Chapter 1

Context and drivers of water reuse in MENA

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Key messages

- In recent decades, the Middle East and North Africa (MENA) region has experienced the fastest global decline in available water resources in the world and, currently, the average per capita renewable water resources availability is 10 times less than the global average.
- This situation has been aggravated locally and millions of people that have been internally displaced now require increased domestic water supply in a context of already stressed water resources.
- MENA's population is expected to grow rapidly from 381 in 2015 to 680 million in 2050. Such population growth, together with a rapid urbanization, agricultural expansion and intensification and changing consumption patterns is forecast to drive the increase of water demand by 50% in 2050.
- Much of the MENA region is forecast to experience more warming than the global average, with average temperatures expected to rise by at least 4°C by 2050, even if global warming is limited to a 2°C increase. Precipitation is also forecast to decrease in most of the MENA region by mid-century.
- Demographic growth and urbanization have also translated into greater wastewater production. The capacity for sanitation and wastewater treatment is not growing at the same rate and therefore the amount of wastewater discharged untreated into the environment keeps growing in some countries. An increasing amount of water pollution further aggravates the situation and makes less water safe for use.
- Water scarcity and pollution are driving thousands of farmers in the region to use marginal quality water to irrigate, posing potential health, agronomic and environmental risks. These risks need to be assessed and mitigated.
- Despite increasing water scarcity, substantial amounts of wastewater (treated or untreated) are still lost in the sea or evaporated on land or across rivers with no beneficial use, missing opportunities for resource recovery.

1.1. Introduction

The MENA region[1] occupies an approximate territory of 12.5 million square kilometers (km^2), which is about 9.5% of the planet's land area (FAO 2022a).[2] Home to 5.4% of the world's population (World Bank 2022a), the region contains only 1% of the world's renewable freshwater (Kandeel 2019). The MENA region is considered the most water-scarce region in the world, with average water resources per capita at 550 cubic meters (m^3)/capita/year (FAO

[1]This book has compiled data from 19 Arab countries of the MENA region (namely, Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, the United Arab Emirates and Yemen). Throughout this book the terms 'MENA region' and/or 'the Region' refer only to those 19 countries.

[2]As the rest of the regional figures in this chapter, these figures have been calculated based on data from the 19 analyzed countries.

2022b). That amount is half the 1,000 m^3/capita threshold for water scarcity and just above the 500 m^3/capita threshold for absolute water scarcity, according to the UN Water Stress Index (Frascari et al. 2018).

The significant population growth, high urbanization rate, migration, irrigation expansion and agricultural intensification have created an increased water demand in the region. On the supply side, available water resources are diminishing due to decreasing precipitation and runoff and increased evapotranspiration, as a result of climate change (IPCC 2021).

This chapter analyzes how these drivers are aggravating the already existing regional water crises. It also shows how water reuse is being adopted formally and informally as part of the solution. It concludes by calling for an accelerated change toward more and safer water reuse.

1.2. Population growth, urbanization, migration and agriculture intensification

Since 2000, the MENA region has experienced an average population growth of 1.8% annually (World Bank 2022b). The total population has increased from around 70 million in 1950 to around 418 million in 2020 (World Bank 2022a). MENA's population is expected to keep growing, in part because of its young age structure, with one-third of the region's population aged under 15. As a result, the population of MENA is projected to more than double between 2000 and 2050.

Population growth is coupled with increasing trends in urbanization. About 73% of the MENA population (305 million) lived in cities in 2020, doubling since 1960 and exceeding the global average of 56% (UN 2018). Table 1.1 shows the relationship between population growth and urbanization in the countries of the MENA region, from 1970 to 2050. In countries such as Algeria, Jordan, Iraq and Morocco more than 60% of people already live in cities. Except for some countries, such as Sudan and Yemen, most countries in MENA have experienced extensive urbanization over the past 30 years, even in countries where population growth has been low or moderate. Urbanization growth is expected to accelerate, and the region's urban population is expected to increase by 10% in 2050, reaching nearly 560 million (UN 2018).

