2020 Report of the Arab Forum for Environment and Development

HEALTH AND THE ENVIRONMENT IN ARAB COUNTRIES

EDITED BY:
NAJIB SAAB
RIMA R. HABIB

المنتدى العربي للبيئة والتنمية
ARAB FORUM FOR
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Preface

Although the environment has always impacted human health and wellbeing, the interconnectedness between the two is especially highlighted now, with the world in the grip of the coronavirus pandemic. Given this context, the topic of the 2020 annual report of the Arab Forum for Environment (AFED), Health and Environment in Arab Countries, is particularly timely and relevant.

Producing the report was in itself a challenging endeavor, not only due to the stressful working conditions created by the pandemic, which put limits on normal interaction, but also due to the consequences of the financial collapse in Lebanon on AFED's operations. This was compounded by the Beirut port explosion on 4 August 2020, which badly affected the AFED Secretariat and its partners in Beirut, damaging our offices and facilities, and causing human and economic tragedy felt by our staff. Combined with the unsettled situation in the region, this has resulted in a disturbing drop in funding from traditional partners and sponsors, threatening the continued existence of AFED itself.

This report is the 13th in the series on the State of Arab Environment, launched by AFED in 2008. The series, which has highlighted environmental challenges and recommended solutions, has inspired policy changes, knowledge sharing, and actions across the Arab region. The series has covered major topics, including climate change, water, energy, the green economy, our ecological footprint, sustainable consumption, financing sustainable development, and environmental education, among others.

The emergence, spread and impact of many diseases and illnesses can be mitigated by the management of environmental risks, which makes it necessary to tackle the underlying environmental causes. While this is a global fact, it is more significant in the Arab region, where environmental risks are higher and rates of development, in most countries, are slower.

During the last decades, the world has achieved a decline in communicable diseases, while simultaneously witnessing an immense rise in diseases and health damages triggered by poor environmental conditions. The World Health Organization (WHO) has estimated that more than 676,000 Arab citizens will lose their lives prematurely in 2020 due to exposure to conventional environmental risks. The diseases most driven and impacted by environmental causes in the Arab countries include cardiovascular diseases, diarrheal diseases, respiratory infections and cancers. The main environmental risk drivers of these disease groups are ambient and household air pollution, lack of access to clean water, marine pollution, uncontrolled urbanization, land degradation and exposure to waste and harmful chemicals. Unrestrained expansion of residential, industrial and agricultural activities into natural habitats will lead to higher rates of disease transmission, especially viruses, from animals to humans.

Goal 3 of the 17 Sustainable Development Goals (SDGs) calls for ensuring healthy lives and promoting well-being for all by 2030. Achieving this goal requires addressing the environmental-related burden of disease, as environmental exposures are key factors impacting human health. An integrated ecological public health approach is needed, which recognizes the complex interactions between biological, behavioral, environmental and social factors. Reducing the environmental burden of disease is possible through measures designed and implemented in such a holistic manner.

The AFED 2020 report discusses the main environmental drivers that impact various aspects of human health in the Arab countries, and proposes an action plan leading to the region meeting SDG Goal 3. These recommendations are placed within an integrated context of sustainable development, by tackling health in terms of social, economic and environmental aspects. The report's seven chapters deal with the relationship between health, water, air, waste, ocean pollution and climate change, as well as progress and obstacles in achieving the environmental health content of the SDGs.

AFED wishes to thank all institutional partners, experts and researchers who contributed to this report, including universities, international organizations and major players in the environmental health domain. Academic AFED members among universities across the Arab region played key role in developing the report. The core content partners were the Faculty of Health Sciences at the American University of Beirut (AUB), which is also hosting the conference, as well as researchers from Arabian Gulf University in Bahrain, Cairo University and Alexandria University in Egypt. The report also received major contribution from the WHO regional Centre for Environmental Health Action (CEHA).

Special thanks go to the sponsors who supported the production of the report, mainly the Kuwait Foundation for the Advancement of Sciences (KFAS), the Islamic Development Bank (IsDB) and the UN Food and Agricultural organization (FAO).

It is hoped that this report, by highlighting the interrelation between environment and human health, will help to enhance environmental management in the Arab countries in such a way to better protect human health, and to invigorate the health systems to better respond to the impact of environmental factors.

Najib Saab
Secretary General
Arab Forum for Environment and Development (AFED)

INTRODUCTION

HEALTH AND THE ENVIRONMENT IN ARAB COUNTRIES

13th Annual Report of the Arab Forum for Environment and Development (AFED)

OVERVIEW

The inherent interconnectedness between health and the environment means that a healthy community is not possible in a contaminated environment and that a clean environment is impossible to attain within an unhealthy community. Maintaining the equilibrium between both is essential, especially in light of emerging challenges as a result of modern lifestyles and novel climatic and health issues. The rate of deaths attributable to environmental factors is on the rise, currently estimated at 23 percent of all deaths in the Arab region. Environmental hazards are responsible for about 23 percent of the total burden of disease in the region as well. The latest report of the Arab Forum for Environment and Development (AFED) – Health and the Environment in Arab Countries – aims to highlight the main environmental health risks the region is faced with, whilst emphasizing concrete recommendations and lessons to be learned from past and current environmental and health crises, including the COVID-19 pandemic.

The Arab region is faced with an array of risk factors including unsustainable development practices, humanitarian emergencies, rapid urbanization, dwindling natural resources, land degradation, and increasing human interaction with animals. Several of the most noticeable consequences these risk factors have led to are air pollution, inadequate wastewater and solid waste management and the COVID-19 pandemic. Air pollution is one of the most common environmental problems in Arab countries, and mortality attributed to poor air quality is notably increasing. Due to modernization and population growth, more waste is also being generated. This waste is subsequently mismanaged, imposing health risks to populations of Arab countries. Additionally, in the past year the COVID-19 pandemic has exposed the region's weak healthcare systems and countries' limited capacity to cope with emergent health crises. It has also made clear that the health of a nation cannot be sustained by only targeting groups that can afford to pay for healthcare services – "health for all", as stressed on in Sustainable Development Goal 3, is a necessity.

Hazardous and toxic materials pose a serious health challenge in the Arab region, due to inadequate management, lack of strict regulations and lax safety measures. The full extent of health consequences of the August 2020 Beirut port explosion, due to unsafely stored ammonium nitrate, is still to be seen. The explosion is expected to have a long-term impact, especially demonstrated in a projected increase in respiratory diseases and certain types of cancer. Uncontrolled use of ammunition and successive wars and conflicts in the Arab region have also impacted the health of millions and led to a disruption in health services and the spread of diseases in camps housing millions of internally displaced persons and refugees.

It is estimated that more than 676,000 Arab citizens will lose their lives prematurely in 2020 due to exposure to conventional environmental risks such as air pollution, lack of clean water and sanitation, climate change, intermingling with toxic chemicals and wastes, alongside exposure to occupational risks. This figure will increase as more emerging environmental risk factors and their impacts are quantified, including hunger and malnutrition. The challenges the Arab region is faced with call for a dire transformation in the way environmental health priorities are managed. Current approaches have laid the ground, but have not proven sufficient to sustainably and efficiently reduce environmental risks on public health and for building up health-supportive and enabling environments.

Concretely, Arab countries must work harder towards achieving the Sustainable Development Goals, a more collaborative approach must be taken to govern environmental policies, more effective climate change mitigation and adaptation strategies should be designed focused on global health, and on the whole, better health risk assessments need to be done and data collected to provide Arab policy-makers with the right tools to tackle current environmental and health challenges.

WATER

Lack of access to safely managed water, sanitation and hygiene (WASH) services is one of the main environmental risks facing Arab populations. The COVID-19 pandemic has highlighted the importance of sound WASH services in the region. The provision of sufficient safe water supply, proper sanitation and hand washing facilities, along with enhanced awareness, is necessary to reduce the spread of infections including the COVID-19 virus. Recent data points to alarming figures, with about 50 million Arabs lacking access to basic drinking water services and 74 million people in the region with no access to basic sanitation services. These poor WASH services are estimated to be the cause of 40,000 premature, avoidable deaths annually.

The provision of safe water supply and sanitation, with the ultimate goal of instating sustainable processes for integrated water resources management, is among the highest-priority challenges facing most Arab countries. Only 9 of the 22 Arab countries are on track to achieve SDG 6 on clean water and sanitation. The region faces many obstructions that hinder progress towards achieving this goal, including conflicts and instability that have impacted water management systems. Water infrastructures, for example, have become targets for destruction during wars. Moreover, the huge influx of refugees in the Arab region has increased the vulnerability of the already scarce water resources.

Meeting the targets of SDG 6 in the Arab region would be a milestone towards developing environmental infrastructures and systems responsive to health needs and development. Countries should develop and implement water and sanitation programs, commit to financing, and advance the enabling environment that make strong policies, laws and plans possible. Overall, political will and prioritization are essential drivers towards change.

AIR

Sociodemographic and economic growth in the Arab world has increased the demand on energy and motor vehicles in recent years. Among other factors, this

has led to air pollution becoming a significant risk to Arab populations. Recorded levels of air pollution often exceeded the WHO limits by 5 to 10 times, and several Arab cities are among the 20 most polluted cities in the world. In many countries in the Arab region there has been a significant rise in the number of deaths attributed to indoor and outdoor air pollution. Likewise, the overall disease burden due to air pollution is increasing, with a higher prevalence of cardiopulmonary disease, cancer incidence, and more cases of asthma. Electricity consumption has increased by 75 percent, leading to a total amount of 766 million tons of CO_2 being emitted in 2015, compared to 436.6 million tons in 2006. Arab countries are now amongst the highest global contributors of carbon monoxide and nitrogen oxide emissions due to inefficient fuel usage, unregulated control of exhaust emissions and an overall increase in vehicles due to urbanization and population growth.

Although available data on air pollution is concerning, there are still large data gaps that prevent an accurate assessment of its impact on human health in the Arab region. The region is for a large part dealing with outdated regulations, lack of law enforcement, and the absence of sustainable air quality monitoring. In order to properly manage air quality in the region, a key step is improving health risk assessments based on air monitoring and modeling studies. Risk management would provide Arab policy-makers with the right tools to control health risks, allocate resources and rank remediation alternatives, ultimately reducing the public health impact of air pollution. The emergence and spread of the coronavirus gave an added sense of urgency to enhancing air quality, as studies have shown evidence of the relationship between air pollution and the increase in and acuteness of cases.

WASTE

Solid waste generation has been increasing at an alarming rate in the Arab region due to population growth, urbanization and changes in consumption and production patterns, which have driven waste systems to the brink. The open dumping of waste is also highly prevalent in the Arab countries, with 53 percent of all generated waste indiscriminately disposed of in an unsanitary manner. Improper collection and inadequate disposal of waste have led to serious air, soil and water contamination, which in turn can have major impacts on the health and wellbeing of the population. Studies have found a high prevalence of respiratory disorders such as shortness of breath, sore throat and cough, alongside high temperature, eye infections and gastrointestinal tract infections among the major health problems attributed, to a large extent, to inappropriate waste management.

The healthcare sector itself is another major contributor to the hazardous waste stream. Due to the expansion of the healthcare sector in the Arab region, medical waste generation has also increased. In several low-income countries, there are no regulations governing this form of waste, meaning that medical wastes are often not separated from general waste. The COVID-19 pandemic has increased the use of single-use items such as masks, gloves, and sanitizer bottles, with a significant portion of this waste winding up in the ocean and along shores.

Lack of legislation has been directly associated with the stagnant state of solid waste management in the Arab region. In concrete terms, Arab countries must work to replace outdated waste facilities with new ones that can reduce associated

health risks and halt the dispersion of pollutants. Public awareness campaigns should also be instilled to promote civic engagement in waste management issues, with a focus on preventable health risks. Adopting a more circular and 3R-centric approach (Reduce-Reuse-Recycle) to waste management is also critical to reduce the harmful impact of waste on human health and nature. The establishment of an effective waste minimization program in the Arab region requires working with various stakeholders involved in the waste value chain, including households, manufacturers and governments.

MARINE ENVIRONMENT

In recent years, the interrelationship between the marine environment and human health in the Arab region has become more apparent due to an increasing number of people moving to coastal areas. Among other factors, the direct discharge of untreated sewage into coastal zones, offshore oil exploration and extraction, and microplastics have impacted the health of the Arab population.

