2020 in the global context*. www.fao.org/3/cb6781en/cb6781en.pdf.

FAO. 2021b. *Global Forest Resources Assessment*. Rome. https://fra-data.fao.org/WO/fra2020/extentOfForest/.

FAO. 2021c. AQUASTAT [online]. Rome. [Cited 15 December 2021]. www.fao.org/aquastat/en/

FAO. forthcoming. *Effect of conflicts on forests and rangelands.* Assessment report prepared for FAO regional Office for the Near East and North Africa. Cairo.

FAO. *Sustainable Development Goals* [online]. Rome. [Cited 15 December 2021]. www.fao.org/sustainable-development-goals/overview/en/

FAO. *Koronivia Joint Work on Agriculture* [online]. Rome. [Cited 15 December 2021] www.fao.org/koronivia/en/

FAOSTAT. FAO's global statistical database on food and agriculture [online]. Rome. [Cited 15 December 2021]. www.fao.org/faostat/en/#data/QC

FAO WaPOR. FAO's portal to monitor Water Productivity through Open access of Remotely sensed derived data [online]. Rome. [Cited 15 December 2021] https://wapor.apps.fao.org/catalog/WAPOR_2/1/L1_LCC_A

FAO. *Participatory land resources planning to promote the scaling out and mainstreaming of sustainable land management in Morocco* (unpublished).

FAO/Near East Forestry Commission. 2002. *The use of treated wastewater (TWW) in forest plantation in the Near East*. www.fao.org/3/AB400e/AB400e.htm.

FAO & CMCC. 2020. *Economic impacts of climate change on agricultural income and labour, and costs of adaptation in the NENA region* (unpublished).

FAO & ITPS. 2015. *Status of the World's Soil Resources (SWSR) – Main Report.* Rome. www.fao.org/3/a-bc602e.pdf.

FAO & ITPS. 2017. *Voluntary Guidelines for Sustainable Soil Management*. Rome. www.fao.org/3/a-bl813e.pdf.

FAO–RNE. 2015. *Towards a regional collaborative strategy on sustainable agricultural water management and food security in the Near East and North Africa region.* Rome.

FAO– NERC. 2020. *Digital innovation for promoting agriculture 4.0 in the Near East and North Africa*. regional Conference for the Near East – Thirty fifth session. Muscat, Sultanate of Oman, 2–4 March 2020. www.fao.org/3/nd262en/nd262en.pdf.

FAO, IFAD, UNICEF, WFP and WHO. 2020. *regional Overview of Food Security and Nutrition in the Near East and North Africa 2019 – Rethinking food systems for healthy diets and improved nutrition*. https://doi.org/10.4060/ca8684en

FAO & UNEP. 2021. *Global assessment of soil pollution: Report*. Rome. https://doi.org/10.4060/cb4894en.

FAO & UN-Habitat. 2021. Background paper on urban rural linkages for sustainable territorial development: Addressing urban transition in the NENA region (unpublished).

Farage, P.K., Ardo, J., Olsson, L., Rienzi, E.A., Ball, A.S. & and Pretty, J.N. 2007. The potential for soil carbon sequestration in three tropical dryland farming systems of Africa and Latin America: A modelling approach. *Soil & Tillage Research*, 94: 457–472.

Figueroa, J. L., Mahmoud, M. & Breisinger, C. 2018. *The role of agriculture and agro-processing for development in Jordan*, Intl Food Policy Res Inst.

Fischer G., Shah M., van Velthuizen H. & Nachtergaele F. 2006. *Agro-ecological zones assessments* - Reprinted from Encyclopaedia of Life Support Systems (EOLSS), Oxford, UK, EOLSS Publishers.

Fisher, J. & Reed, B. 2018. *Gender equality in the 2030 agenda: Gender-responsive water and sanitation systems.*

Fortmann, L. 2009. *Gender in agriculture sourcebook*. World Bank, Food and Agricultural Organization, and International Fund for Agricultural Development. Washington, DC, World Bank, *Exp. Agric.*, 45(4): 515.

Fragaszy, S. R., Jedd, T., Wall, N., Knutson, C., Fraj, M. B., Bergaoui, K., Svoboda, M. Hayes, M. & McDonnell, R. 2020. Drought monitoring in the Middle East and North Africa (MENA) region: Participatory Engagement to Inform Early Warning Systems. *Bull. Am. Meteorol. Soc.*, 101(7): E1148–E1173.

French Agricultural Research Centre for International Development (CIRAD). 2017. Living territories – Elodie Valette UMR ART-DEV, CIRAD Jean-Michel Sourisseau UMR ART-DEV, CIRAD.

GAEZ V4, Global Agro-Ecological Zoning Version 4 Data Portal [online]. [Cited 15 December 2021]. https://gaez.fao.org/pages/data-viewer

Garnier, J., Beusen, A., Thieu, V., Billen, G. & Bouwman, L. 2010. *N: P: Si nutrient export ratios and ecological consequences in coastal seas evaluated by the ICEP approach. Global Biogeochem. Cycles*, 24(4).

GEF. 2018. *GEF-7 Replenishment Programming Directions*. Global Environment Facility. Fourth Meeting for the Seventh Replenishment of the GEF Trust Fund. April 25, 2018. Stockholm. www.thegef.org/sites/default/files/council-meeting-documents/GEF-7%20Programming%20Directions%20-%20GEF_R.7_19.pdf

Ghazouani, W., Molle, F. & Rap, E. 2012. Water users associations in the NENA region: IFAD interventions and overall dynamics, *Draft. Submitt. to IFAD*.

Gholizadeh, A., Žižala, D., Saberioon, M. & Borůvka, L. 2018. *Soil organic carbon and texture retrieving and mapping using proximal, airborne and Sentinel-2 spectral imaging*.

Givati, A., Thirel, G., Rosenfeld, D. & Paz, D. 2019. Climate change impacts on streamflow at the upper Jordan River based on an ensemble of regional climate models. *J. Hydrol. Reg. Stud.*, 21: 92–109, doi:https://doi.org/10.1016/j.ejrh.2018.12.004.

GIZ. 2018. *Improving living conditions in poverty-stricken areas in Amman via the implementation of green infrastructure (ILCA).* https://c40-production-images.s3.amazonaws.com/other_uploads/images/2243_Brochure_Green_Infrastructure.original.pdf?1560444744

Gleeson, T., Wada, Y., Bierkens, M. F. P. & Van Beek, L. P. H. 2012. Water balance of global aquifers revealed by groundwater footprint. *Nature,* 488(7410): 197–200.