Population growth in some of the MENA countries was not limited to natural demographic increases but was also affected by an influx of cross border displacement of people, due to the turmoil and series of conflicts and economic crises in countries such as Syria, Iraq, Yemen or Lebanon. Not only were citizens moving from rural to urban areas, but refugees from other countries were also relocating to cities. About 2.7 million refugees are hosted in different MENA countries, with an additional 12.4 million people internally displaced. Abrupt relocations of population further increase water demand and impact water quality in host communities. Migration puts increased pressure on municipal water resources for both migrant and host communities. The Syrian refugees in Jordan, for instance, have contributed to a 40%

increase in the demand for water in the northern governorates (Borgomeo et al. 2021). In Lebanon, 25% of the population are refugees who require an increased domestic water supply in a context where local authorities already struggle to provide water for its population.

Urbanization and income growth are some of the key drivers of the changing lifestyle and diets in the MENA region, which in turn contribute to increased water demand. Even though poverty persists, and about 20% of the population lives on less than USD 2 a day (World Bank 2022c), average income per capita has increased. This rise in income has transformed consumption patterns and diets toward water-intensive products such as meat and dairy (Mateo-Sagasta et al. 2018). The growing demand for water-intensive products, as seen in other parts of the world, has increased the demand for irrigation in many MENA countries such as Tunisia, Egypt and Morocco, as these countries are major exporters of many fruits and vegetables.

TABLE 1.1 Population growth and urbanization for MENA countries.

Country/Region	Population (millions)[a]					Urban population (%)[b]	
	1970	2001	2015	2020 (estimated)	2050 (forecast)	2015	2050 (forecast)
Algeria	14.5	31.5	39.7	43.9	66.6	70.8	84.5
Bahrain	0.2	0.7	1.4	1.7	2.4	89.0	93.2
Egypt	34.5	70.2	92.4	102.3	174.1	42.8	55.6
Iraq	9.9	24.2	35.6	40.2	79.2	69.9	80.5
Jordan	1.7	5.2	9.3	10.2	14.2	90.3	95.3
Kuwait	0.7	2.1	3.8	4.3	5.4	100	100
Lebanon	2.3	4.0	6.5	6.8	6.6	88.1	93.4
Libya	2.1	5.4	6.4	6.9	8.8	79.3	88.4
Mauritania	1.1	2.7	4.0	4.6	9.0	51.1	72.9
Morocco	16.0	29.1	34.7	36.9	47.5	60.8	77.2
Oman	0.7	2.3	4.3	5.1	7.6	81.4	94.9
Palestine	1.1	3.3	4.5	4.8	10.1	75.4	85.5
Qatar	0.1	0.6	2.6	2.9	3.9	98.9	99.7
Saudi Arabia	5.8	21.2	31.7	34.8	46.7	83.2	90.4
Sudan	10.3	28.0	38.9	43.8	81.2	33.9	52.6
Syria	6.4	16.8	18.0	17.5	34.6	52.2	71.9
Tunisia	5.1	9.8	11.2	11.8	13.9	68.1	80.2
UAE	0.2	3.3	9.3	9.9	10.3	85.7	92.4
Yemen	6.2	17.9	26.5	29.8	57.9	34.8	57.2
TOTAL	**119.1**	**278.3**	**380.8**	**418.3**	**680.0**	**71.3**	82.4

SOURCES: [a]UN 2019; [b]UN 2018.

The agricultural sector is the largest user of water in MENA (FAO 2022c). By 2050, the agricultural sector is expected to produce about 100% more food to ensure food security, which will require substantial and additional amounts of water.

Forecasts suggest that these drivers will continue into the next decades, increasing the demand for water resources. It is anticipated that these trends in population growth combined with economic growth will result in a 50% increase in water demand by 2050 (Mualla 2018).