Arab countries produce an estimated 12 billion m^3 per year of wastewater, with no more than 60 percent treated. Only half of the treated water is re-used, and the remaining is discharged, alongside untreated wastewater, mainly in the sea. Untreated sewage can lead to the spread of pathogens that cause disease in humans. Harmful algal bloom (HAB), which has repeatedly killed thousands of tons of fish especially in the Gulf region, is largely attributed to the increase of nutrients from discharged sewage, in combination with high water temperatures. Consumption of seafood contaminated with algal toxins can result in many seafood-poisoning syndromes. Some toxic marine phytoplankton can be acutely lethal.

Oil exploration, extraction and transport in a region that is a leading oil exporter, has resulted in major pollution to the marine environment, and has led to heavy metal contamination of fish that are subsequently consumed by humans. Although most of the recorded petroleum, hydrocarbon and metal concentrations in the marine environment of the Arab countries fall within the permissible limit for human consumption, hotspots of contaminations were identified in localized areas, influenced by oil pollution from refineries, industrial activities and intensive dredging, alongside recreational activities.

Microplastics can also accumulate in the food chain through fish and shellfish, with consequences for human health. Important to note in this regard is that the Mediterranean Sea is considered one of the most affected regions of the world in terms of microplastics pollution.

More research is needed to explore the direct impact of the state of the marine environment on human health in the Arab region, with a focus on pathogens, toxin transfer to humans and antimicrobial resistance.

CLIMATE CHANGE

Climate change has been recognized as a health risk globally, and in the Arab region specifically. Worldwide, direct impacts of climate change – as witnessed by rising temperatures, extreme weather events and sea level rise – include cardiovascular diseases, respiratory diseases, heatstroke, injuries and fatalities.

Indirect impacts include the spread of waterborne, foodborne and vector-borne diseases, water and food insecurity, displacement and forced migration, and effects on mental and occupational health. Climate change also indirectly impacts health by impeding sustainable development and exacerbating poverty. The available literature indicates that climate change has already imposed a health burden in the Arab region, leading to an increase in overall mortality and morbidity from, for example, communicable and non-communicable diseases. A 1°C increase in average temperature is expected to lead to a 3 percent increase in mortality from all causes.

Thus far, insufficient attention has been placed on the impact of climate change on the health of Arab populations. There is also a clear variability in the quality and amount of information provided by different countries. Countries are urged to include health in the national communications reports submitted periodically to international bodies, and researchers are urged to conduct studies that narrow the gaps in knowledge. With a few exceptions in some Arab countries, public health issues are generally missing in national climate change adaptation strategies. The region is largely lacking national adaptation plans that address legislative and advisory responses, based on projected health risks, to heat waves, extreme weather events, air pollution and infectious diseases. Malaria, which already infects 3 million people annually in the Arab region, will become more prevalent and enter new territories as higher temperatures reduce the incubation period, spread the range of malaria-bearing mosquitoes and increase their abundance. It is important for the region to gain a better understanding of the various factors influencing the impact of climate change on health in order to design effective mitigation and adaptation strategies, catered to country-specific situations, with direct and clear effects on the Arab population's health.

CONCLUSION AND RECOMMENDATIONS

The effect of the environmental hazards on human health has become undeniable. When looking specifically at the Arab region, lack of safely managed water, increased waste generation and poor disposal methods, climate change, and pollution of the marine environment all have a noticeable adverse impact on the population's health. Adding on to this, the region has witnessed the effect of the recent COVID-19 pandemic on both human health of people and on the environment. The pandemic has at the very least made clear that "health for all" is a necessity, not only in terms of access to healthcare and sanitation services, but also to expedite steps towards a greater consideration of the region's largely avoidable environmental risks on human health. In a collaborative approach, the Ministries of Health and Ministries of Environment in the Arab region should emphasize the importance of the public health and environmental sectors. They should assume both their governance and surveillance responsibilities, and catalyze the relevant sectors to take preventive actions and corrective interventions.

Looking specifically at the provision of safe water services, Arab countries should develop and implement water and sanitation programs that include comprehensive monitoring of the quantity and quality of water supplies. In terms of air pollution, air quality standards need to be updated to comply with health-based international ones and data gaps need to be filled to gain an accurate assessment of the impact of air pollution on rates of morbidity and mortality in the region. A network of operational monitoring stations in all Arab countries

is also essential for the surveillance of air quality. Taking note of climate change influences specific to the region, effective and tailored climate change mitigation and adaptation strategies with direct and clear effects on the Arab population's health must be developed, with immediate action on adaptation measures. The adverse impacts of the increase in waste generation in the region and its subsequent mismanagement are exacerbated by a lack of legislation. Legislation needs to be developed, as well as a comprehensive monitoring and evaluation framework to assess the impact of waste on human health. More attention needs to be geared towards the state of the region's marine environment and its potential dangers to human health. Regular monitoring of heavy metal levels in fish species, for example, is necessary to prevent health risks and to ensure nutritional safety conditions. Marine litter, leading to excess microplastics, also should be tackled. For any measures to bear genuine results, proper mechanisms to enforce standards and regulations are needed.

Overall, exchange of expertise in health and environment-related disciplines across the Arab countries is needed, with regional cooperation intensified, encompassing emergency preparedness to face health and environmental disasters. Establishing a primary health care system, including health education, is an urgent task. Ultimately, regional strategies setting common goals to achieve the SDGs are required.

Interconnectedness between natural environment and human health has always been a vital concern; the threat of intensifying pandemics brings it to the center stage. It has never been more obvious that a healthy environment is a prerequisite to healthy people.

OVERVIEW OF THE ENVIRONMENTAL HEALTH SITUATION IN THE ARAB REGION

Basel Al-Yousfi, Mazen Malkawi

I. INTRODUCTION

The interrelationship between health and the environment means that one can never have a healthy community in a contaminated environment, nor a clean environment in an unhealthy community. Indeed, health equity is intimately linked to socio-economic equality and environmental justice.

The World Health Organization defines environmental risks to health as "all the environmental, physical, chemical, biological and work-related factors external to a person, and all related behaviors. It focuses especially on the part of the environment that can reasonably be modified" (WHO, 2020). Acknowledging the extent to which focusing on sound control can prevent disease and illnesses and management of environmental risks adds impetus to efforts encouraging preventive public health measures through all available policies, strategies, interventions, technologies and knowledge.

Exposure to high levels of household (indoor) and ambient (outdoor) air pollution, lack of access to safely managed water, sanitation, and hygiene services, contact with toxic chemicals and wastes, imposition of occupational hazards and poor environmental health services in emergencies have been identified as the main environmental risks affecting health in the Arab region (WHO et al. 2017). These environmental risk factors are the result of different ecological, social and economic driving forces and pressures the Arab region is faced with, including unsustainable development, humanitarian emergencies, population dynamics (migration and displacement), fragile eco-systems (arid region, desertification, water scarcity, etc.), rapid urbanization, climate change, weak monitoring and surveillance systems, and greater human-animal interaction. These hazards fuel the region's inherent vulnerability to respond to outbreaks (occurrence of disease cases in excess of normal expectancy), epidemics (disease that affects a large number of people within a community, population, or region) and pandemics (an epidemic that is spread over multiple countries or continents such as COVID-19).

The Arab Strategy and Guidelines of Action on Health and Environment 2017-2030 indicates that based on data collected in 2016, environmental hazards are responsible for about 23 percent of the total burden of disease, including more than 628,000 deaths per year and 24 million yearly disability-adjusted life years (DALYs) (WHO, UNEP, & LAS, 2017). It is worth mentioning, though, that Arab countries differ greatly in their socioeconomic, demographic, environmental and health conditions and capabilities, both locally and nationally. Figure 1 provides a clear illustration of this variability in terms of environmental health impacts, manifesting in gradient mortality and morbidity rates.

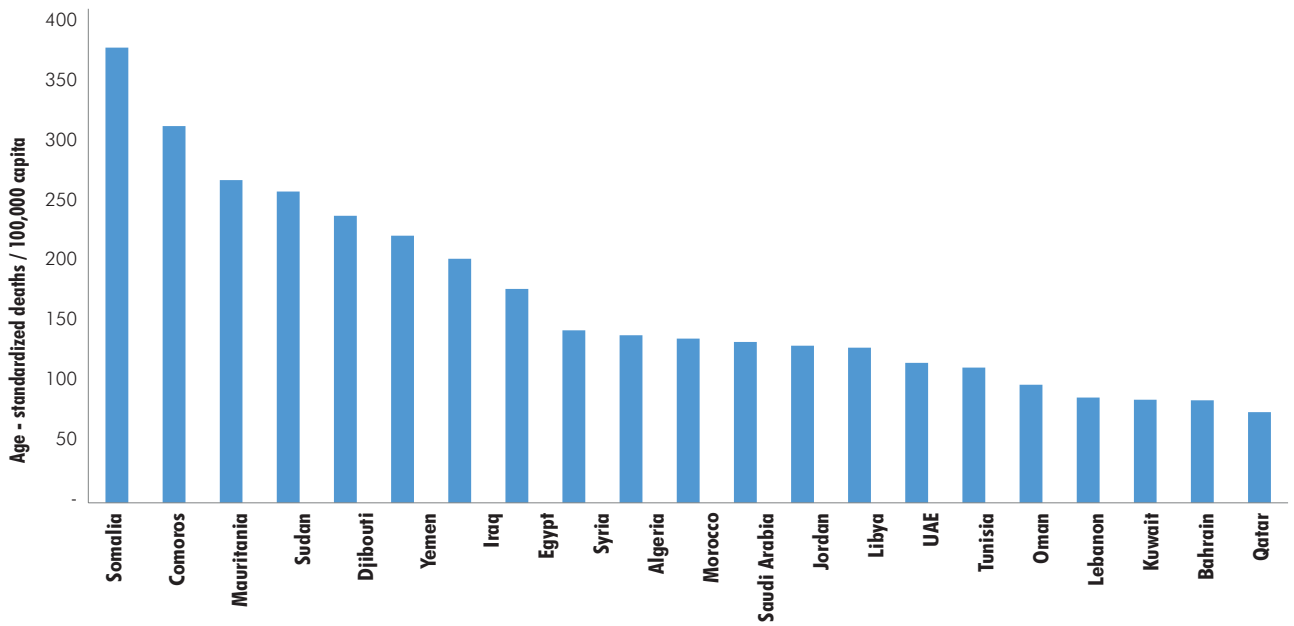
Based on data published by WHO and other regional and international organizations Arab countries can be grouped in three groups based on environmental health indicators and outcomes of public health, and according to the performance of health systems, merits of environmental services and intrinsic potential for funding them (Prüss-Üstün & Corvalán, 2019; WHO et al. 2017):

1. **Group 1- High-Income Countries** (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and UAE): 13 percent of the population of the Arab region falls under this group. The level of environmental health services is good and the annual environmental burden of disease is 25.4 DALYs per 1000 population. The main environmental risk factors prevailing include air pollution, chemical exposure, housing and urban environmental determinants of injuries.

2. **Group 2- Middle-Income Countries** (Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, and Tunisia): 57 percent of the Arab region's population lives in this group. The level of environmental health services is hardly satisfactory, and the annual environmental burden of disease is 39.3 DALYs per 1000 population. The main environmental risk factors prevailing include water and sanitation, air pollution, exposure to chemicals and wastes, and food contamination. It is worth noting that due to multiple current crises, some of these countries are increasingly facing additional environmental health pressures and capacity deterioration.

3. **Group 3- Low-Income Countries** (Comoros, Djibouti, Mauritania, Somalia, Su-

FIGURE 1 **ANNUAL DEATHS ATTRIBUTABLE TO ENVIRONMENTAL RISKS[1]**



dan, and Yemen): 30 percent of the population of the Arab Region falls under this group. The level of environmental health services is lacking, and the annual environmental burden of disease is 91.4 DALYs per 1000 population. The main environmental risk factors prevailing include water and sanitation, indoor air pollution, exposure to chemicals and wastes, and food contamination.