Global Soil Partnership. 2014. The Near East and North Africa (NENA) Soil Partnership Conference*.* 17–19 June 2014. Amman.

Goma M. 2005. *Participatory management of salt-affected soils in Egypt: Role of Executive Authority for Land Improvement Projects—EALIP.* In Promoting participatory management of the land system to enhance soil conservation*,* P. Zdruli and G Trisorio Liuzzi, eds. Workshop proceedings, Alexandria, Egypt. MEDCOASTLAND publication 3: 101–118, IAM: Bari.

Goode, D. J., Senior, L. A., Subah, A. & Jaber, A. 2013. *Groundwater-level trends and forecasts, and salinity trends, in the Azraq, Dead Sea, Hammad, Jordan Side Valleys, Yarmouk, and Zarqa groundwater basins, Jordan.* US Department of the Interior, US Geological Survey.

Gubert, F. & Nordman, C. J. 2010. Migration trends in North Africa: Focus on Morocco, Tunisia and Algeria. *OECD J. Gen. Pap.*, 2009(4): 75–108.

Hamadeh, Shadi, Salwa Tohmé Tawk & Mounir Abi Said. 2014. *Urban agriculture and food security in the Middle Eastern Context: A case study from Lebanon and Jordan.* In Food Security in the Middle East, edited by Zahra Babar and Suzi Mirgani. London, Hurst.

Hashimoto, T., Loucks, D. P. & Stedinger, J. 1982. Reliability, resilience and vulnerability for water resources system performance evaluation. *Water Resour. Res*. 18(1): 14–20.

Herman, J. D., Reed, P. M., Zeff, H. B. & Characklis, G. W. 2015. How should robustness be defined for water systems planning under change? *Journal of Water Resources Planning and Management*, 141(10): 04015012. https://doi.org/10.1061/(asce)wr.1943-5452.0000509

Hofste, R. *et al.* 2019. Aqueduct 3.0: Updated Decision-Relevant Global Water Risk Indicators, *WRI Publ.*, doi:10.46830/writn.18.00146

Hou, D. 2020. Knowledge sharing and adoption behaviour: An imperative to promote sustainable soil use and management. *Soil Use and Management*, 36(4): 557-560. https://doi.org/10.1111/sum.12648

Hussmann, S. 2018. *Automation in agriculture - Securing food supplies for future generations*. IntechOpen.

ICARDA. 2017. *ICARDA Strategic Plan 2017–2026. Science for resilient livelihoods in dry areas*. CGIAR. https://repo.mel.cgiar.org/handle/20.500.11766/8237

IDRC. 2011. *Climate change adaptation in Africa program.* Annual report 2010–2011.

Internal Displacement Monitoring Centre (IDMC). 2007. Sudan: Population Figures and Profile, Internal Displacement Monitoring Centre, November 2007

Internal Displacement Monitoring Centre (IDMC). 2020. Global Internal Displacement Database [online]. [Cited 15 December 2021]. www.internal-displacement.org/database/displacement-data

International Groundwater Resources Assessment Center. Transboundary Aquifers of the World GIS data layer [online]. [Cited 15 December 2021] www.un-igrac.org/ggis/transboundary-aquifers-world-map

International Organization for Migration (IOM). 2019. *Decades-old conflict over water in Yemeni village comes to an end*. [online]. [Cited 15 December 2021]. www.iom.int/news/decades-old-conflict-over-water-yemeni-village-comes-end

IPBES. 2018a. *The IPBES assessment report on land degradation and restoration*. Montanarella, L., Scholes, R. and Brainich, A., eds. Bonn, Germany, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPBES. 2018b. Summary for policymakers of the thematic assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Scholes, R. *et al.*, eds. Bonn, Germany, IPBES Secretariat.

IPCC. 2014. *Summary for policymakers.* In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler et al, eds. Cambridge, United Kingdom and New York, USA, Cambridge University Press. www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf

IPCC. 2019. Climate change and land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. www.ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf

Jasechko, S., Perrone, D., Befus, K. M., Cardenas, M. B., Ferguson, G., Gleeson, T., Luijendijk, E., McDonnell, J. J., Taylor, R. G. & Wada, Y. 2017. Global aquifers dominated by fossil groundwaters but wells vulnerable to modern contamination. *Nat. Geosci*., 10(6): 425–429.

Jeuland, M. 2015. Challenges to wastewater reuse in the Middle East and North Africa. *Middle East Dev. J.*, 7(1): 1–25, doi:10.1080/17938120.2015.1019293

Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T. *et al.*, **eds.** 2013. *Soil Atlas of Africa.* Publications Office of the European Union, Luxembourg, doi 10.2788/52319

Joodaki, G., Wahr, J. & Swenson, S. 2014. Estimating the human contribution to groundwater depletion in the Middle East, from GRACE data, land surface models, and well observations. *Water Resour. Res*., 50(3): 2679–2692.

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L. & Schösler, H. 2016. Transition towards circular economy in the food system, *Sustainability*, 8(1): 69.

Kassim, Y., Mahmoud, M., Kurdi, S. & Breisinger, C. 2018. *An agricultural policy review of Egypt. First steps towards a new strategy.* IFPRI. Working paper 11.

Khalil A.A., Essa, Y.H. & Hassanein, M. K. 2014. Monitoring agricultural land degradation in Egypt Using MODIS NDVI satellite images. *Nat Sci 2014,* 12(8):15-21, available at www.sciencepub.net/nature

Khudhaire, H. Y. & Naji, H. I. 2021. Adoption PPP model as an alternative method of government for funding abandoned construction projects in Iraq, in *IOP Conference Series: Materials Science and Engineering*, vol. 1076, p. 12115, IOP Publishing.

Knoema. 2017. *Fertilizer consumption per unit of arable land*. World Data Atlas, available at https://knoema.com/atlas/ranks/Fertilizer-consumption#

Kochhar, R. 2015. *A global middle class is more promise than reality*.

Korhonen, J., Honkasalo, A. & Seppälä, J. 2018. Circular economy: The concept and its limitations. *Ecol. Econ.*, 143: 37–46.

Kulp, S.A. & Strauss, B.H. 2019. New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nature communications*, 10(1): 1–12.

Kummu, M., De Moel, H., Porkka, M., Siebert, S., Varis, O. & Ward, P. J. 2012. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Sci. Total Environ.*, 438: 477–489.