1.3. Water scarcity and water stress

Water stress in the MENA region, measured as water withdrawals as a percentage of total renewable surface freshwater availability,[3] is greater than in any other region in the world. Currently, the average per capita renewable water resources availability is 10 times less than the worldwide average (Table 1.2) (FAO 2022b). Eight countries in the region (Kuwait, United Arab Emirates, Saudi Arabia, Libya, Qatar, Yemen, Algeria and Bahrain), hosting 60% of the regional population, are in the global top 10 highest levels of water stress (World Bank 2018). MENA water resources have experienced the fastest global rates of decline, decreasing by about two thirds over the last 40 years (World Bank 2018). The surface water resources of the region are not only the scarcest, but they are also the most variable and unpredictable in the world. Surface freshwater availability varies greatly from year to year (World Bank 2018).

Demographic growth and urbanization have also led to greater wastewater production. The capacity for sanitation and wastewater treatment is not growing at the same rate in many countries and therefore the amount of wastewater discharged untreated into the environment keeps growing (WHO 2021).

Climate change profoundly affects the availability and quality of water resources in the region, further worsening the vulnerability of the region’s water security (IPCC 2021). Increased temperatures and evapotranspiration and reduced precipitation and runoff commencing from climate change pose additional pressures on water resources (World Bank 2018).

Since the 1960s, temperatures in the MENA region have increased by about 0.3°C per decade (Waha et al. 2017). In general, the hotspots of temperature increase are in Southern Egypt, Eastern Turkey and most of the Saharan desert, where temperatures increased up to 4°C per decade (ESCWA 2019). Even if global warming is limited to a 2°C increase by 2050, the MENA region is set to experience temperatures well beyond this projection because of the desert warming amplification phenomenon. Temperatures are expected to rise in the region by at least 4°C by 2050 (Wehrey et al. 2022).

[3] Physical water scarcity is measured in terms of water usage relative to the natural endowment of surface freshwater resources, so it does not capture the contribution of non-conventional water supplies or groundwater resources that may have been developed to relieve water stress.

Precipitation levels in the MENA region have also fallen and most of the countries have become drier, with an annual average precipitation below 350 millimeters (ESCWA 2019). Whereas average global precipitation has risen since 1950, with a faster rate of increase since the 1980s (IPCC 2021), precipitation in the MENA region is forecast to decrease. Significant declines are forecast around the Mediterranean region of North Africa (Morocco, Algeria, Tunisia and Northern Egypt) and the Levant (Lebanon, Jordan and Syria) (ESCWA 2019). Rainfall in Jordan, for example, is forecast to decrease by 30% by the end of this century (Wehrey et al. 2022).

The MENA region is expected to become a global hotspot for droughts (Driouech et al. 2020) with declining precipitation, declining runoff and increasing evaporation by 2050 (IPCC 2021). These trends suggest interrelated implications leading to intensifying the region's current water scarcity.

Increased water scarcity is forecast to make gross domestic product drop between 6 to 14% yearly by 2050, reduce labor demand by up to 12% and lead to significant land-use changes, including the loss of beneficial hydrological services (World Bank 2018; Taheripour et al. 2020).

TABLE 1.2 Per capita water resources in MENA countries.

Country/Region	Per capita annual renewable fresh water (m³)			
	1970	2000	2015	2020
Algeria	763	366	282	276
Bahrain	506	158	78	74
Egypt	1,593	804	596	584
Iraq	8,478	3,604	2,393	2338
Jordan	497	176	96	94
Kuwait	23	9	4.931	5
Lebanon	1,862	1,077	660	657
Libya	301	127	106	105
Mauritania	9,364	4,104	2,662	2589
Morocco	1,737	985	815	805
Oman	1,803	600	300	290
Palestine	708	248	176	172
Qatar	444	905	21	21
Saudi Arabia	375	110	73	71
Sudan	708	NA	926	904
Syria	2,471	983	982	992
Tunisia	872	468	404	399
UAE	453	43	16	16
Yemen	329	114	75	74
MENA	1,752	827	561	551

NOTES: NA=data not available. *SOURCE*: FAO 2022b.

By 2041–2070, groundwater recharge could tumble 30 to 70% (relative to 1961–1990). Morocco and Tunisia are especially vulnerable due to their preexisting water scarcity and heavy reliance on groundwater sources (World Bank 2018). Climate change could also degrade important coastal groundwater sources as sea level rise drives saltwater intrusions into freshwater aquifers (IPCC 2021).