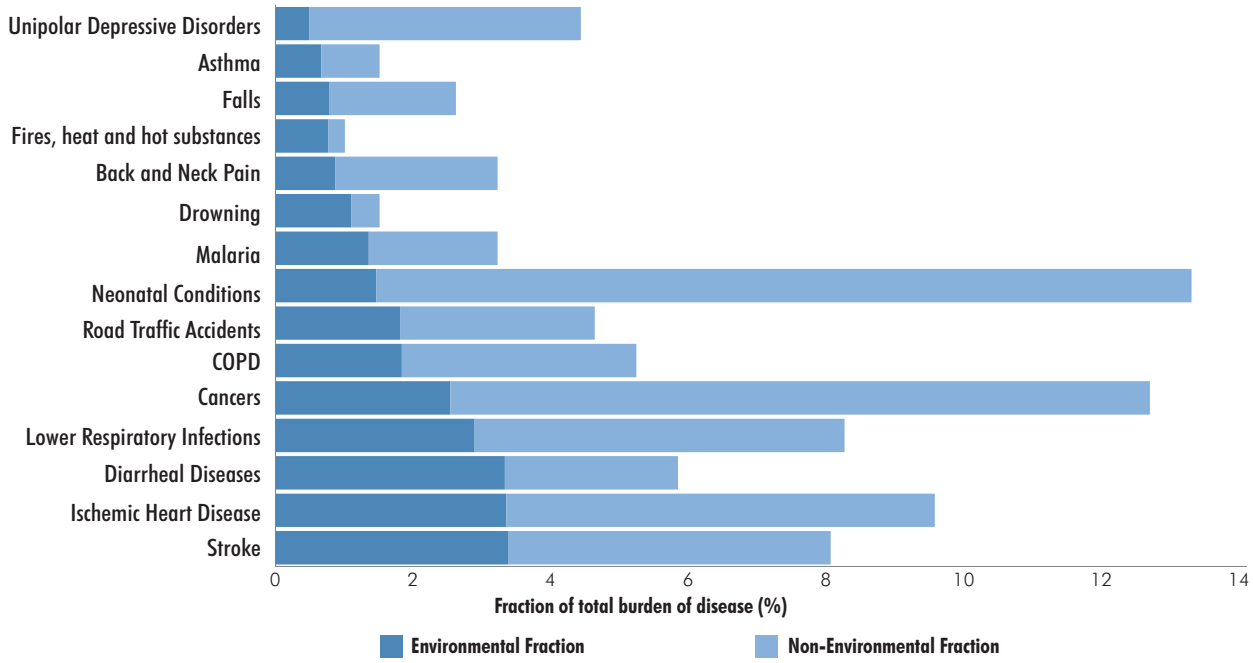
II. BURDEN OF ENVIRONMENTAL RISKS ON HEALTH IN THE ARAB REGION

Out of the 133 illnesses and injuries reported to WHO, 101 diseases and injuries have significant links with the environment, 92 of which are quantifiable (Prüss-Üstün & Corvalán, 2012). Figure 2 lists diseases with the strongest environmental ties and contributions. WHO is using these quantifiable linkages to estimate the burden of modifiable environmental risks on health globally.

The latest estimate, done in 2019, concluded that the rate of deaths attributable to environmental risks has been stagnant since 2016, at a level of about 23 percent (higher amongst children and vulnerable groups) of all deaths and disease burden in the Arab region (Prüss-Üstün et al., 2019). The Arab region's population increased from 405.2 million in 2016 to about 436.4 million in 2020. Accordingly, the number of environmentally-related premature deaths increased from 628,000 in 2016 to 676,350 in 2020[2].

The recent COVID-19 pandemic has revealed the world's vulnerability and under-preparedness to tackle major episodes of novel communicable disease outbreaks. The last decade has seen a distinct shift in the burden of diseases, as the world is diverting away from communicable, infectious, parasitic and mal-nutritional diseases towards non-communicable diseases (NCDs) and injuries. Such a trend in NCD prevalence is a consequence of pressures imposed by modern society, an inactive living style, overconsumption of food, expanded life expectancy (due to medical advancements), as well as emerging environmentally related causalities (versus the traditional ones). This shift is mainly due to a global decline in contagious disease prevalence rates and a reduction in the environmental risks triggering infectious disease outbreaks, i.e., a

FIGURE 2 DISEASES AND INJURIES WITH STRONGEST LINKAGES TO ENVIRONMENTAL RISKS[3]



higher share of the population with access to safe water, basic hygiene and improved sanitation, and a lower share of households using solid fuels for cooking. In terms of the total disease burden, regardless of the public health and environmental protection improvements, NCD prevalence has increased globally as well as in most of the Arab countries, as illustrated in Figure 3 (AFED, 2016).

As described below, the adverse health burdens of the aforementioned, conventional environmental risks in the Arab region have

FIGURE 3 CAUSES OF DEATH ATTRIBUTABLE TO THE ENVIRONMENT IN THE WORLD AND THE ARAB REGION

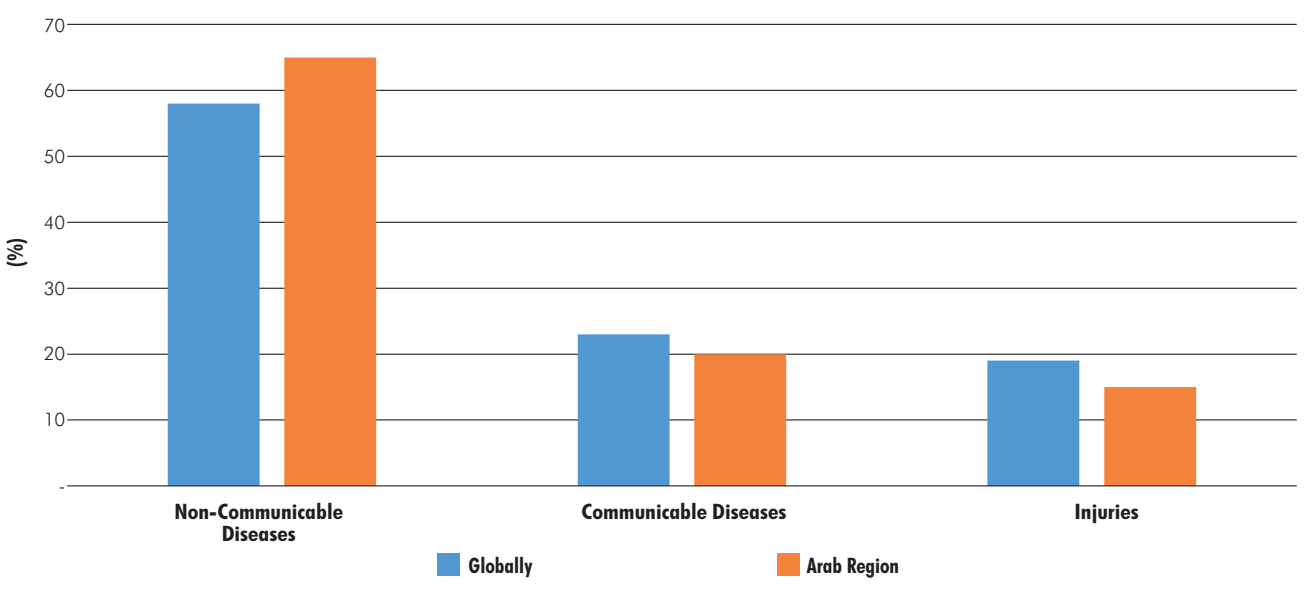


TABLE 1 **LEVELS OF AIR POLLUTION AND HEALTH IMPACTS IN 2016[4]**

Country	Concentrations of fine particulate matter (PM2.5) mg/m^3	Proportion of population with primary reliance on clean fuels and technologies (%)	Ambient and household air pollution attributable death rate (per 100,000 population)
Algeria	35.2	93	40
Bahrain	69	>95	15
Comoros	18.6	9	94
Djibouti	40.4	12	99
Egypt	79.3	>95	73
Iraq	57.7	>95	35
Jordan	32.1	>95	26
Kuwait	57.2	>95	37
Lebanon	30.7	No data	52
Libya	44.2	No data	43
Mauritania	40.8	47	88
Morocco	31	>95	40
Oman	38.2	>95	22
Palestine	No data	No data	No data
Qatar	90.3	>95	13
Saudi Arabia	78.4	>95	39
Somalia	29.5	<5	152
Sudan	47.9	41	105
Syria	39.4	>95	44
Tunisia	35.7	>95	57
United Arab Emirates	39.4	>95	16
Yemen	45	65	90

been scientifically quantified by WHO and other international partners, while impact estimations of the remaining novel and emerging risks (e.g. nanoparticles) are still being researched and debated amongst experts.

A. Air Pollution

Air pollution is one of the major avoidable causes of illness and disease globally. WHO estimated in 2016 that about 36 percent of deaths from lung cancer, 35 percent of deaths from chronic obstructive pulmonary disease (COPD), 34 percent of deaths from stroke and 27 percent of deaths from heart disease are collectively attributable to air pollution (WHO, 2019).

The adverse effects and impacts of air pollution on health in the Arab region are no different from other parts of the world, yet our environmental monitoring and health surveillance systems, and thus our early warning capacities, are considerably lower. For example, although over 90 percent of our urban populations are exposed to high levels of air pollutants, the number of Arab cities that are monitoring and reporting air quality and atmospheric pollution is quite narrow in comparison to other parts of the world (WHO, 2019). The number of source apportionment and chemical composition studies is also limited (Karagulian et al., 2015). However, the sparsely available studies report that about 50 percent of our ambient air pollution linked with particulate matters (PM) originates from natural dust and sea salt, while the rest stems from transportation, energy production, industrial emissions, and

TABLE 2 **ACCESS TO WATER, SANITATION AND HEALTH IN THE ARAB REGION IN 2017[6]**

Country	Population using at least basic sanitation services (%)	Population using safely managed sanitation services (%)	Population using at least basic drinking-water services (%)	Population using safely managed drinking-water services (%)	Population with basic handwashing facilities at home (%)	Population practicing open defecation (%)
Algeria	88	18	94		84	1
Bahrain	100	96	100	99		0
Comoros	36		80			1
Djibouti	64	36	76			17
Egypt	94	61	99		90	0
Iraq	94	41	97	59	95	0
Jordan	97	81	99	94		0
Kuwait	100	100	100	100		0
Lebanon	98	22	93	48		0
Libya	100	26	99			0
Mauritania	48		71		43	32
Morocco	89	39	87	70	97	7
Oman	100		92	90		0
Palestine						
Qatar	100	96	100	96		0
Saudi Arabia	100	78	100			0
Somalia	38		52		10	28
Sudan	37		60		23	24
Syria	91		97		71	
Tunisia	91	78	96	93	79	0
UAE	99	96	98			0
Yemen	59		63		50	20

residential anthropogenic sources. As indicated in Table 1, these sources contribute collectively to very high levels of outdoor air pollution, reaching up to 9 times the recommended WHO levels. Although the Arab region is considered rich in oil and gas and renewable energy, some of our countries are still forced to rely on unclean fuels for cooking, heating and lighting domestically. The combined health impacts of these types of air pollution (natural and anthropogenic) are summarized in Table 1. Using these available air pollution rates to estimate the number of deaths in the Arab Region depicted a premature mortality figure of about 472,200 premature deaths in 2020 alone.

B. Water, Sanitation and Hygiene

Lack of access to basic and/or safely managed drinking water and sanitation services is quite common in the Arab region, with variabilities between and within countries. Unfortunately, this lack is evidently increasing due to ongoing crises and emergencies affecting several Arab countries, where it is suspected that the exact circumstances of the level and merits of such services are simply unknown. However, the recent, scarcely available data sets are summarized in Table 2, outlining rates of service accessibility and shortcomings imposed on Arab countries in terms of water, sanitation and hygiene risks. Analyzing these rates for Arab populations in 2020 points to quite alarming findings: about 50 million people do not have access to basic drinking water services; 74 million do not have access to basic sanitation services, and about 25 million people are still practicing open defecation. Moreover, while data available on the

accessibility to safely managed drinking water and sanitation services is also lacking, there is sufficient evidence to believe that the proportion of the Arab population lacking access to safely managed WASH services is indeed much higher than those deprived of access to basic services. The Institute for Health Metrics and Evaluation (IHME) estimated that WASH risk factors in the Arab region are prematurely causing about 40,000 deaths annually[5]. The majority of these avoidable deaths are happening in least developed Arab countries and impoverished communities.