Land Matrix Initiative. Land Matrix Public Database on Land Deals [online]. [Cited 15 December 2021]. https://landmatrix.org/list/deals

Lewis, P., Monem, M.A. & Impiglia, A. 2018. Impacts of climate change on farming systems and livelihoods in the Near East and North Africa – With a special focus on small-scale family farming. Cairo, FAO. 92 pp. www.fao.org/3/ca1439en/CA1439EN.pdf.

Lincoln Institute of Land Policy, UN-Habitat & New York University. 2014. Atlas of Urban Expansion [online]. [Cited 15 December 2021]. www.atlasofurbanexpansion.org/

Liniger, H., Harari, N., Fleiner, R. & van Lynden, G. 2018. *Achieving land degradation neutrality: The role of knowledge sharing and evidence-based decision-making*. Questionnaires on Sustainable Land Management (SLM) Technologies and Approaches: A tool to help document, assess, and disseminate SLM practices. World Overview of Conservation Approaches and Technologies (WOCAT).

Liniger, H.P. & Critchley W., eds. 2007. *Where the land is greener – Case studies and analysis of soil and water conservation initiatives worldwide.* World Overview of Conservation Approaches and Technologies (WOCAT).

Liu G. 2018. Soil salinity prediction and mapping by machine learning regression in Central Mesopotamia, Iraq. *Land Degradation and Development*, 29: 4005–4014. DOI:10.1002/ldr.3148

Loudyi, D. & Sameh, A. K. 2020. Flood risk management in the Middle East and North Africa (MENA) region, Urban Water Journal, 17:5, 379-380

Lovatelli, A. 2021. A glance on the status of aquaculture development in the Near East and North Africa. FAO Aquaculture News Magazine, 63, Rome.

MacArthur Foundation, Ellen. 2019. Cities and circular economy for food.

Mahdi, M. 2014. *The future of land tenure in Morocco. A land grabbing case.* https://www.researchgate.net/publication/279330975_The_future_of_land_tenure_in_Morocco_A_land_grabbing_case

Mahmoud, M., Al Shaibani, R. A., Almohamadi, A., Hashim, K., Cabanero, A. & Saeed, K. 2017. *Assessment of the status of solar PV in Yemen.* World Bank.

Marshall, N. 2010. Understanding social resilience to climate variability in primary enterprises and industries. *Global Environmental Change*, 20(1): 36–43. https://doi.org/10.1016/j.gloenvcha.2009.10.003

Massadeh, S. A. 2014. An intelligent automated irrigation system for the Jordan Valley area, *World Comput. Sci. Inf. Technol. J.*, 4(11).

Maystadt, J.-F. & Ecker, O. 2014. Extreme weather and civil war: Does drought fuel conflict in Somalia through livestock price shocks? *Am. J. Agric. Econ.*, 96(4): 1157–1182.

McGill, J., Prikhodko, D. , Sterk, B. & Talks, P. 2015. Egypt: Wheat sector review, FAO Invest. Centre. Ctry. Highlights eng no. 21.

Miller, N.F. & Wetterstrom, W. 2000. *The beginnings of agriculture: The ancient Near East and North Africa*.

Ministry of the Environment, Jordan. 2020. MoEnv. Agriculture Sector Green Growth National Action Plan 2021–2025. Amman.

Ministry of Water and Irrigation, Jordan. 2016. National Water Strategy of Jordan, 2016–2025, Water Reallocation Policy, Jordan.

Miri, A., Hasan, A., Ekhtesasi, M. R., Panjehkeh, N. & Ghanbari, A. 2009. Environmental and socioeconomic impacts of dust storms in Sistan region, Iran. *International Journal of Environmental Studies*, 66(3):343–355.

Mirkin, B. 2013. *Arab Spring: Demographics in a region in transition.* United Nations Development Programme, regional Bureau for Arab States. https://arab-hdr.org/wp-content/uploads/2020/12/AHDR-ENG-Arab-Spring-Mirkinv3.pdf

Montgomery, D.R. 2007. Soil erosion and agricultural sustainability. *Proc Natl Acad Sci USA,*104(33):13268–72.

Naouri, M., Hartani, T. & Kuper, M. 2017. *The "innovation factory": User-led incremental innovation of drip irrigation systems in the Algerian Sahara.*

Near East Forestry and Range Commission (NEFRC). 2017. *Rangelands management in the Near East and North Africa region: Bridging the gap between growing needs and shrinking resources.* Twenty-third session. Beirut, 11–14 December 2017.

Near East Forestry and Range Commission (NEFRC). 2019. *Forest and rangelands in land degradation neutrality targets and the Nationally Determined Contributions to mitigate/adapt to climate change in the Near East and North Africa region.* Twenty-Fourth Session. http://foris.fao.org/static/NEFRC24/FO_NEFRC_2019_6.pdf

Negm, A., Saavedra, O., El-Adawy, A. 2017. *Nile Delta biography: challenges and opportunities. In: Negm AM (ed) The Nile Delta, The handbook of environmental chemistry, vol 55*. Springer International Publishing, Switzerland, pp 3–18. https://doi.org/10. 1007/698_2016_62

NERC. 2020. *The impact of COVID-19 in the Near East and North Africa region and FAO's response plan*. NERC/20/8. 35 Session. https://www.fao.org/3/nd678en/nd678en.pdf

Nin-Pratt, A., El-Enbaby, H., Figueroa, J. L., ElDidi, H. & Breisinger, C. 2017. *Agriculture and economic transformation in the Middle East and North Africa: A review of the past with lessons for the future.*

Nunes A., Oliveira G., Mexia T., Valdecantos A., Zucca C., Costantini E., Abraham E. *et al.* 2016. Ecological restoration across the Mediterranean Basin as viewed by practitioners. *Science of the Total Environment* 566–567, 722–732. http://dx.doi.org/10.1016/j.scitotenv.2016.05.136

OECD & FAO. 2018. *OECD-FAO Agricultural Outlook 2018–2027*. Special focus: Middle East and North Africa. Paris, OECD Publishing; Rome, FAO. 112 pp. https://doi.org/10.1787/agr_outlook-2018-en

OECD. Climate-related development finance data, database [online]. [Cited 15 December 2021]. www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf

Oxford Poverty and Human Development Initiative (OPHI). 2018. *Global Multidimensional Poverty Index 2018: The most detailed picture to date of the world's poorest people*. University of Oxford, UK. https://ophi.org.uk/wp-content/uploads/G-MPI_2018_2ed_web.pdf

Orr, B.J., Cowie, A.L., Castillo Sanchez, V.M., Chasek, P., Crossman, N.D., Erlewein, A., Louwagie G. *et al.* 2017. *Scientific conceptual framework for land degradation neutrality*. A Report of the Science-Policy Interface. Bonn, Germany, United Nations Convention to Combat Desertification (UNCCD). www.unccd.int/sites/default/files/documents/2017-08/LDN_CF_report_web-english.pdf