1.4. Water reuse as a response to the MENA water crisis

Water scarcity and pollution are forcing thousands of farmers in the MENA region to use raw or diluted wastewater to irrigate. The use of raw wastewater in agriculture has been reported in different countries of the region although the total extent of the practice is unknown. The lack of data is due partly to the informal character of most of the wastewater irrigation or even, in some cases, a deliberate intention not to disclose data. This may be done because farmers fear difficulties when trading their produce or when practitioners do not want to acknowledge what could be perceived as malpractice.

Direct use of untreated wastewater occurs where alternative water sources are scarce or unavailable, i.e., usually in drier climates but also in wetter climates in the dry season. The reasons for such use can be lack or low quality of alternative water sources (e.g., groundwater salinity), or the unaffordable costs of accessing freshwater (e.g., costs of pumping). Although officially disapproved or illegal in most countries, direct use of untreated wastewater is a reality that still takes place around towns and cities (Raschid-Sally and Jayakody 2008).

The most common reuse form is in agriculture. For example, untreated wastewater is used on farms because it is cheaper than using groundwater from boreholes, for which farmers have no capacity to pay. In other cases, farmers use wastewater from malfunctioning treatment plants or sewers, taking advantage of the already collected resource. In other cases, wastewater is the only water flowing in irrigation canals in the dry season and at the tail ends of irrigation schemes. In some extreme cases, farmers rupture or plug sewage lines to access the wastewater.

Indirect water reuse is by far the most extensive type of reuse in the region (Velpuri et al. in review). It occurs when treated or untreated wastewater is discharged into freshwater streams where it becomes diluted and is subsequently used – mostly unintentionally – by downstream users (e.g., farmers, households or industries). In areas where a large portion of the wastewater is still not safely treated (WHO 2021), the practice poses risks to farmers and consumers, particularly if such water is used to irrigate vegetables to be eaten raw. Additionally, the opportunity to sell crops into urban food markets encourages farmers to seek irrigation water in the city vicinity.

Several examples of indirect use of untreated wastewater have been reported across the region. For instance, in Egypt, untreated wastewater is discharged into el Rwahi Drain, which finally ends up in the Rosetta Branch of the River Nile. Similarly, the Zarkoun Drain discharges into the Mahmoudiah Canal. Eventually, this water is used for irrigation (Tawfik et al. 2021). Another example is from the extreme east of Algeria. The Medjerda wadi is one of the water sources used for agricultural irrigation in the city of Souk Alhras (northeast of Algeria). The wadi receives contaminated raw domestic and industrial wastewater, which farmers use to meet the water requirements of their crops (Mamine et al. 2020).

This reality should not be neglected. Farmers are using polluted water to irrigate. Risks need to be assessed (Mara and Bos 2010), and the practice needs to become safer. Solutions need to consider cost-effective wastewater treatment, but not only that. A combination of solutions from farm to fork can offer multiple barriers to health risks (WHO 2006, 2016). On-farm practices such as the use of drip irrigation or irrigation stoppage several days before harvesting to favor pathogen die off can be very effective to ensure food safety (Abi Saab et al. 2022) and can offer an additional safety net in case wastewater treatment is interrupted or dysfunctional. Once harvested, produce should not be recontaminated during transport or in markets by, for example, using unhygienic practices or unsafe water.

BOX 1.1 The benefits of planned water reuse in agriculture.

The recovery of resources such as water, nutrients/fertilizers and organic matter from wastewater, in support of food production, can have benefits for all sectors involved: cities, agriculture and the environment.

Agriculture can benefit from the reuse of urban effluents in several ways, the most important being: (i) improving the reliability of the water supply, (ii) improving the fertilizing capacity of the nutrients of the urban effluents and (iii) bringing agricultural production closer to consumption centers.

Cities can benefit from reuse mainly for three reasons: (i) they can strengthen their food security by supplying peri-urban agriculture with water and nutrients; (ii) reuse can effectively contribute to solve their wastewater treatment problem and in particular the removal of nutrients, which can be used by plants rather than ending up in water bodies causing eutrophication of lakes or pollution of groundwater with nitrates; and (iii) they can increase their water availability, when wastewater is reused for municipal uses, or when reclaimed water is exchanged for fresh water between cities and agriculture.