C. Climate Change

Evidence linking climate change and health continues to build up, and there is increasing demand to thoroughly assess the health effects and impacts of climate change. Adverse health effects resulting from climate change touch the entire world. However, health vulnerability and resilience are of particular concern in less developed countries, and considering the compound effect of air pollution and the need for clean energy are of high priority in emerging economies (Patz et al., 2008; WHO, 2014). Historically, the Arab region's cumulative contributions to GHG emissions, and thus global warming, are limited. Nonetheless, the region is the second worst health-impacted by climate change after Africa (Patz, 2018), meaning that those who have contributed the least to climate change, since the industrial revolution, are adversely affected the most. Water scarcity, food security, coastal zone deterioration and sand storms are key concerns in the Arab region. These risks to health security – affecting all Arab countries disproportionately – are exacerbated by more frequent extreme weather events such as floods, droughts, and cyclones, infectious disease outbreaks, as well as internal migration (rural to urban, IDPs) and external migration (refugees, expats).

Direct health effects of climate change include greater risks of injury and death due to intense heat waves and fires, increased risk of foodborne, waterborne, airborne and vector-borne diseases, increased risk of undernutrition, excess morbidity and mortality due to heat exhaustion and heat strokes, and worsened cardiovascular and respiratory illnesses that arise from extreme weather events such as heat waves, sand storms and air pollution episodes. Indirect health effects

TABLE 3 **MORTALITY RATE ATTRIBUTED TO UNINTENTIONAL POISONINGS IN 2016[7]**

Country	Mortality rate attributed to unintentional poisoning (per 100,000 population) in 2016	Country	Mortality rate attributed to unintentional poisoning (per 100,000 population) in 2016
Algeria	0.8	**Morocco**	0.6
Bahrain	0.2	**Oman**	0.4
Comoros	2.4	**Palestine**	No Data
Djibouti	2.4	**Qatar**	0.4
Egypt	0.2	**Saudi Arabia**	0.7
Iraq	0.5	**Somalia**	4.6
Jordan	0.6	**Sudan**	3.9
Kuwait	0.2	**Syria**	0.4
Lebanon	0.3	**Tunisia**	0.5
Libya	0.6	**United Arab Emirates**	0.3
Mauritania	1.9	**Yemen**	3.8

are those associated with the possibility of mass displacement of communities and disruption of livelihoods in drought-struck, low-lying zones and small island states, increased risk of violent conflicts associated with resource scarcity and population movement, slowdown in economic growth, exacerbation of poverty, proliferation of slummed urbanization, and an increase in health inequity, education imparity and environmental pressure (WHO, 2017).

Climate change magnifies and exacerbates all the health impacts imposed by conventional environmental risks. All Arab countries are experiencing climatic changes, including rise in temperature and heat waves, reduction in rainfall, water scarcity, food insecurity, deterioration in air quality, and an increase in the frequencies and durations of sand and dust storms. These factors pose serious risks to public health in the region, manifested in weather-related mortality and injuries, water-borne (e.g., diarrhea, cholera, dengue) and food-borne diseases (e.g., malnutrition, stunting) and/or air-borne communicable or non-communicable diseases (e.g., pneumonia, asthma, cardiovascular disease).

D. Toxic chemicals and wastes

Exposure to various chemicals occurs every day and through multiple interaction routes such as ingestion, inhalation, and skin contact, as well as via the umbilical cord into the unborn child. If handled carefully, many chemicals are harmless or even beneficial. Other chemicals are real threats to our health and to the ecosystems. Chemical production continues to increase and, with it, the potential for chemical exposure throughout life cycles. Production of chemicals in the Middle East increased by 8.5 percent during the period 2000-2017 (UNEP, 2019).

Globally, WHO estimates that 1.6 million lives and 45 million DALYs were lost in 2016 due to human exposure to selected chemicals (21 deaths per 100,000 population) (WHO, 2018). Unfortunately there are no credible estimates in specified to Arab countries or at the regional level. If the global rate is utilized to forecast the burden of exposure to toxic chemicals in the Arab region, one can estimate about 90,000 deaths occur annually, encompassing unintentional poisonings. Table 3 summarizes the rate of death of unintentional poisonings in Arab countries in 2016.

The problem of waste in most Arab countries is in dire need of immediate solutions technically, financially and politically. In the absence of dedicated facilities to handle hazardous waste, there is a real concern that such waste will be disposed of together with non-hazardous waste, thereby contaminating landfills, soil, water, air and biota, and exposing the public health to great

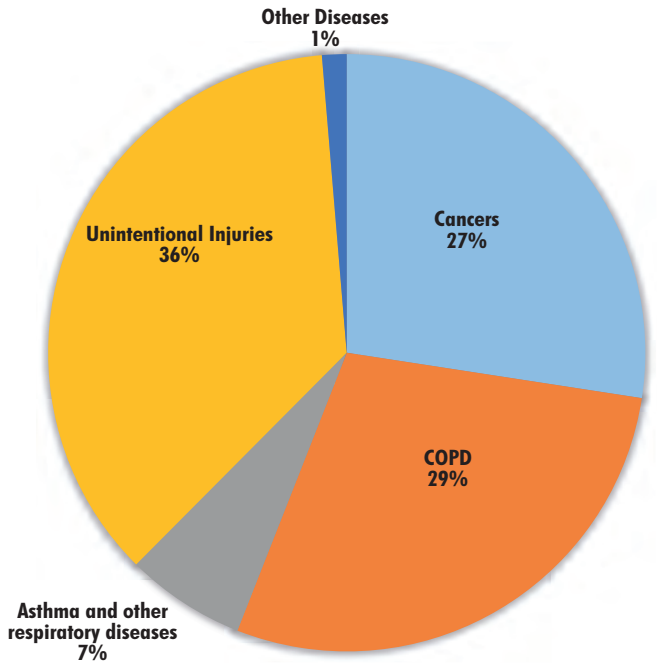
environmental risks. The environmental health risks and impacts stemming from various wastes are common to all Arab countries, and since the potentially health-threatening components within each waste type are different. However, the actual risks posed vary widely between countries and communities based on operational practices, storage methods, personal hygiene, enforcement of regulations and quality of management, as well as levels of income. Interdisciplinary initiatives are needed to improve knowledge on risks imposed to human health from wastes. These should incorporate short- and long-term epidemiologic and toxicological studies on specific groups, exposure scenarios to individual chemicals and chemical mixtures, and should include transformation, fate and transport, as well as synergistic and antagonistic effects. Waste management in the Arab region should first and foremost protect the public health and the population, and minimize indirect impacts from environmental exposures to potential hazardous risks.

While many Arab countries are still struggling with the basic sound management of traditional wastes, the highly consuming modern society is significantly increasing rates and types of wastes generated in the Arab region (e.g., from municipal to electronic to hazardous etc.), and thus escalating the adverse impacts of mismanagement. However, no credible estimate is available that quantifies the burden of disease stemming from the waste dilemma in the region. Healthcare waste, including medical sharps, infectious and hazardous streams, if not handled or separated properly, can result in serious illness and disease (e.g., hepatitis, HIV), imposing additional risks to patients, health workers, visitors and the public at large.

E. Occupational Risks

After homes, the workplace is where people spend most of their adult lives. In the course of a career, people experience diverse, often high-level, exposure to various environmental hazards, with subsequent health effects, which can be undoubtedly avoidable. Occupational risks account for a large fraction of the global disease burden. Figure 4 lists the main diseases that are directly linked to occupational hazards in the Eastern Mediterranean region, encompassing most Arab countries. Across the entire population,

FIGURE 4 **DEATHS ATTRIBUTABLE TO OCCUPATIONAL RISKS BY DISEASE[8]**



at least 2.1 percent (1.35 percent in the Arab region) of all deaths and 2.7 percent (2.1 percent in the Arab region) of all DALYs are attributable to working environments (Wolf et al., 2018). These percentages might even be higher amongst certain vulnerable groups in informal sectors (e.g., migrant workers, child workers). Accordingly, in the Arab region about 31,000 people are losing their lives prematurely every year due to occupational exposure and workplace hazards.

F. Other Environmental Risk Factors

The Arab region is faced with serious emerging challenges stemming from our new "modern" lifestyle and the prevailing patterns of unsustainable production and consumption, on top of the traditional environmental health risk factors. The emerging environmental risk factors such as radiation, various wastes, environmental emergencies, and unsafe food are also adversely affecting public health, with variable consequences and different magnitudes, although there are no unified methodologies to track and quantify their impact at local levels. New environmental, climatic and health issues are also emerging and are imposing dangers that require

rapid identification and public health responses. Recent examples include the pressing dilemma of managing electronic waste, nanoparticles, micro-plastics and endocrine-disrupting chemicals, to mention a few. Poor management of such newly rising environmental hazards can endanger public health and severely compound other predicaments such as socio-economic and technological risks.

III. GAPS AND CHALLENGES

The current situation and challenges call for a dire transformation in the way we prevent, control and manage our environmental health priorities. Current approaches have laid the ground, but have not proven sufficient for sustainably and efficiently reducing environmental risks on public health and for building up health-supportive and enabling environments. The below section lists the WHO Regional and Global Strategies on Health, Environment and Climate Change's main challenges that have caused for the rate of deaths attributable to environmental risks to remain stagnantly high for the last years (WHO, 2020; WHO, 2015; WHO, UNEP, LAS, 2017):

- Uneven and unsustainable developments has left some parts of the Arab populations and societies still lacking access to basic environmental services such as safe sanitation, safe drinking water, clean energy and air quality, and reliable, safe food.

- Current governance mechanisms, including those at the local level, are still inadequate to deal effectively with the cross-cutting nature of environmental health issues. Health wellbeing and/or environmental welfare are rarely central to decisions and policies that are affecting developmental trends. This has resulted in missed opportunities for human health protection and environmental preservation. Financial and human resources allocated to health promotion and pollution prevention remain insufficient to reduce the substantial burden of disease caused by environmental risk factors on health in the Arab region.

- Large-scale changes that societies are continuing to experience often include increasing demand for energy, transport and technological

innovation, construction and urbanization, as well as more flexible mobility of people, goods and services. Moreover, there are gaps in institutional capacities for health protection throughout the region to keep up with modern day societal transformations, namely in terms of knowledge, legislation, enforcement, management of hazards, and accident response.

- Traditional approaches, focusing on medical treatment of individual diseases rather than reducing the adverse impact of the determinants of health, will be insufficient to tackle modern environmental challenges and increasingly complex health impacts.

- Aggravated by inefficient communication, evidence is still incomplete or lacking for certain environmental risks on health, such as climate change, electronic waste and numerous chemicals or their mixtures. Knowledge gaps continue to prevent efficient implementation of health-protective strategies based on evidence.

- Notwithstanding the limited contributions of the Arab region to climate change, the health impacts on Arab populations are tremendous, affecting people's health and well-being negatively with much higher consequences than in other parts of the world.

IV. NEW PERSPECTIVES: REGIONAL AND NATIONAL EFFORTS

Providing benefits almost immediately, the 2030 Agenda for Sustainable Development offers significant win-win scenarios for protecting health, climate and the environment. The Sustainable Development Goals (SDGs), with their underpinning holistic approach, offer tangible opportunities in the Arab world and beyond to make a lasting contribution to curtailing the global disease burden attributable to environmental risk factors, and they help "ensure healthy lives and well-being for all at all ages". Armed with the evidence of what is achievable, and needed, public health and environmental policy-makers and public health practitioners alike are encouraged in their mandated efforts to promote sustainable development through healthy societies.

In 2014, the Ministers of Health of the 22 countries of the Eastern Mediterranean region (including 19 Arab countries) endorsed the WHO strategy and framework of action on health and environment 2015-19, and started implementation by compiling national health and environment strategies in Sudan, Egypt, and Lebanon.

In 2017, the Ministers of Health and Environment of the 22 Arab countries endorsed the 2017-2030 Arab Strategy and guidelines of action on health and the environment. Later on, Arab leaders unanimously adopted the Arab Strategy during a Summit in Saudi Arabia in 2018. Arab countries continued to compile national data and have started to develop their strategic plans of action on health and the environment, which has happened so far in Bahrain, Iraq, Kuwait, Oman, Saudi Arabia, Syria, Tunisia and UAE.

In 2019 and during the World Health Assembly (WHA), The Ministers of Health of all WHO member states endorsed the global strategy on health, environment and climate change. This strategy aims to provide a vision and way forward on how the world needs to respond to environmental health risks and challenges until 2030, and aims to ensure safe, enabling and equitable environments for public health by transforming our way of living, working, producing, consuming and governing.