Ouda, S., Ewise, M. & Noreldin, T. 2016. Projection of productivity of cultivated crops in rain-fed areas in Egypt under climate change. *Cogent Food & Agriculture*, 2:1, DOI: 10.1080/23311932.2015.1136256

Oudra, I. & Talks, P. 2017. *Nationally Determined Contribution support on the groundwater, energy and food security nexus in Morocco.*

Paltan, H., Allen, M., Haustein, K., Fuldauer, L. & Dadson, S. 2018. Global implications of 1.5 °C and 2 °C warmer worlds on extreme river flows. *Environ. Res. Lett.*

Prăvălie, R., Patriche, C., Borrelli, P., Panagos, P., Roșca, B., Dumitraşcu, M., Nita, I.A., Săvulescu, I., Birsan, M.V. & Bandoc, G. 2021. Arable lands under the pressure of multiple land degradation processes. A global perspective. *Environmental Research*, 194, art no.110697

Prudhomme, C., Giuntoli, I., Robinson, E. L., Clark, D. B., Arnell, N. W., Dankers, R., Fekete, B. M., Franssen, W., Gerten, D. & Gosling, S. N. 2014. Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment. *Proc. Natl. Acad. Sci.*, 111(9): 3262–3267.

Qadir, M, Quillérou, E., Nangia, V., Singh, M., Thomas, R.J., Drechsel, P. & Noble, A.D. 2014. Economics of salt-induced land degradation and restoration. *Natural Resources Forum* 38(2014): 282–295.

Qdais H.A., Abdulla F. & Kurbatova A. 2019. Wastewater reuse in Jordan and its potential as an adaptation measure to climate change. *Journal of Environmental Engineering and Science*, 14(4): 203–211 https://doi.org/10.1680/jenes.19.00029

Radwan, T. M., Blackburn, G. A., Whyatt, J. D. & Atkinson, P. M. 2019. Dramatic loss of agricultural land due to urban expansion threatens food security in the Nile Delta, Egypt. *Remote sensing*, 11(3): 332. https://doi.org/10.3390/rs11030332

Raleigh, C., **Linke, A., Hegre, H. & Karlsen, J.** 2010. Introducing ACLED-Armed Conflict Location and Event Data.- *Journal of Peace Research*, 47(5): 651–660.

Republique Algerienne Démocratique et Populaire. 2021. Ministere des ressources en eau, *Comptabilité rapide de l'eau - Cas du Périmètre d'Irrigation El Hemiz (Mitidja Est*) (unpublished).

RICCAR regional Knowledge Hub [online]. [Cited 15 December 2021]. www.riccar.org

Rodin, J. 2014. *The resilience dividend: Being strong in a world where things go wrong*. New York, USA, Public Affairs.

Rodriguez, D. J., Serrano, H. A., Delgado, A., Nolasco, D. & Saltiel, G. 2020. *From waste to resource: Shifting paradigms for smarter wastewater interventions in Latin America and the Caribbean*.

Romeo, R., Grita, F., Parisi, F. & Russo, L. 2020. *Vulnerability of mountain peoples to food insecurity: Updated data and analysis of drivers.* Rome, FAO and UNCCD. https://doi.org/10.4060/cb2409en

Rose L. 2019. *The global land tenure situation of Indigenous Peoples and trends of land grabbing.* International Work Group for Indigenous Affairs Briefing paper. www.iwgia.org/en/documents-and-publications/documents/publications-pdfs/english-publications/18-iwgia-brief-the-global-land-tenure-situation-of-indigenous-peoples-and-trends-of-land-grabbing-2019-eng/file.html

Royaume du Maroc. 2015. *3ème rapport sur l'État de l'Environnement du Maroc, 2015.* www.environnement.gov.ma/fr/etat-de-l-environnement/119-etatenv/3438-rapport-sur-l-etat-de-l-environnement-au-maroc-reem

Sadoff, C. W., Borgomeo, E. & De Waal, D. 2017. *Turbulent waters: Pursuing water security in fragile contexts.* World Bank.

Sadoff, C. W., Hall, J. W., Grey, D., Aerts, J., Ait-Kadi, M., Brown, C., Cox, A., Dadson, S., Garrick, D. & Kelman, J. 2015. *Securing water, sustaining growth*. Report of the GWP/OECD Task Force on Water Security and Sustainable Growth.

Sadok, W., Schoppach, R., Ghanem, M.E., Zucca, C. & Sinclair, T.R. 2019. Wheat drought-tolerance to enhance food security in Tunisia, birthplace of the Arab Spring. *European Journal of Agronomy,* 107: 1–9. https://doi.org/10.1016/j.eja.2019.03.009

Sahin, A. Z. & Rehman, S. 2012. Economical feasibility of utilizing photovoltaics for water pumping in Saudi Arabia, *Int. J. Photoenergy*.

Sarraf, M., Larsen, B. & Owaygen, M. 2004. *Cost of environmental degradation – The case of Lebanon and Tunisia*. Environmental economics series, paper no. 97. The World Bank Environment Department.

Scheierling, S. M., Young, R. A. & Cardon, G. E. 2006. Public subsidies for water-conserving irrigation investments: Hydrologic, agronomic, and economic assessment. *Water Resour. Res.*, 42(3).

Schwilch G. 2010. *Coping with degradation through SLWM*. Centre for Development and Environment. SOLAW Background thematic report - TR12. 4. FAO.

Sebnie, W., Mengesha, M., Girmay, G., Feyisa T., Asgedom B., Beza G. & Dejene D. 2020. Evaluation of micro-dosing fertilizer application on sorghum (Sorghum bicholor L) production at Wag-Lasta Areas of Amhara region, Ethiopia. *Scientific Reports*, 10: 6889. https://doi.org/10.1038/s41598-020-63851-6

Seitzinger, S. P., Bouwman, A. F. & Kroeze., C. 2010. Preface to special section on past and future trends in nutrient export from global watersheds and impacts on water quality and eutrophication. *Global Biogeochem. Cycles*, 24(4).

Shaddad, S.M., Buttafuoco, G., Elrys, A. & Castrignanò, A. 2019. Site-specific management of salt affected soils: A case study from Egypt. *Science of the Total Environment*, 688. https://doi.org/10.1016/j.scitotenv.2019.06.214

Shah, T., Rajan, A., Rai, G. P., Verma, S. & Durga, N. 2018. Solar pumps and South Asia's energy-groundwater nexus: Exploring implications and reimagining its future. *Environ. Res. Lett.*, 13(11): 115003.