The environment, and especially aquatic ecosystems, can benefit from the safe treatment and reuse of wastewater. Reuse can improve water quality and increase its availability for environmental uses. In addition, reuse systems associated with peri-urban agriculture and agroforestry have a high potential for carbon sequestration and climate change mitigation.

On the other hand, despite increasing water scarcity, substantial amounts of wastewater (treated or untreated) are still lost in the sea or evaporated on land or across rivers with no beneficial use. The direct and planned use of recycled water is still marginal (see Chapter 2). Accelerating change toward more and safer water reuse has benefits for all sectors involved (Box 1.1) but will require the formulation and implementation of appropriate and effective policies (Box 1.2; see Chapter 3), including incentives for financial sustainability of wastewater treatment reuse projects (see Chapter 4) and affordable regulations that ensure safety (see Chapter 5).

BOX 1.2 Increasing importance of wastewater treatment in MENA's water strategies.

In the MENA region, and under the current water scarcity situation, which is expected to worsen, treated wastewater constitutes a constant and perennial resource. Most national water strategies and plans in the region rely on wastewater treatment as a key component in the national water resources mix to reduce water deficits, preserve the natural environment and support socioeconomic development.

In Morocco, and since the implementation of the National Liquid Sanitation Plan (PNA) in 2006 and the new National Shared Liquid Sanitation Plan (PNAM) in 2019, more than 157 wastewater treatment plants have been developed and the rate of treatment has increased from 7% in 2006 to more than 50% in 2020 (Alami 2022). The reuse of treated wastewater is part of the recently introduced water strategy relating to the development of water supply by valuing non-conventional resources. Morocco's long-term objective is to reuse 300 million m^3 per year by 2050, across the whole country (SK 2022).

The first pilar of Egypt's National Water Resources Plan (2017–2037) is composed of a set of actions to manage water quality, such as pollution control, and sewage and industrial water treatment. In 2021, Egypt's Minister of Housing, Utilities and Urban Communities announced that Egypt is constructing 151 sewage treatment plants across the republic, with a capacity of 5 million m^3 of water per day (Morsy 2021).

In Jordan, one of the most water-scarce countries in the world, the government has a 2016–2025 National Water Strategy which charts a target volume of treated wastewater of 240 million m^3 annually by 2025 (MWI 2016).

References

Abi Saab, M.T.; Jomaa, I.; El Hage, R.; Skaf, S.; Fahed, S.; Rizk, Z.; Massaad, R.; Romanos, D.; Khairallah, Y.; Azzi, V.; Sleiman, R.; Abi Saad, R.; Hajjar, C.; Sellami, M.H.; Aziz, R.; Sfeir, R.; Nassif, M.H.; Mateo-Sagasta, J. 2022. Are fresh water and reclaimed water safe for vegetable irrigation? Empirical evidence from Lebanon. *Water* 14(9): 1437. https://doi.org/10.3390/w14091437

Alami, M. 2022. Réutilisation des eaux usées: Un investissement de 2,34 milliards à l'horizon 2027. La Vie Éco. Available at https://www.lavieeco.com/economie/reutilisation-des-eaux-usees-un-investissement-de-234-milliards-a-lhorizon-2027/ (accessed on August 31, 2022).

Borgomeo, E.: Jägerskog, A.; Zaveri, E.; Russ, J.; Khan, A.; Damania, R. 2021. *Ebb and flow: Volume 2. Water in the shadow of conflict in the Middle East and North Africa*. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-1746-5

Drechsel, P.; Qadir, M.; Galibourg, D. 2022. The WHO guidelines for safe wastewater use in agriculture: A review of implementation challenges and possible solutions in the global south. *Water* 14: 864. https://doi.org/10.3390/w14060864

Driouech, F.; ElRhaz, K.; Moufouma-Okia, W.; Khadija, A.; Saloua, B. 2020. Assessing future changes of climate extreme events in the CORDEX-MENA region using Regional Climate Model ALADIN-Climate. *Earth Systems and Environment* 4: 477–492. https://doi.org/10.1007/s41748-020-00169-3

ECP (Egyptian Code of Practice) 501. 2015. *Egyptian code of practice for the reuse of treated wastewater for agricultural purposes*. Cairo, Egypt: The Ministry of Housing Utilities and Urban Communities. (In Arabic).