In principle the three aforementioned strategies, as implemented in the region, aim at reducing the burden of environment risks to health by:

- Scaling up actions on health determinants for public health protection, environmental

safeguard, and sustainable development improvement as outlined in the SDG 2030 Agenda and guiding such actions by monitoring progress towards related sustainable development goals and targets.

- Acting in a multi-sectoral overarching manner on all social and environmental determinants of health, employing health in all policies approach as well as health for all by all principles.

- Building up governance, regulatory, political and social mechanisms for generating evidence-based systems relying on risk assessment, management and communication approaches.

- Strengthening public health and environmental protection sectors' leadership, governance and enforcement mandates, and coordination and advocacy roles.

V. CONCLUSION AND RECOMMENDATIONS

Environmental exposure, hazards and risks are among of the key determinants of health throughout a lifetime. It is estimated that more than 676,000 Arab citizens will lose their lives prematurely in 2020 due to exposure to conventional environmental risks such as air pollution, lack of clean water and improved sanitation, climate change, intermingling with toxic chemicals and wastes and exposure to occupational risks. This figure will increase as more emerging environmental risk factors and their impacts are quantified.

The Arab strategy on health and the environment (2017-2030) outlines, however, nine environmental health priorities in the following areas: 1- Water, sanitation and health; 2- Air pollution; 3- Food safety; 4- Chemical safety; 5- Waste management and environmental health services; 6- Environmental health emergency management; 7- Climate change and health; 8- Sustainable development and health; and 9- Occupational health and safety. More research is needed to further understand the health impacts of modern environmental risks that are emerging, such as electronic waste and nanoparticles.

Environmental protection is a prerequisite for saving humanity, when embedded within sound public, community and individual health wellbeing systems. Many measures can be taken immediately to curtail environmental risks (natural or man-made) and alleviate the disease burden attributable to environmental hazards. Examples include the promotion of safer water and improved sanitation services, the use of cleaner fuels and sustainable energy, more judicious handling and management of toxic substances (at home and in the workplace), and sound protection against occupational exposure. Accordingly, under the stewardship of public health and the environmental sectors, and in mutual cooperation between all pertinent

stakeholders, actions taken by sectors such as energy, transport, municipality, agriculture and industry are vital to address the environmental root causes of ill health. Clearly, actions do not come from the public health or environmental protection sectors alone, but rather from all sectors impacting environmental determinants of health. Consortia acting for collective coordination of environmental health safeguard will strengthen developments and sustain improvements for the sake of human well-being and welfare.

The traditional approach to managing the disease burden of environmental risks relied on treating the symptoms rather than mitigating or controlling the root causes. A multi-sectoral shift in the approach is needed to focus on upstream preventive and corrective interventional actions to minimize environmental risks. The enormity of the environment-related burden of disease means that these hazards and related health risks cannot be addressed effectively if they are tackled separately. It is essential to adopt and implement an integrated "ecological public health approach" which recognizes the complex interactions between biological, behavioral, environmental, social and developmental nexuses. The direct and indirect impacts of emerging environmental risks, such as climate change and ecosystems and biodiversity deterioration, need to be tackled urgently in the Arab region, as they are set to become the most challenging risks Arab generations will face in the upcoming decades. Considering the high burden of modifiable environmental risk factors for communicable and non-communicable diseases in the Arab region, and the availability of cost-effective environmental health interventions from prevention to mitigation to control, it is vital that a collaborative multidisciplinary approach is adopted and that resources are made available to carry it out going forward.

Many aspects of environmental health services are situated outside the mandate of a single agency and the health and/or the environmental sectors. Therefore, the Arab region shall assume a comprehensive, integrated multi-sectoral framework of work for managing environmental health risks and services, steered by health in all policies (HiAP) and "health for all by all" principles. Our actions shall focus on supporting the leadership role of the public health and environmental protection sectors in regulating and monitoring environmental health factors and nexuses with the burden of disease, promoting preventive interventions and catalyzing adequate environmental health services and actions by other relevant sectors (e.g., water, municipalities, energy, agriculture, industry, transport, etc.). In a collaborative multi-agency strategic approach, the Ministries of Health and Ministries of Environment in the Arab region should be assuming the roles of stewarding brokers and interlocutors in partnership with other stakeholders. This would emphasize the leadership of the public health and environmental sectors in terms of governance and surveillance responsibilities, and would catalyze relevant sectors to take preventive actions and corrective interventions.

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NOTES:

1. Data extracted from the Arab Strategy and Plan of Action on Health and Environment 2017-2030.

2. Population of the Arab Countries in 2016 and projections for 2020 were extracted from http://www.worldometers.info

3. Reproduced from Prüss-Üstün et. al. Preventing disease through healthy environments: A global assessment of the burden of disease from environmental risks. Geneva: World Health Organization, 2019

4. Extracted from the WHO databases on health impacts of air pollution https://apps.who.int/gho/data/node.main.122?lang=en

5. Data extracted from the IHME global burden of disease site https://vizhub.healthdata.org/gbd-compare/

6. Data extracted from the WHO Data Base on Exposure to Water, Sanitation and Hygiene https://apps.who.int/gho/data/node.main.46?lang=en

7. Extracted from the WHO database on health impacts of unintentional poisonings https://apps.who.int/gho/data/node.main.SDGPOISON393?lang=en

8. Based on data extracted from Wolf et al., 2018

OPINION

CORONAVIRUS IS A WARNING TO US TO MEND OUR BROKEN RELATIONSHIP WITH NATURE

Marco Lambertini, Elizabeth Maruma Mrema, Maria Neira

The world must embrace a recovery that involves sustainable farming and clean energy. Anything else is a false economy

In 1997, a large area of rainforest in south-east Asia was burned to the ground to make way for palm oil plantations. A combination of deforestation, forest fires and drought are believed to have forced hundreds of fruit bats away from their natural habitats towards fruit orchards planted in close proximity to intensive pig farms. These conditions led to the emergence of the Nipah virus, which spilled over from infected bats to pigs, and from pigs to pig farmers. Over the next two years, the disease would kill more than 100 people. This should have served as a warning.

Now, 20 years later, we are facing a health crisis of an altogether different scale, with Covid-19 causing the most tragic health, social and economic crisis in living memory.

We have seen many diseases emerge over the years – such as Zika, AIDS, SARS and Ebola – and although they are quite different at first glance, they all originated from animal populations under conditions of severe environmental pressures. And they all illustrate that our destructive behaviour towards nature is endangering our own health – a stark reality we've been collectively ignoring for decades. Research indicates that most emerging infectious diseases are driven by human activities.

The unsafe handling, consumption and trade in high-risk wildlife species is just one example of the ways in which our broken relationship with nature is affecting human health. In many countries, wild animals are captured and brought live to markets to be sold. However, unless well-managed and regulated, these markets can pose a significant risk to humans, wildlife and livestock, by bringing high-risk species – many of which are endangered – into close contact with other animals, wild and domesticated, and people, thereby creating the conditions for disease spillover.

Considerably strengthening and enforcing regulation, enhancing food safety, ending the illegal and unsustainable wildlife trade, and providing alternative livelihood options to reduce the consumption of wildlife everywhere are critical steps to help prevent future zoonotic diseases from emerging. It is therefore encouraging to see some progress in recent months: in February, China announced a temporary ban on the trade and consumption of wild animals, which it is now looking to make permanent; while Vietnam has signalled it may take similar steps to help curb the spread of disease and prevent future outbreaks.

While action on the illegal, unregulated and high-risk wildlife trade is important, we must not make the mistake of thinking it is sufficient. We must also urgently tackle the underlying issues that are driving the destruction of nature.

We must recognise that the way we currently produce and consume food, and our blatant disregard for the environment more broadly, has pushed the natural world to its limits. Nature is currently declining globally at rates unprecedented in human history, and this is actually increasing our vulnerability to new diseases, particularly as a result of land-use change through activities such as deforestation, and agricultural and livestock intensification. These outbreaks of disease are manifestations of our dangerously unbalanced relationship with nature.

Worryingly, while Covid-19 has given us yet another reason to protect and preserve nature, we have actually seen the reverse take place. From the Greater Mekong to the

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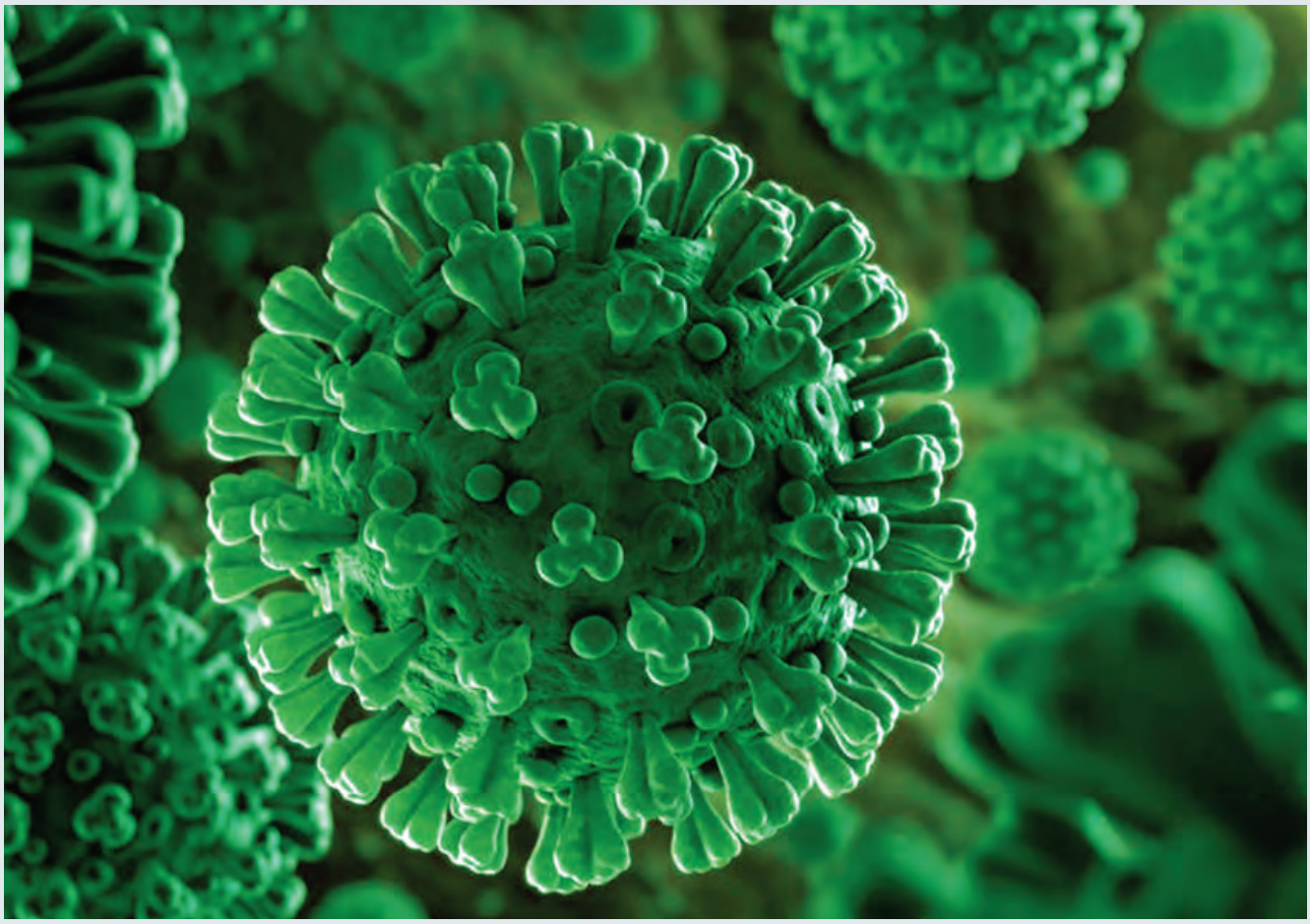

Amazon and Madagascar, alarming reports have emerged of increased poaching, illegal logging and forest fires, while many countries are engaging in hasty environmental rollbacks and cuts in funding for conservation. This all comes at a time when we need it most.

As the world emerges from this crisis, it is crucial that governments restore ecosystems and put economies on a sustainable path if we're to reduce our vulnerability to health threats.