Shamout, N. 2015. *Syrian perspective on transboundary water management in the Orontes Basin.* Sci. Dipl. Transbound. water Manag. Orontes River case.

Shamrukh, M. Yavuz Corapcioglu, M. & Hassona, F. 2005. Modeling the effect of chemical fertilizers on ground water quality in the Nile Valley aquifer. *Egypt. Ground Water*, 39(1): 59–67.

Siebert, S., Henrich, V., Frenken, K. & Burke, J. 2013. *Update of the digital global map of irrigation areas to version 5.* Bonn, Germany, Rheinische Friedrich-Wilhelms-Universität and Rome, FAO. www.fao.org/3/I9261EN/i9261en.pdf

Soffiantini, G. 2020. Food insecurity and political instability during the Arab Spring. *Glob. Food Sec.*, 26: 100400, doi:https://doi.org/10.1016/j.gfs.2020.100400

Solyman, A. & Abdel Monem, T. 2020. Mapping Egypt vulnerability to sea level rise scenarios, in E.-S. E. Omran and A.M. Negm, eds., Climate Change Impacts on Agriculture and Food Security in Egypt, Springer Water. https://doi.org/10.1007/978-3-030-41629-4_9

Steenbergen, F. Lawrence, van, P., Haile, A. M., Salman, M., Faurès, J.-M., Anderson, I. M. , Nawaz, K. & Ratsey, J. 2010. Guidelines on spate irrigation. *FAO Irrig. Drain. Pap.*, (65).

Stockman, U., Minasny, B. & McBratney, A.B. 2014. How fast does soil grow? *Geoderma*, 216: 48–61. https://doi.org/10.1016/j.geoderma.2013.10.007

Suárez-Varela, M., Blanco Gutierrez, I., Varela-Ortega, C., Esteve, P., Jaouani, A., Gafrej, R., Souissi, Y., Abdel-Motaleb, A., Chenini, F. & Choukr-Alla, R. 2018. *Review of the use of economic instruments in water management in Egypt, Morocco and Tunisia.*

Sun, Q., Miao, C., Duan, Q., Ashouri, H., Sorooshian, S. & Hsu, K.-L. 2018. A Review of global precipitation data sets: Data sources, estimation, and intercomparisons. *Rev. Geophys.*, 56(1): 79–107, doi:https://doi.org/10.1002/2017RG000574

Thomas R.J., Reed, M., Clifton, K., Appadurai, A.N., Mills, A.J., Zucca, C., Kodsi, E. *et al.* 2018. A framework for scaling sustainable land management options. *Land Degradation and Development,* 29(10): 3272–3284. DOI: 10.1002/ldr.3080

Taher, T.M. 2016. Groundwater abstraction management in Sana'a Basin, Yemen: A local community approach*. Hydrogeology Journal*, 6/2016.

Toan, T. D. 2016. Water pricing policy and subsidies to irrigation: A review. *Environ. Process.*, 3(4): 1081–1098.

Toop, T. A., Ward, S., Oldfield, T., Hull, M., Kirby, M. E. & Theodorou, M. K. 2017. AgroCycle – Developing a circular economy in agriculture. *Energy Procedia*, 123: 76–80.

UN Water. 2021. *Summary progress update 2021: SDG 6 — water and sanitation for all*. Geneva, Switzerland.

UN-Habitat. 2019. Urban-rural linkages: Guiding principles. https://urbanrurallinkages.files.wordpress.com/2019/04/url-gp.pdf

UN-Habitat. 2020a. *Global Database of Metropolises 2020* [online]. [Cited 15 December 2021]. https://drive.google.com/file/d/1oWF7SMJW7rrXhb8-SUO3d35blxZaKacN/view

UN-Habitat. 2020b. Mainstreaming urban-rural linkages in national urban policies: National urban policy guide. https://unhabitat.org/sites/default/files/2020/06/mainstreaming-url-in-nup-guide-_web.pdf

UN-Habitat Palestine. 2021. Final Technical progress report, alleviating quarantine effects among the elderly. Home garden interventions, 2020–21 (unpublished).

United Nations Convention to Combat Desertification (UNCCD). 2016. *Achieving land degradation neutrality at the country level - Building blocks for LDN target setting*. Bonn, Germany, Global Mechanism of the UNCCD. www.unccd.int/publications/achieving-land-degradation-neutrality-country-level-building-blocks-ldn-target-setting

United Nations Convention to Combat Desertification (UNCCD). 2017. *The Global Land Outlook*. First edition. Bonn, Germany.

United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2018. *World Urbanization Prospects: The 2018 revision, online edition*. https://population.un.org/wup/Download/

United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2019. *World Population Prospects 2019, online edition. Rev. 1*. https://population.un.org/wpp/Download/Standard/Population/

United Nations, Department of Economic and Social Affairs (UNDESA) Population Division. 2020. *International Migrant Stock 2020*.

UN Department of Economic and Social Affairs (UNDESA). 2021. *Global SDG Indicators Database.* [online]. [Cited 15 December 2021]. https://unstats.un.org/sdgs/indicators/database/

UNDP & GEF. 2018. *Climate change adaptation in the Arab States*, Bangkok.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2017. *Arab Horizon 2030: Prospects for enhancing food security in the Arab region.* 162 pp. www.unescwa.org/publications/arab-horizon-2030-prospects-enhancing-food-security-arab-region

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019a. Assessing the impact of changes in available water on productivity of agricultural crops, Morocco case study report, Beirut, 19-00115. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-morocco-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019b. Assessing the impact of changes in available water on productivity of agricultural crops, Sudan case study report, Beirut, 19-00116. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-sudan-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019c. Assessing the impact of changes in available water on productivity of agricultural crops, Tunisia case study report, Beirut, 19-00222. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-tunisia-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019d. Assessing the impact of changes in available water on productivity of agricultural crops, Jordan case study report, Beirut, 19-00082. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-jordan-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019e. Assessing the impact of changes in available water on productivity of agricultural crops, Yemen case study report, Beirut, 19-00082. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-yemen-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019f. Assessing the impact of changes in available water on productivity of agricultural crops, Palestine case study report, Beirut, 19-00082. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-palestine-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019g. Assessing the impact of changes in available water on productivity of agricultural crops, Egypt case study report, Beirut, 19-00096. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-egypt-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019h. Assessing the impact of changes in available water on productivity of agricultural crops, Iraq case study report, Beirut, 19-00127. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-iraq-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2019i. Assessing the impact of changes in available water on productivity of agricultural crops, Lebanon case study report, Beirut, 19-00097. www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-lebanon-arabic.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2020a. *Climate resilient agriculture: Translating data to policy actions – Case study of AquaCrop simulation in Morocco*. Beirut. https://www.unescwa.org/sites/default/files/inline-files/national-assessment-report-morocco-summary-english.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2020b. *Climate resilient agriculture: Translating data to policy actions – Case study of AquaCrop simulation in Tunisia*. Beirut. https://www.unescwa.org/sites/default/files/inline-files/national-assessment-report-tunisia-summary-english.pdf.