ESCWA (Economic and Social Commission for Western Asia of the United Nations). 2019. *Moving towards water security in the Arab Region*. Beirut, Lebanon: United Nations publication issued by ESCWA.

FAO (Food and Agriculture Organization of the United Nations). 2022a. *Land area. Estimated average for the MENA region*. AQUASTAT Database. Available at https://www.fao.org/aquastat/statistics/query/index.html (accessed on March 05, 2022).

FAO. 2022b. *Total renewable water resources per capita. Estimated average for the MENA region*. AQUASTAT Database. Available at https://www.fao.org/aquastat/statistics/query/index.html (accessed on March 05, 2022).

FAO. 2022c. *Agricultural water withdrawal as % of total water withdrawal. Estimated average for the MENA region*. AQUASTAT Database. Available at https://www.fao.org/aquastat/statistics/query/index.html (accessed on August 08, 2022).

Frascari, D.; Zanaroli, G.; Motaleb, M.A.; Annen, G.; Belguith, K.; Borin, S.; Choukr-Allah, R.; Gibert, C.; Jaouani, A.; Kalogerakis, N.; Karajeh, F.; Ker Rault, P.A.; Khadra, R.; Kyriacou, S.; Li, W.-T.; Molle, B.; Mulder, M.; Oertlé, E.; Ortega, C.V. 2018. Integrated technological and management solutions for wastewater treatment and efficient agricultural reuse in Egypt, Morocco, and Tunisia. *Integrated Environmental Assessment and Management* 14(4): 447–462. https://doi.org/10.1002/ieam.4045

IPCC (International Panel on Climate Change). 2021. Technical Summary. In: Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S.L.; Péan, C.; Berger, S.; Caud, N.; Chen, Y.; Goldfarb, L.; Gomis, M.I.; Huang, M.; Leitzell, K.; Lonnoy, E.; Matthews, J.B.R.; Maycock, T.K.; Waterfield, T.; Yelekçi, O.; Yu, R.; Zhou, B. (eds.). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge, United Kingdom: Cambridge University Press. pp.33–144. doi:10.1017/9781009157896.002

Kandeel, A. 2019. *Freshwater resources in the MENA region: Risks and opportunities*. Middle East Institute.

Mamine, N.; Khaldi, F.; Grara, N. 2020. Survey of the physico-chemical and parasitological quality of the wastewaters used in irrigation (Souk Ahras, North-East of Algeria). *Iranian (Iranica) Journal of Energy & Environment* 11(1): 78–88. https://dx.doi.org/10.5829/ijee.2020.11.01.13

Mara, D.; Bos, R. 2010. *Risk analysis and epidemiology: the 2006 WHO guidelines for the safe use of wastewater in agriculture*. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Mateo-Sagasta, J.; Zadeh, S.M.; Turral, H. 2018. *More people, more food, worse water? A global review of water pollution from agriculture*. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO) and the International Water Management Institute (IWMI). 228p.

Morsy, A. 2021. Egypt builds 151 dual, triple sewage treatment plants for EGP 32 bln. Ahram Online. Available from https://english.ahram.org.eg/NewsContent/1/64/409876/Egypt/Politics-/Egypt-builds--dual,-triple-sewage-treatment-plants.aspx (accessed on August 31, 2022).

Mualla, W. 2018. Water demand management is a must in MENA countries… but is it enough. *Journal of Geological Resource and Engineering* 6: 59–64.

MWI (Ministry of Water and Irrigation). 2016. National Water Strategy 2016–2025. Amman, Jordan: Ministry of Water and Irrigation.

Raschid-Sally, L.; Jayakody, P. 2009. *Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment*. (Vol. 127). Colombo, Sri Lanka: International Water Management Institute (IWMI).