We must embrace a just, healthy and green recovery, and kickstart a wider transformation towards a model that values nature as the foundation for a healthy society, and a well-resourced and equitable economy. This means shifting to more sustainable practices, such as regenerative and diversified agriculture and diets, sustainable animal farming, green urban spaces and clean forms of energy.

Not doing so, and instead attempting to save money by neglecting environmental protection, health systems and social safety nets, has already proven to be a false economy. The bill will be paid many times over.

The UN biodiversity summit, scheduled for September, offers world leaders a first opportunity to signal their support for a new relationship with our natural world. We hope they will take it and accelerate action through to next year when they are scheduled to take critical decisions on the environment, climate and development. Together, these represent an unmissable opportunity to secure a new deal for nature and people that sets nature on the path to recovery by the end of the decade and safeguards human health and livelihoods in the long term.

Rebalancing our relationship with nature will require concerted effort and determination. But it will also create a healthier and more prosperous future for people and planet, and put us in a better position to prevent the next pandemic. Surely, it is an effort we should all be willing to make.

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HEALTH AS A REGIONAL SUSTAINABLE DEVELOPMENT GOAL

Rima R. Habib, Nataly W. El-Haddad, Shelby Surdyk

I. INTRODUCTION

In September 2015, the United Nations (UN) General Assembly discussed the post-2015 development agenda and launched the 2030 Agenda for Sustainable Development. This resulted in the Sustainable Development Goals (SDGs), a set of 17 goals guiding global action towards achieving a sustainable future for all by the year 2030. The SDGs consist of a set of targets subsequent to the Millennium Development Goals (MDGs) of the year 2000, which had aimed to establish an adequate infrastructure for the basic needs in developing countries by 2015. Arab countries' achievement of the eight MDGs varied between countries and regions of different income and fragility.

Similarly, fragile Arab countries have struggled to achieve the SDGs. They face a number of challenges in their healthcare systems, including a deficient number of physicians, poor coverage of data on healthcare facilities, debt-related vulnerabilities, and lack of emergency preparedness – weaknesses that have manifested themselves amidst the novel coronavirus pandemic. The 2019 novel coronavirus disease (COVID-19) pandemic is expected to have extreme and possibly disastrous systemic impacts for the Arab world. The Arab world experiences exceptional political instability. Armed conflicts and occupation in some Arab countries have had disastrous consequences including the destruction of infrastructure and health systems, which may deprive these countries from making progress on SDG 3 and other SDGs. Three Arab countries, namely Yemen, Somalia, and Syria, are ranked at the top of high risk countries in the 2020 Fragile State Index. This endemic political uncertainty has affected the Arab world (for example, by hosting refugees) and has challenged Arab countries in achieving the SDGs.

This chapter reviews the progress of Arab countries in achieving SDG 3, health and wellbeing for all, summarizes the challenges they face in meeting its targets, and proposes an integrated framework for health and sustainable development. New perspectives on local and regional efforts are recommended, along with a universal health coverage approach to achieve health for all.

II. HEALTH AND SUSTAINABLE DEVELOPMENT: AN INTEGRATED FRAMEWORK

Goal 3 of the SDGs aims to "ensure healthy lives and promote wellbeing for all at all ages" (UN General Assembly, 2015). Health targets present in the MDGs, which included goals

FIGURE 1 SDG 3 TARGETS AND MEANS OF IMPLEMENTATION

SDG 3
Ensure healthy lives and promote wellbeing for all at all ages

Target 3.1
- By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births.

Target 3.2
- By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births.

Target 3.3
- By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

Target 3.4
- By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.

Target 3.5
- Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.

Target 3.6
- By 2020, halve the number of global deaths and injuries from road traffic accidents.

Target 3.7
- By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.

Target 3.8
- Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.

Target 3.9
- By 2030, substantially reduce the number of death and illness from hazardous chemicals and air, water and soil pollution and contamination.

Means of Implementation

Target 3.A
- Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries, as appropriate.

Target 3.B
- Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.

Target 3.C
- Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.

Target 3.D
- Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risk.

Source: Targets of SDG 3 (UN, 2015)

related to communicable diseases, child health, and maternal health (UN General Assembly, 2000), were further developed in SDG 3 to encompass a more comprehensive array of health issues. Health-related MDGs were only partially successful. The most successful achievement was in improving maternal and child health and the least successful was in reducing communicable diseases (Iqbal & Kiendrebeogo, 2014; MDG Monitor, 2016). Lower income Arab countries faced more challenges in achieving the MDGs than higher income countries, and inequalities were also apparent within countries, between poor and wealthy areas (United Nations & League of Arab States, 2013). Thus, additional resources were needed to address the broader and more detailed health-related SDGs, particularly SDG 3 (GBD 2015 SDG Collaborators, 2016).

SDG 3 includes nine targets for a number of health indicators including: maternal health, children's health, communicable and non-communicable

diseases, substance abuse, road traffic injuries and deaths, sexual and reproductive health, universal health coverage, and environmental health. In addition, it includes four means of implementation with specific targets relating to frameworks adoption for tobacco control, innovation in medicine and immunization, capacity building and financial support for health, and preparedness and response to health risks (UN, 2015). The SDG 3 targets and means of implementation are presented in Figure 1.

Although SDG 3 is the primary health-oriented goal, other SDGs are intrinsically related to the health goal and are essential to guide the development of policies and interventions that protect public health. The complex interactions between the SDGs of the 2030 Agenda (as shown in Figure 2) must be recognized, and the SDGs can only be addressed as a package, not as individual goals or targets. Consequently, an integrated health-centered approach encompassing all the SDGs will assist in achieving better health and sustainable development.

III. HEALTH PROFILE IN THE ARAB WORLD

Health in the Arab countries is highly impacted by the socio-political context in each country. The socio-economic inequalities, the political instability and the preponderance of armed conflicts and the dearth of resources have shaped

FIGURE 2 RELATIONSHIP BETWEEN SDG 3 AND THE OTHER SDGS IN THE 2030 AGENDA

Source: UNEP report (OECPR, 2016)

TABLE 1 **TOP 3 CAUSES OF DALYS IN 2017 FOR EACH ARAB COUNTRY**

Income	Arab Country	Top 3 causes of DALYs in 2017												
		Neonatal Disorders	Lower Respiratory infections	Diarrheal diseases	Conflict and terror	HIV/ AIDS	Congenital Defects	Ischemic heart disease	Stroke	Low back pain	Headache disorders	Diabetes	Drug use disorders	Road Injuries
LIC	Somalia	1	2	3										
	Syria				1			2	3					
	Yemen	1			2			3						
LMIC	Comoros	1	2	3										
	Djibouti	2	3			1								
	Egypt		3					1						2
	Mauritania	1	3	2										
	Morocco	2						1	3					
	Sudan	1					2	3						
	Tunisia							1	3					2
UMIC	Algeria	2					3	1						
	Iraq	2			1		3							
	Jordan	1					2	3						
	Lebanon							1				3	2	
	Libya				2			1					3	
HIC	Bahrain							2		3		1		
	Kuwait							1		2	3			
	Oman	3						2						1
	Qatar									3			1	2
	Saudi Arabia							2			3			1
	UAE							3					1	2
Not classified	Palestine	1					3	2						
Legend	1st Cause	2nd Cause	3rd Cause											
	1	2	3											

Source: Data presented in this figure was obtained from Institute for Health Metrics and Evaluation [IHME] (2018)

public health in Arab countries. This has been documented in studies on the Arab burden of disease and the 2030 Agenda implementation in the Arab world (Bissat & Rihan, 2019; Mokdad et al., 2014). In this chapter, we reflect on the differences in health indicators in the Arab countries. We distinguished countries by their levels of income, classified as low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs), and high-income countries (HICs) (based on the 2020 World Bank classification).

A. Top Causes and Risks of DALYs in the Arab World

Mental disorders, such as depression and anxiety, and lower respiratory infections widely contribute to DALYs (see Annex 1) lost in the Eastern Mediterranean region (Charara et al., 2017; GBD 2015 Eastern Mediterranean Region Lower Respiratory Infections Collaborators, 2018). Diabetes, among other non-communicable diseases (NCDs), is also on the rise in the Arab world; accordingly, interventions are needed to control this 'epidemic' (Abuyassin & Laher, 2016).

Cancer is also one of the striking diseases contributing to morbidity and mortality in the Arab world. Lung, bladder, prostate, breast, colorectal, and liver cancers are highly prevalent in various Arab countries (Guraya, 2018; Haddad et al., 2018; Hashim et al., 2018; Salim et al., 2009). There are still discrepancies in the incidence and mortality rates between countries, with Lebanon having one of the highest rates of all cancers in the Eastern Mediterranean region (Kulhanova et al., 2017). According to the most recently published data on the National Cancer Registry of Lebanon in 2016, the age standardized incidence rates (ASR) for all cancers was 253.5/100,000 for males and 262.2/100,000 for females (MoPH, 2016). As per GLOBOCAN 2018, the ASR (world) incidence rate in Lebanon is 242.8/100,000 (240.7 for males and 248.9 for females), with the top 5 cancers being in the breast, bladder, lung, prostate, and colorectum (Ferlay et al., 2018). In fact, breast cancer is among the leading causes of mortality for females in Lebanon, with ASR incidence rates increasing from 71/100,000 in 2004 to 97.6/100,000 in 2018 (Ferlay et al., 2018; Lakkis et al., 2017). The incidence rates for geriatric cancers in Lebanon are expected to rise among people between 65 and 74 years of age (Haddad et al., 2018).

It should be noted that in Lebanon, urinary bladder cancer, an environmentally acquired malignancy, is the highest worldwide, and tobacco is considered a major risk factor for this disease (Kobeissi et al., 2013; Lakkis et al., 2018). Bladder cancer was the third most common

TABLE 2 **TOP 10 RISK FACTORS CONTRIBUTING TO DALYS IN 2017 FOR EACH ARAB COUNTRY**

Income	Arab Country	Top 10 risk factors contributing to DALYs in 2017														
		Malnutrition	WASH	Air Pollution	Dietary Risks	High blood pressure	High fasting plasma glucose	Tobacco	Occupational Risks	Unsafe sex	High body-mass index	Impaired Kidney Function	High LDL	Drug use	Other environmental	Alcohol use
LIC	Somalia	1	2	3	4	5	6	7	8	9	10					
	Syria	8		7	1	2	5	6			3	9	4	10		
	Yemen	1	3	9	2	4	8	5			7		6		10	
LMIC	Comoros	1	4	6	2	3	5	8	9		7		10			
	Djibouti	1	6	7	3	4	5	8	10	2	9					
	Egypt	6		8	1	2	4	5			3	9	7	10		
	Mauritania	1	2	3	4	5	6	8			7	9	10			
	Morocco	6		8	2	1	3	7	10		4	9	5			
	Sudan	1	4	6	2	3	7				5	10	8	9		
	Tunisia	8		7	1	2	4	3			5	9	6	10		
UMIC	Algeria	5		8	1	3	4	6			2	10	7	9		
	Iraq	1		7	2	4	5	6			3	10	8	9		
	Jordan	1		9	4	5	3	6			2	10	7	8		
	Lebanon	8		9	4	5	3	2			1	10	6	7		
	Libya	9		8	1	3	4	6			2	10	5	7		
HIC	Bahrain	10		6	3	5	2	5	9		1		8	7		
	Kuwait	8		9	2	5	4	3	10		1		6	7		
	Oman	5		9	2	3	4	8	10		1		6	7		
	Qatar	9		8	4	6	3	7	5		1		10	2		
	Saudia Arabia	9		7	2	4	3	8			1	10	5	6		
	UAE			8	3	5	4	6	10		1		7	2		9
Not classified	Palestine	1		8	2	5	3	6			4	9	7	10		

Legend	1st Risk Factor	2nd Risk Factor	3rd Risk Factor	4th Risk Factor	5th Risk Factor	6th Risk Factor	7th Risk Factor	8th Risk Factor	9th Risk Factor	10th Risk Factor
	1	2	3	4	5	6	7	8	9	10

Source: Data presented in this figure was obtained from Institute for Health Metrics and Evaluation [IHME] (2018)

cancer in Lebanon between 2005 and 2011, with an ASR incidence rate of 31.2/100,000 in males and 7.3/100,000 in females (Lakkis et al., 2018). More recent data from GLOBOCAN 2018 shows that bladder cancer is the second most common cancer in Lebanon, accounting for 10.5 percent of cancer cases, with an ASR (world) of 40/100,000 for males and 9.4/100,000 for females (Ferlay et al., 2018). This shows that bladder cancer is notably increasing and is therefore one of the most urgent health-related issues that should be addressed in Lebanon. Egypt has also shown a high incidence of bladder cancer (Kyritsi et al., 2018). Tobacco and air pollution are among the top risk factors for DALYs in most Arab countries (Table 2), contributing to the high incidence of cancer, including lung and bladder cancer.