United Nations Economic and Social Commission for Western Asia (ESCWA). 2020c. *Impacts of Climate Change on Water Resources, Agriculture and Food Security in the Arab region.* Beirut. www.unescwa.org/sites/default/files/event/materials/cc_impact_on_water_resources_and_agriculture_in_the_arab_region_27_july_-_rn.pdf

United Nations Economic and Social Commission for Western Asia (ESCWA). 2021. *ESCWA background paper on* climate change: Implications for the region's agriculture policies. Rome, FAO.

United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017a*. Arab Climate Change Assessment Report – Main Report*. Beirut. www.unescwa.org/sites/www.unescwa.org/files/publications/files/riccar-main-report-2017-english_0.pdf

United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2017b. The regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socioeconomic Vulnerability in the Arab region (RICCAR), regional knowledge hub data portal. [online]. [Cited 15 December 2021]. https://rkh.apps.fao.org/home/1

United Nations Economic and Social Commission for Western Asia (ESCWA), United Nations Children's Fund, Oxford Poverty and Human Development Initiative & League of Arab States. 2017c. *Arab Multidimensional Poverty Report.* www.unescwa.org/sites/www.unescwa.org/files/publications/files/multidimensional-arab-poverty-report-english.pdf

United Nations Economic and Social Commission for Western Asia (ESCWA) *et al.* 2018*. Arab Climate Change Assessment Report – Snapshot of Key Findings.* Beirut. http://riccar.org/sites/default/files/2020-01/RICCAR-Booklet-Snapshot%20of%20Key%20findings.pdf

United Nations Economic and Social Commission for Western Asia (ESCWA) & Islamic Development Bank. 2019. "Expert Group Meeting on Mainstreaming Climate Action into National Development Planning in the Arab region: Report", Amman, 25–27 November 2019.

United Nationals Environment Assembly. *Sand and dust storms*. UNEA- 2 Fact Sheet. [online]. [Cited 15 December 2021]. https://uneplive.unep.org/media/docs/assessments/Sand_and_Dust_Storms_fact_sheet.pdf

United Nations Environment Programme (UNEP) & FAO. 2020. *The UN Decade on Ecosystem Restoration 2021–2030*. https://wedocs.unep.org/bitstream/handle/20.500.11822/30919/UNDecade.pdf

United Nations Environment Programme/Mediterranean Action Plan and Plan Bleu. 2020. *State of the Environment and Development in the Mediterranean.* Nairobi.

United Nations Environment Programme (UNEP). 2007. *Environment Outlook for the Arab region. Environment for Development and Human Well-being.* Nairobi.

United Nations Environment Programme (UNEP). 2016. *GEO-6 regional Assessment for West Asia*. Nairobi.

United Nations Environment Programme (UNEP). 2017. Sand and dust storms: Subduing a global phenomenon. UN Environment Frontiers 2017 Report. https://wedocs.unep.org/bitstream/handle/20.500.11822/22267/Frontiers_2017_CH4_EN.pdf?sequence=1&isAllowed=y

United Nations Environment Programme (UNEP). 2018. Africa Waste Management Outlook. United Nations Environment Programme, Nairobi, Kenya.

United Nations Environment Programme (UNEP). 2019. Waste Management Outlook for West Asia.

United Nations Environment Programme (UNEP). 2021. *Food Waste Index Report 2021*. Nairobi.

United Nations Environment Programme (UNEP), World Meteorological Organization (WMO) & United Nations Convention to Combat Desertification (UNCCD). 2016. *Global assessment of sand and dust storms.* Nairobi. https://library.wmo.int/opac/doc_num.php?explnum_id=3083

United Nations Framework Convention on Climate Change (UNFCCC). 2021. National Adaptation Plans. www4.unfccc.int/sites/NAPC/Pages/national-adaptation-plans.aspx

United Nations General Assembly (UNGA). 2019. *Eradicating rural poverty to implement the 2030 Agenda for Sustainable Development.* Report of the Secretary-General. 74th Session. New York, USA. https://digitallibrary.un.org/record/3825877?ln=en

United Nations High Commissioner for Refugees (UNHCR). 2020a. *Population figures, UNHCR data on displacement.* [online]. [Cited 15 December 2021]. www.unhcr.org/refugee-statistics/download/?url=TKsZ3Z

United Nations High Commissioner for Refugees (UNHCR). 2020b. *Sudan's internally displaced yearn for real peace to go home.* [online]. [Cited 18 January 2022].

UNICEF. 2020. MENA Gen 2030. https://data.unicef.org/resources/middle-east-north-africa-generation-2030/

United Nations. 2019. *World Population Prospects 2019*, New York, USA.

United Nations Statistical Division. 2021. *Environmental Indicators.* [online] [cited 01 December 2021] https://unstats.un.org/unsd/envstats/qindicators

Veolia Water. 2011. *Sustaining growth via water productivity: 2030/2050 scenarios.* http//growingblue.com/wpcontent/uploads/2011/05/IFPRI_VEOLIA_STUDY_2011. pdf

Verner, D. 2012. *Adaptation to a changing climate in the Arab countries: A case for adaptation governance and leadership in building climate resilience*. World Bank.

Verner, D., Vellani, S., Klausen, A.-L. & Tebaldi, E. 2017. *Frontier agriculture for improving refugee livelihoods: Unleashing climate-smart and water-saving agriculture technologies in MENA.* World Bank.

Vicedo-Cabrera, A. M. *et al.* 2021. The burden of heat-related mortality attributable to recent human-induced climate change. *Nature Climate Change,* 11: 492–500.

Vos, J. & R. Boelens. 2016. *The politics and consequences of virtual water export*. Eating, Drinking: Surviving: The International Year of Global Understanding - IYGU, edited by P. Jackson, W. E. L. Spiess , and F. Sultana, pp. 31–41, Springer International Publishing.