SK. 2022. Baraka: Le Maroc prévoit le traitement de 100 millions de m^3 des eaux usées d'ici 2027. L'Opinion. Available at https://www.lopinion.ma/Baraka-Le-Maroc-prevoit-le-traitement-de-100-millions-de-m3-des-eaux-usees-d-ici-2027_a26911.html (accessed August 31, 2022).

Taheripour, F.; Tyner, W.E.; Sajedinia, E.; Aguiar, A.; Chepeliev, M.; Corong, E.; de Lima, C.Z.; Haqiqi, I. 2020. *Water in the balance: The economic impacts of climate change and water scarcity in the Middle East*. Washington, DC.: World Bank.

Tawfik, M.H.; Hoogesteger, J.; Elmahdi, A.; Hellegers, P. 2021. Unpacking wastewater reuse arrangements through a new framework: Insights from the analysis of Egypt. *Water International* 46(4): 605–625. https://doi.org/10.1080/02508060.2021.1921503

UN (United Nations). 2018. *Urban population (% of total population)*. Estimated average for the MENA region. Department of Economic and Social Affairs. Population Division. World Urbanization Prospects: The 2018 Revision. Retrieved from https://population.un.org/wup/Download/ (accessed on March 05, 2022).

UN (United Nations). 2019. *Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.* Retrieved from https://population.un.org/wpp/Download/ (accessed on March 5, 2022).

Velpuri, N.M.; Mateo-Sagasta, J.; Mohammed, O. In review. Spatially explicit wastewater generation and tracking in the MENA region. *Science of the Total Environment*.

Waha, K.; Krummenauer, L.; Adams, S.; Aich, V.; Baarsch, F.; Coumou, D.; Schleussner, C.F. 2017. Climate change impacts in the Middle East and Northern Africa (MENA) region and their implications for vulnerable population groups. *Regional Environmental Change* 17: 1623–1638. https://doi.org/10.1007/s10113-017-1144-2

Wehrey, F.; Fawal, N. 2022. *Cascading climate effects in the Middle East and North Africa: Adapting through inclusive governance.* CEIP: Carnegie Endowment for International Peace. Retrieved from https://policycommons.net/artifacts/2267979/cascading-climate-effects-in-the-middle-east-and-north-africa/3027645/ (accessed on July 18, 2022).

World Bank. 2018. Beyond scarcity: *Water security in the Middle East and North Africa. MENA Development Report*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/27659

World Bank. 2022a. *Population, total*. Estimated percentage for the MENA region. Retrieved from https://data.worldbank.org/indicator/SP.POP.TOTL (accessed on March 05, 2022).

World Bank. 2022b. *Population growth (annual %)*. Estimated average for the MENA region. Retrieved from https://data.worldbank.org/indicator/SP.POP.GROW (accessed on March 05, 2022).

World Bank. 2022c. *World Development Indicators. Poverty and Inequality Platform. people lived below the $1.90 per day poverty line in 2018. Middle East and North Africa.* Retrieved from https://data.worldbank.org/region/middle-east-and-north-africa (accessed on March 05, 2022).

Wehrey, F.; Fawal, N. 2022. *Cascading climate effects in the Middle East and North Africa: Adapting through inclusive governance.* CEIP: Carnegie Endowment for International Peace. Retrieved from https://policycommons.net/artifacts/2267979/cascading-climate-effects-in-the-middle-east-and-north-africa/3027645/ (accessed on July 18, 2022).

WHO (World Health Organization). 2006. *Guidelines for the safe use of wastewater, excreta and greywater*. World Health Organization: Paris, France, 2006; Volume II, 182.

WHO. 2016. Sanitation safety planning: manual for safe use and disposal of wastewater, greywater and excreta. World Health Organization: Geneva. http://www.who.int/water_sanitation_health/publications/ssp-manual/en/

WHO. 2021. *Country files for SDG 6.3.1. Proportion of wastewater safely treated.* Available at https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/monitoring-and-evidence/water-supply-sanitation-and-hygiene-monitoring/2021-country-files-for-sdg-6.3.1-proportion-of-water-safely-treated (accessed on April 15, 2022).