Tables 1 and 2 show the top 3 causes and top 10 risk factors contributing to DALYs in each Arab country, as per the 2017 data from the Institute of Health Metrics and Evaluation (IHME). The top causes of DALYs are ischemic heart disease, neonatal disorders, conflict and terror, lower respiratory infections, diarrheal diseases, drug use disorders, congenital defects, road injuries, strokes, headache disorders, low back pain, diabetes, and HIV/AIDS.

The disparities between Arab countries are apparent in the different causes of DALYs and the associated risk factors. NCDs, road injuries, and mental health ranked as the top causes in countries with higher income. Communicable and neonatal diseases ranked as the top causes in lower income countries. The most important risk factors contributing to DALYs in countries of lower income were malnutrition, water, sanitation and hygiene (WASH), and air pollution. In comparison, in countries with higher income, the highest risk factors included high body-mass index (BMI), high blood pressure, drug use, dietary risks, high fasting plasma glucose, and tobacco. Malnutrition is apparent among citizens of Yemen and Somalia, who are experiencing famine due to armed conflict (Hurley, 2019; Maxwell & Fitzpatrick, 2012). The inequalities between Arab countries are illustrated in Table 2, showing that malnutrition is dominant in LICs and LMICs, including Yemen, Somalia, Sudan, and Mauritania, while high-BMI is dominant in all HICs, including Qatar, Saudi Arabia, UAE, and Bahrain.

B. Infectious Disease Outbreaks and COVID-19

Concerns over populations' health in the Arab world are increasing, especially with outbreaks of new infectious diseases, such as the Middle-East Respiratory Syndrome (MERS) in 2012 and the novel coronavirus disease of 2019 (COVID-19), which disrupt actions towards improving health and achieving SDG 3. The MERS was a viral outbreak that was first reported in September 2012 in Saudi Arabia, and was associated with exposure to infected camels (WHO, 2019a; WHO, 2020c). Since 2012, MERS has spread in 27 countries, with around 2,519 laboratory-confirmed cases and 866 deaths, marking a case-fatality rate of 34.3 percent (WHO, 2020b). This disease outbreak was a public health crisis that threatened the health infrastructure and the economy in countries of the Arabian Peninsula (Ghazal et al., 2017; WHO, 2020b). A study done on a hospital in Saudi Arabia illustrates the added costs to the healthcare systems, where the outbreak was responsible for an additional cost of USD16,400 per month for infection control items such as soap, masks, and sanitizers (Al-Tawfiq et al., 2019). The pilgrimage (Hajj) season was not stopped during the MERS outbreak; however, Saudi Arabia authorities, WHO, and other health and travel agencies recommended that certain vulnerable groups, such as the elderly and ill, postpone pilgrimage plans and that countries with returning pilgrims strengthen surveillance for MERS cases (Eurosurveillance editorial team, 2014; Memish et al., 2013). These

TABLE 3 **REPORTED LABORATORY-CONFIRMED COVID-19 CASES AND DEATHS IN ARAB COUNTRIES AS OF SEPTEMBER 30, 2020**

Income	Arab Country	Total Confirmed Cases (Absolute numbers)	Total Deaths (Absolute numbers)	Transmission Classification
HIC	Saudi Arabia	334,187	4,739	Sporadic Cases
	Qatar	125,533	214	Community Transmission
	Kuwait	104,568	607	Community Transmission
	Oman	98,585	935	Community Transmission
	UAE	93,090	416	Community Transmission
	Bahrain	70,422	246	Clusters of Cases
UMIC	Iraq	358,290	9,122	Community Transmission
	Algeria	51,368	1,726	Community Transmission
	Lebanon	38,363	361	Community Transmission
	Libya	34,014	540	Community Transmission
	Jordan	10,049	57	Community Transmission
LMIC	Morocco	121,183	2,152	Clusters of Cases
	Egypt	103,079	5,914	Clusters of Cases
	Tunisia	17,405	246	Clusters of Cases
	Sudan	13,640	836	Community Transmission
	Mauritania	7,488	161	Community Transmission
	Djibouti	5,416	61	Sporadic Cases
	Comoros	478	7	Community Transmission
LIC	Syria	4,148	197	Community Transmission
	Somalia	3,588	99	Sporadic Cases
	Yemen	2,035	588	Community Transmission
-	Palestine	50,115	360	Community Transmission

Source of data: (WHO, 2020d) Coronavirus Disease (COVID-19) Dashboard–September 30, 2020

impacts of MERS show how health issues can be interrelated to other SDGs, including SDG 8 on economic growth.

More recently in 2019, the COVID-19 virus, SARS-CoV-2, which was first identified in Wuhan, China, has spread globally with almost all countries/territories worldwide reporting laboratory-confirmed cases. WHO declared it as a pandemic and a Public Health Emergency of International Concern that constitutes a risk to countries with vulnerable health systems (Sohrabi et al., 2020; WHO, 2020d). All Arab countries have reported cases of coronavirus infections, and the number of cases is on the increase (WHO, 2020d). A list of those countries with the confirmed COVID-19 cases, deaths, and transmission classification as of September 30, 2020 are presented in Table 3. Most of the listed countries (15 countries) have reported 'Community Transmission', indicating an outbreak of a local transmission, while 4 countries (Bahrain, Morocco, Egypt, and Tunisia) have reported 'clusters of cases', indicating that COVID-19 cases are clustered in time, geographic area, or common exposure. Only Saudi Arabia, Djibouti, and Somalia have reported 'sporadic cases', showing that only few cases are detected locally or imported. Comoros was the last of all Arab countries to report cases of COVID-19.

Saudi Arabia, reported 334,187 cases, as of September 30, 2020 (Table 3). In this respect, it was uncertainty whether the Hajj season would

take place this year, amidst the pandemic. Some countries, including Indonesia and Singapore, had already decided to skip Hajj 2020 (Gozali, 2020), while other countries, including Morocco, were waiting for the decision of Saudi Arabia in this regard (Hatim, 2020). Saudi Arabia had already temporarily suspended Umrah-related travels (similar to Hajj but can be done any time of year) on February 27, 2020; whereas the Minister of Hajj and Umrah asked Muslims to wait on planning to attend the Hajj until the situation is clarified (Al Jazeera, 2020; Ebrahim & Memish, 2020; Gautret et al., 2020). Saudi Arabia later decided to scale-back the Hajj 2020 and allow only up to 10,000 pilgrims of those residing in the kingdom to participate in Hajj compared to an average of 2.5 million international pilgrims in previous years (Liubchenkova, 2020; Parveen, 2020; Zumla et al., 2020). Decisions to suspend Umrah and scale-back Hajj 2020 are expected to have had large economic costs on Saudi Arabia's health, transport, and airline sectors and to have severely affected the livelihoods and employment of native and immigrant workers in the country's holy cities (Ebrahim & Memish, 2020; Parviz, 2020; Zumla et al., 2020).

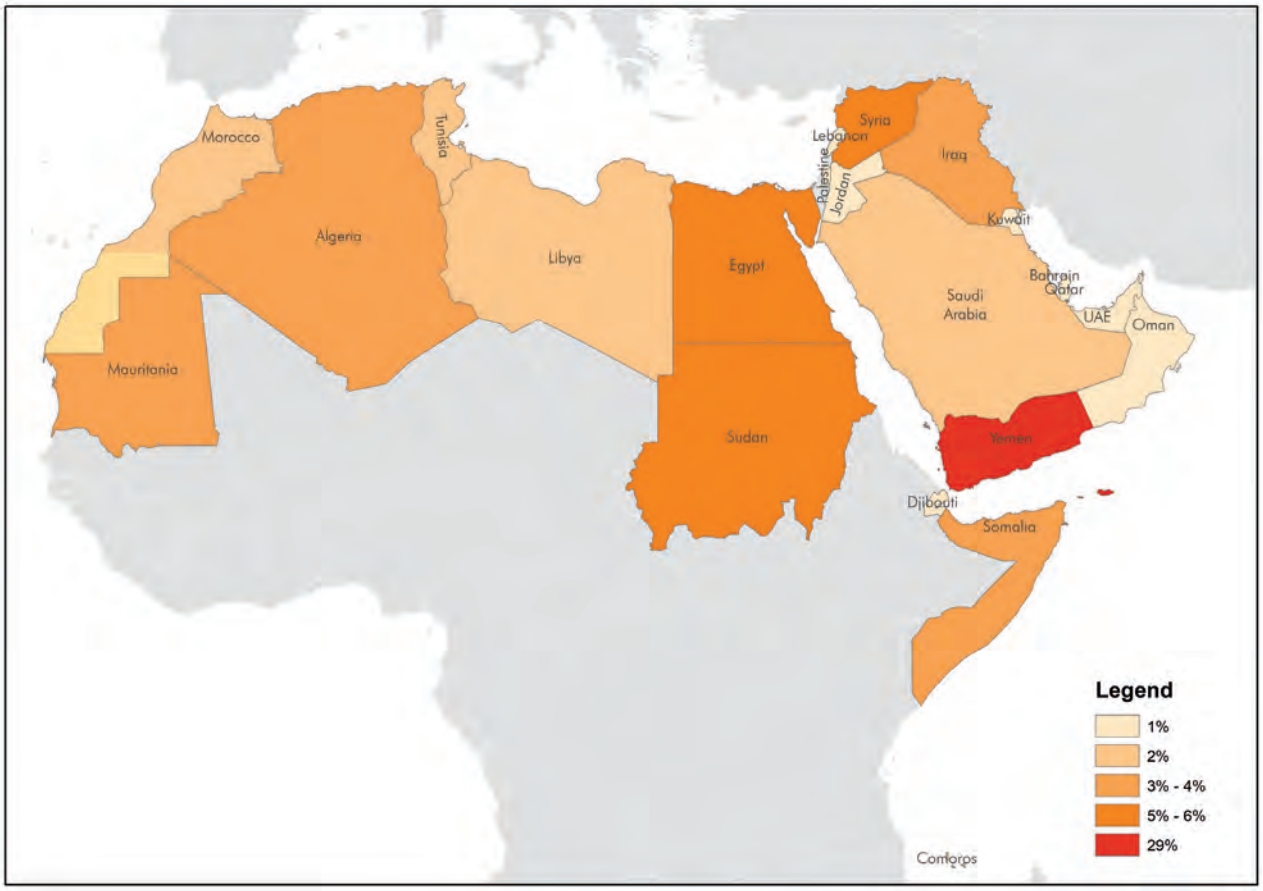
COVID-19 related deaths were also reported in most Arab countries (Table 3), including Iraq (9,122), Egypt (5,914), Saudi Arabia (4,739), Morocco (2,152), and Algeria (1,726) (WHO, 2020d). Arab countries of various income levels faced challenges in dealing with the COVID-19 emergency, exacerbating health outcomes. In addition, LICs and LMICs lacked the capacity and resources to conduct laboratory tests on a wide scale, and therefore, the infected numbers were expected to be higher than what was reported (Abdellatif & Hsu, 2020; Cousins, 2020). In fact, the low numbers of cases and deaths in some of the Arab countries (e.g. Comoros, Somalia, Mauritania, and Syria) were attributed to a lack of testing (either due to armed conflict or due to the lack of financial and technical resources) (Abdellatif & Hsu, 2020; Mumtaz, 2020). This public health crisis may increase in intensity with a potential second wave of transmission and a higher peak in cases, increasing the pressure on the healthcare systems if effective control measures are not taken (Aleta et al., 2020; Leung et al., 2020; Xu & Li, 2020).

Assessing COVID-19 related case-fatality ratios provides insight on the burden suffered in individual Arab countries. We produced a map (Figure 3) to show COVID-19 related case-fatality ratios in the Arab world, using data from the COVID-19 dashboard produced and updated in real-time by the Center for Systems Science and Engineering (CSSE) at the Johns Hopkins University (JHU) (CSSE-JHU, 2020; Dong et al., 2020). The case-fatality ratios show differences between the countries; Yemen having the highest case-fatality ratio, and Qatar, Bahrain, UAE, and other Gulf countries having the lowest case-fatality ratios. It should be noted that these ratios are COVID-19 mortality rates out of the number of reported cases that are of course testing- and diagnosis-dependent; in addition, the ratios are not age-adjusted and therefore provide a crude estimate of the case-fatality ratios.