Voss, K. A., Famiglietti, J. S., Lo, M. De Linage, C., Rodell, M. & Swenson, S. C. 2013. Groundwater depletion in the Middle East from GRACE with implications for transboundary water management in the Tigris-Euphrates-Western Iran region. *Water Resour. Res*., 49(2): 904–914.

Waha, K., Krummenauer, L., Adams, S., Aich, V., Baarsch, F., Coumou, D., Fader *et al.* 2017. Climate change impacts in the Middle East and Northern Africa (MENA) region and their implications for vulnerable population groups. *Reg. Environ. Chang*., 17(6):1623–1638., doi:10.1007/s10113-017-1144-2

Wang, C. H. & Blackmore, J. M. 2009. Resilience concepts for water resource systems. *Journal of Water Resources Planning and Management*, 135(6): 528–536, https://doi.org/10.1061/(asce)0733-9496(2009)135:6(528)

Ward, C. 2016. *regional strategic review paper for NENA*.

World Economic Forum (WEF). 2019. *The Middle East and North Africa risks landscape*. Briefing paper, available at www3.weforum.org/docs/WEF_MENA_Risks_Briefing_Paper.pdf

Wenger, C. & Abulfotuh, D. 2019**.** *Rural migration in the Near East and North Africa – regional trends*. Cairo, FAO. Licence: CC BY-NC-SA 3.0 IGO

World Food Programme (WFP). 2013. In FAO, 2018. *Drought characteristics and management in North Africa and Near East*. FAO Water Report 45. Rome. www.fao.org/3/CA0034EN/ca0034en.pdf.

World Food Programme (WFP). 2020. *Impact of COVID-19 in the Middle East, North Africa, Central Asia, and Eastern Europe*. Update #7.

Wheeler, A. S. & Garrick, D. E. 2020. A tale of two water markets in Australia: Lessons for understanding participation in formal water markets. *Oxford Rev. Econ. Policy*, 36(1): 132–153

World Health Organization (WHO). 2017. *One Health.* [online]. [Cited 15 December 2021]. www.who.int/news-room/q-a-detail/one-health

World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP). 2013. *Establishing a WMO Sand and Dust Storm Warning Advisory and Assessment System regional Node for West Asia: Current capabilities and needs.* Technical Report 1121. Geneva, Switzerland.

Woertz, E. 2019. *The political economy of the Near East and North Africa (NENA): Implications for food security, nutrition and agriculture*. Foresight document prepared for FAO.

World Bank. 2010. Yemen: Assessing the impact of climate change and variability on the water and agriculture sectors, and policy implications. Report No. 54196-YE. Washington, DC: The World Bank.

World Bank. 2017a. *Beyond scarcity: Water security in the Middle East and North Africa*. MENA Development Report. License: CCBY 3.0 IGO, Washington, DC. https://openknowledge.wrldbank.org/handle/10986/27659

World Bank. 2017b**.** *Brief: Help women farmers "get to equal,".* Washington, DC.

World Bank. 2018. *World Development Indicators, Agriculture, forestry, and fishing, value added (% of GDP).* [online]. [Cited 15 December 2021]. https://databank.worldbank.org/source/world-development-indicators

World Bank. 2019. *World Development Indicators, GDP per capita (current USD).* [online]. [Cited 15 December 2021]. https://databank.worldbank.org/source/world-development-indicators

World Bank. 2020. *Poverty and shared prosperity 2020: Reversals of fortune*. Washington, DC, doi: 10.1596/978-1-4648-1602-4

World Bank. 2021. Annual freshwater withdrawals, agriculture [online]. [Cited 15 December 2021]. https://data.worldbank.org/indicator/ER.H2O.FWAG.ZS

World Bank. 2021. MENA Crisis Tracker – 1/5/2021, Washington, DC.

Wu W., Zucca C., Muhaimeed, A. S., Al-Shafie, W. M., Al-Quraishi, A. M. F., Nangia, V., Zhu, M. & Zdruli, P. 2018. *Maintaining soil health in dryland areas.* In: Reicoski, ed, Managing soil health for sustainable agriculture*.* Cambridge, UK, Burleigh and Dods Science Publishing,.

Zdruli, P., Cherlet, M. & Zucca, C. 2017. *Desertification: Mapping constraints and challenges*. Encyclopedia of Soil Science, Third edition, (ed. R. Lal). Taylor & Francis. DOI: 10.1081/E-ESS3-120052917

Zdruli, P. & Zucca, C. 2018. *Maintaining soil health in dryland areas. In: Reicoski (ed) Managing soil health for sustainable agriculture.* Burleigh and Dods Science Publishing, Cambridge ISBN-13: 9781786761927

Zerboni, A., Brandolini, F., Mariani, G. S., Perego, A., Salvatori, S., Usai, D., Pelfini, M. & Williams, M. A.J. 2020. *The Khartoum-Omdurman conurbation: A growing megacity at the confluence of the Blue and White Nile Rivers*.

Ziadat, F., Berrahmouni, N., Grewer, U., Bunning, S., Bockel, L. & Oweis, T. 2015. *Reversing land degradation in the drylands: Scaling out and monitoring proven sustainable land management options*. In Griffiths, J., ed. Living land, pp. 14–17. United Nations Convention to Combat Desertification.

Ziadat, F., Bunning, S. & De Pauw, E. 2017. *Land resource planning for sustainable land management*. Rome, FAO. www.fao.org/3/i5937e/i5937e.pdf.

Zucca, C., Biancalani, R., Kapur, S., Akça, E., Zdruli, P., Montanarella, L. & Nachtergaaele, F. 2014. *The role of soil information in land degradation and desertification mapping. A review*. In: Kapur S. and Erşahin S., eds, Soil Security for Ecosystem Management. Mediterranean Soil Ecosystems 1: 31-59. Springer Briefs in Environment, Security, Development and Peace. Vol 8. DOI 10.1007/978-3-319-00699-4_3

Zucca, C., Fleiner, R. & Bonaiuti E. 2020. *Impacts and damages caused by sand and dust storms (SDS), and causal relationships with land management and land degradation. A global overview*. WOCAT Technical Report.

GLOSSARY

Agricultural land: Land used primarily for agricultural purposes. FAOSTAT defines agricultural area as the sum of areas under (a) arable land; (b) permanent crops – land cultivated with long-term crops that do not have to be replanted for several years; and (c) permanent meadows and pastures.

Agroforestry: Land-use systems or practices in which trees are deliberately integrated with crops and/or animals on the same land management unit.

Alkalinization: A net increase of alkali salts in the (top) soil leading to a decline in agricultural productivity.

Anthropogenic activities: Activities related to human beings.

Arable land: Land under temporary agricultural crops, temporary meadows for mowing or pasture, market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for 'arable land' are not meant to indicate the amount of land that is potentially cultivable.

Carbon sequestration: The process of removing carbon from the atmosphere and depositing it in reservoirs such as oceans, forests or soils through physical or biological processes.

Climate-smart agriculture: An approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate.

Conjunctive use (of surface water and groundwater): The coordinated management of surface water and groundwater supplies to maximize overall water yield; in other words, the integrated management of ground and surface water resources, to enhance security of water supply and environmental sustainability.

Conservation agriculture: An approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing the resource base and the environment. Conservation agriculture is characterized by three principles: continuous minimum mechanical soil disturbance; permanent organic soil cover; and diversification of crop species grown in sequences or associations.

Conservation tillage: An approach to soil management which excludes conventional tillage operations that invert the soil and bury crop residues. There are five types of conservation tillage system: no-tillage (slot planting), mulch tillage, strip or zonal tillage, ridge till (including no-till on ridges), and reduced or minimum tillage.

Consumptive use of water: The part of water withdrawn from its source for use in agriculture, industry or domestic purposes that has evaporated, transpired, or been incorporated into products. The part of water withdrawn that is not consumed is called return flow.

Cropland (or cultivated land): In SOLAW, the term cropland is used to indicate land that is under agricultural crops. In statistical terms, cropland is the sum of arable land (see definition above) and permanent crops.

Desertification: The degradation of land in arid, semi-arid, and dry subhumid areas due to various factors, including climatic variations and human activities.

Drylands: Arid, semi-arid, and dry subhumid areas (other than polar and subpolar regions), in which the ratio between mean annual precipitation and mean annual reference evapotranspiration ranges from 0.05 to 0.65.

Ecosystem services (or environmental services): The benefits that people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and the non-living physical components of the environment (such as air, soil, water and sunlight), interacting as a functional unit.

Eutrophication: The enrichment of freshwater bodies by inorganic nutrients (e.g. nitrate, phosphate), leading typically to excessive growth of algae.

Evapotranspiration: The combination of evaporation from the soil surface and transpiration from plants.

Farmer Field School: An approach based on people-centred learning. Participatory methods to create an environment conducive to learning: the participants can exchange knowledge and experience in a risk-free setting.

Freshwater: Naturally occurring water on the Earth's surface in lakes and rivers, and underground in aquifers. Its key feature is a low concentration of dissolved salts. In this report, when not otherwise specified, the term water is used as a synonym of freshwater.

Groundwater: Corresponds to the water found in aquifers underground in cracks and other spaces.

Renewable water resources: The conventional measure of freshwater available to a nation (surface water and groundwater), comprising resources deriving from the rainfall within a nation's boundaries. It excludes transboundary and fossil water resources.

Land degradation neutrality (LDN): LDN refers to the conservation, restoration of degraded lands and raising levels of carbon sequestration, and improvement of the legislative and institutional frameworks.

Land degradation: The reduction in the capacity of the land to provide ecosystem goods and services over a period of time for its beneficiaries.

Nationally Determined Contribution (NDC): NDCs are non-binding national plans highlighting climate actions, including targets for greenhouse gas emissions reductions, policies and measures that governments aim to implement in response to climate change and to achieve global targets set out in the Paris Agreement.

Policy coherence: Relates to the relations across and continuance within and between policies.

Protected agriculture: When technology is used to modify the natural environment (temperature, rainfall, humidity, wind, etc.) that surrounds a crop to harvest higher yields with an extended season.

Rangeland: Land on which the indigenous vegetation (climax or subclimax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife.

Riparian: Relating to land adjoining a stream or river.

Runoff: Part of the water from precipitation or irrigation that flows over the land surface in stream flow and is not absorbed into the ground.

Salinization: The process by which salt accumulates in or on the soil. Human-induced salinization is mostly associated with poor irrigation practices.

Sodic soil: A soil that contains sufficient sodium to adversely affect the growth of most crop plants (sodic soils are defined as those soils that have an exchangeable sodium percentage of more than 15).

Wadi: The bed or valley of a seasonal stream in arid or semi-arid areas that is usually dry, except for a short time after spate flow events (a few hours to a few days).

Water accounting: A systematic method of organizing and presenting information relating to the physical volumes and flows of water in the environment and economy, as well as the economic aspects of water supply and use.

Water audit: A systematic study of the current status and future trends in both water supply and demand, with a particular focus on issues relating to accessibility, uncertainty and governance in a given spatial domain.

Water demand management: A set of actions consisting of controlling water demand, either by raising the efficiency of its use (see definition below) or by operating intra and intersectoral reallocation of water resources.

Water harvesting: A technology by which rainwater is collected and either directly applied to the cropped area and stored in the soil profile for immediate uptake by the crop (runoff irrigation), or stored in a water reservoir for future productive use (for example, used for supplementary irrigation).

Water productivity: The amount or value of output (including services) provided by water, in relation to the volume of water used. Crop water productivity refers to the ratio between crop yield and water supply. Economic water productivity is expressed as the ratio between added value of a product and water supply.

Water resources assessment (see water accounting): Water resources assessment focuses on the supply side of water accounting and provides a systematic assessment of water resources, including their variability and trends.

Water right: In its legal sense, a legal right to abstract or divert and use water from a given natural source; to impound or store a specified quantity of water in a natural source behind a dam or other hydraulic structure; or, to use or maintain water in a natural state (ecological flow in a river, and water for recreation, religious/spiritual practices, drinking/washing/bathing or animal watering).

Water stress: This is a measure of the ratio of water withdrawals to renewable surface water supply. It should be noted that its metric does not account for the contribution of non-conventional water supplies or groundwater resources that may have been developed to relieve water stress.

Water-use efficiency: The ratio between the amount of water actually used for a specific purpose and the amount of water withdrawn or diverted from its source to serve that use.

Water withdrawal: Water abstracted from streams, aquifers or lakes for any purpose (e.g. irrigation, industrial, domestic, commercial).

Waterlogging: State of land in which the water table is located at or near the soil surface, affecting crop yields.

The State of Land and Water Resources for Food and Agriculture

in the Near East and North Africa region

FAO Regional Office for the Near East and North Africa

(202) 3331 6000 to 3331 6007
(202) 3749 5981, (202) 3337 3419
FAO-RNE@fao.org
https://www.fao.org/neareast/about/en/

Food and Agriculture Organization of the United Nations
Cairo, Egypt

ISBN 978-92-5-136288-4
CC0265EN/1/06.22