Net of the effect of the low testing levels for COVID-19 infections in poorly resourced countries like Yemen, the difference in the case-fatality ratios is not unrealistic nor surprising considering the large difference between LICs and HICs in resources, health infrastructure, and healthcare services available for infected patients' care and support.

On the other hand, the very low number of cases reported in Yemen compared to the higher numbers reported in Gulf countries reflects on the large difference in the testing capacity in the two categories of countries. The Arab LICs could not support large-scale COVID-19 testing campaigns and have hardly any ability to generate public health data in crisis situations. On the other hand, the Arab HICs have enough resources to purchase testing kits and to carry out testing campaign, regardless of the adequacy of their existing emergency preparedness. The COVID-19 outbreak uncovered the deleterious consequences of the weak health systems, the lack of emergency preparedness in most Arab countries, and the inability to mobilize resources for public health and patient care in Arab LICs and LMICs. In Lebanon, COVID-19 cases tripled in August after the massive and devastating explosion in the Beirut Port on August 4, 2020 (Abouzeid et al., 2020). This blast killed over 190 people, injured over 6500, and resulted in widespread destruction of dwellings, hospitals, and essential food and medical supplies, leaving Lebanon in a state of humanitarian emergency (Abouzeid et al., 2020). The marked increase in

FIGURE 3 **COVID-19 CASE-FATALITY RATIOS IN THE ARAB WORLD AS PER SEPTEMBER 30, 2020**



Source: Data in this map was extracted from the COVID-19 dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) on September 30, 2020. The dashboard data is based on multiple sources, including WHO, WorldoMeters, and the Palestine (West Bank and Gaza) website for COVID-19 (CSSE-JHU, 2020).

COVID-19 cases after this disaster is an example of the poor emergency preparedness in a fragile state that was overwhelmed by the COVID-19 pandemic.

IV. PROGRESS TOWARDS ACHIEVING THE SDG 3 TARGETS IN THE ARAB WORLD

Estimates for the SDG 3 health indicators in Arab countries classified by income (LICs, LMICs, UMICs, and HICs) are presented in Table 4. The estimates, based on data from the World Health Statistics of 2019 (WHO, 2019e), show the health disparities prevalent in the Arab world. The national averages demonstrate a higher burden in LICs and LMICs compared to UMICs and HICs, despite the common history and culture shared by some countries across income categories. For example, under-five mortality rates and neonatal mortality in Syria (LIC) are 17 and 9 per 1,000 live births, respectively, whereas in Lebanon (UMIC), they are 8 and 5 per 1,000 live births, respectively (Table 4). The data presented as national averages do not allow for a reflection on the contextual differences present in different areas of various income levels within the same country (UN & LAS, 2013).

Compared with previous estimates in WHO World Health Statistics 2016 (WHO, 2016c), non-communicable diseases (NCDs) and air pollution mortality rates have increased over time in all countries. For instance, NCDs and road traffic injuries were the leading causes of death and disability-adjusted life years (DALYs) in Saudi Arabia in 2010 (Memish et al., 2014). Road traffic injuries are still the leading cause of DALYs in Saudi Arabia, with the rate per 100,000 population increasing

TABLE 4 **SDG 3 INDICATORS AS REPORTED IN ARAB COUNTRIES CLASSIFIED BY NATIONAL INCOME**

SDG 3 Targets	Indicators	LIC[1]	LMIC[2]	UMIC[3]	HIC[4]
Target 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births.	3.1.1 Maternal mortality ratio (per 100,000 live births), 2015	732 (Somalia) 385 (Yemen) 68 (Syria)	33 (Egypt) 62 (Tunisia) 121-602 (others)	140 (Algeria) 9-58 (others)	4 (Kuwait) 6 (UAE) 12-17 (others)
	3.1.2 Proportion of births attended by skilled health personnel (%), 2009-2018*	96 (Syria) 45 (Yemen) No data (Somalia)	69-92	96-100 no data (Lebanon)	100
Target 3.2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births.	3.2.1 Under-five mortality rate (per 1,000 live births), 2017	127 (Somalia) 55 (Yemen) 17 (Syria)	13-23 (Tunisia, Egypt, Morocco) 62-79 (Djibouti, Sudan, Mauritania)	8-30	7-11
	3.2.2 Neonatal mortality rate (per 1,000 live births), 2017	9-39	8-14 (Tunisia, Egypt, Morocco) 30-34 (Others)	5-17	3-5
Target 3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.	3.3.1 New HIV infections (per 1,000 uninfected population), 2017	0.03 (Somalia) no data (Syria, Yemen)	0.01-0.61	0.03 (Algeria, Lebanon) no data (others)	0.04-0.07 (Bahrain, Kuwait, Qatar) no data (others)
	3.3.2 Tuberculosis incidence (per 100,000 population), 2017	266 (Somalia) 48 (Yemen) 19 (Syria)	269 (Djibouti) 13-99 (others)	12 (Lebanon) 40-70 (others)	0.8 (UAE) 6.7-27 (others)
	3.3.3 Malaria incidence (per 1,000 population at risk), 2017	41.9 (Yemen) 36.7 (Somalia) 0 (Syria)	0 (Egypt, Morocco) 4 (Comoros) 31.9-53.9 (Djibouti, Sudan, Mauritania) no data (Tunisia)	0 (Algeria, Iraq) no data (others)	0-0.1 (Oman, Saudi Arabia, UAE) no data (others)
	3.3.4 Hepatitis B prevalence (%), 2015	10.54 (Somalia) 2.54 (Yemen) 0.37 (Syria)	1.96-4.29 (Comoros, Sudan, Mauritania) 0.45-0.8 (others)	0.06-1.01	0.08-0.44
	3.3.5 Number of people requiring interventions against neglected tropical diseases, 2017*	7,342,169 (Yemen) 2,532,411 (Somalia) 1,925,000 (Syria)	11,031,353 (Sudan) 5,021,586 (Egypt) 855,084 (Mauritania) 828,148 (Comoros) 110,561 (Djibouti) 6,926 (Morocco) 4,800 (Tunisia)	2,170,486 (Iraq) 13,140 (Algeria) 2,834 (Libya) 155 (Jordan) 1 (Lebanon)	1,021 (Saudi Arabia) 0-21 (Others)

TABLE 4 CONT. **SDG 3 INDICATORS AS REPORTED IN ARAB COUNTRIES CLASSIFIED BY NATIONAL INCOME**

SDG 3 Targets	Indicators	LIC[1]	LMIC[2]	UMIC[3]	HIC[4]
Target 3.4: By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.	3.4.1 Probability of dying from 4 major NCDs (%), 2016	21.8-30.6	12.4-27.7	14.2-21.3	11.3-17.8
	3.4.2 Suicide mortality rate (crude, per 100,000 population), 2016	8.5 (Yemen) 4.7 (Somalia) 1.9 (Syria)	2.9-8.1	5.2 (Libya) 2.9-3.3 (others)	2.3-6.6
Target 3.5: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.	3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders	No data	No data	No data	No data
	3.5.2 Alcohol consumption (litres of pure alcohol per capita ≥15 years), 2016	0-0.3 (Somalia, Syria, Yemen)	1.9 (Tunisia) 0.4-0.9 (others) 0 (Mauritania)	0 (Libya) 0.4-1.5 (others)	0 (Kuwait) 0.2-3.8 (others)
Target 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents.	3.6.1 Road traffic mortality rate (crude, per 100,000 population), 2016	26.5 (Syria) 27.1 (Somalia) no data (Yemen)	9.7 (Egypt) 19.6 - 26.5 (others) no data (Djibouti)	18.1 - 26.1 no data (Algeria)	9.3-28.8 no data (Bahrain)
Target 3.7: By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.	3.7.1 Proportion of women of reproductive age (15-49 years) who have their need for family planning satisfied with modern methods (%), 2009-2018*	53.3 (Syria) 37.7 (Yemen) no data (Somalia)	28.8-80 no data (Djibouti)	24-77.2 no data (Lebanon)	68.9 (Qatar) 39.6 (Oman) no data (others)
	3.7.2 Adolescent birth rate (per 1,000 women aged 15-19 years), 2009-2017*	54-67	56-87 (Egypt, Comoros, Mauritania, Sudan) 20.6 (Djibouti) 6.9 (Tunisia) no data (Morocco)	82 (Iraq) 10.9-26 (others) no data (Lebanon)	34.2 (UAE) 6.1-14.3 (others) no data (Saudi Arabia)
Target 3.8: Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.	3.8.1 UHC service coverage index, 2015	22-60	33-68	63-76	63-77
	3.8.2 Proportion of population with large household expenditures on health >10%; >25% of total household expenditure or income (%), 2009-2015*	No data	16.7 for >10% and 2.4 for >25% (Tunisia) no data (others)	No data	No data

TABLE 4 CONT. **SDG 3 INDICATORS AS REPORTED IN ARAB COUNTRIES CLASSIFIED BY NATIONAL INCOME**

SDG 3 Targets	Indicators	LIC[1]	LMIC[2]	UMIC[3]	HIC[4]
Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	3.9.1 Air pollution mortality rate (age-standardized, per 100,000 population), 2016	212.8 (Somalia) 194.2 (Yemen) 75.2 (Syria)	49.1 (Morocco) 56.1 (Tunisia) 108.9-184.9 (Others)	49.7-75.1	40.1-103.8
	3.9.2 Water, Sanitation and Hygiene for All (WASH) mortality rate (crude, per 100 000 population), 2016	86.6 (Somalia) 10.2 (Yemen) 3.7 (Syria)	1-2 (Tunisia, Morocco, Egypt) 17.3-50.7 (others)	0.6-3	0.1 (Saudi Arabia) 0 (others)
	3.9.3 Poisoning mortality rate (crude, per 100 000 population), 2016	4.6 (Somalia) 3.8 (Yemen) 0.4 (Syria)	0.2-0.6 (Tunisia, Morocco, Egypt) 1.9-3.9 (others)	0.3-0.8	0.2-0.7
Target 3.A: Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries, as appropriate.	3.A.1 Tobacco smoking prevalence (%), 2016	18.4 (Yemen) no data (Somalia, Syria)	13.1-33.5 no data (Sudan, Mauritania)	15.6 (Algeria) 33.8 (Lebanon) no data (others)	8.1-21.7
Target 3.B: Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.	3.B.1 DTP3 immunization (%), 2017	42-68	68-99	63-99	97-99
	3.B.1 MCV2 immunization (%), 2017	46 (Yemen) no data (Somalia, Syria)	72-99 no data (Comoros, Mauritania)	68-99	93-99
	3.B.1 PCV3 immunization (%), 2017	68 (Yemen) no data (Somalia, Syria)	68-99 no data (Comoros, Egypt, Tunisia)	33 (Iraq) 68-94 (Algeria, Lebanon, Lybia) no data (Jordan)	96-99
	3.B.2 Total net official development assistance to medical research and basic health sectors (US$ per capita), by recipient country, 2017*	10.09 (Yemen) 3.74 (Somalia) 1.59 (Syria)	8.85 (Djibouti) 0.05-3.66 (others)	6.44 (Lebanon) 4.05 (Jordan) 0.01-0.89 (others)	No data

from 27.4 in 2016 to 28.8 in 2019 (as shown in Table 1), followed by NCDs (16.4 percent in 2019), with ischemic heart disease being the second leading cause of DALYs (Table 1). On the other hand, road traffic mortality has relatively decreased in LMICs, UMICs, and HICs between 2016 and 2019. In addition, suicide rates have decreased in LICs and LMICs but slightly increased in UMICs.

TABLE 4 CONT. **SDG 3 INDICATORS AS REPORTED IN ARAB COUNTRIES CLASSIFIED BY NATIONAL INCOME**

SDG 3 Targets	Indicators	LIC[1]	LMIC[2]	UMIC[3]	HIC[4]
Target 3.C: Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.	3.C.1 Density of medical doctors (per 10,000 population), 2009-2018*	12.2 (Syria) 3.1 (Yemen) 0.2 (Somalia)	12.7 (Tunisia) 7.3-7.9 (Morocco, Egypt) 1.7-4.1 (others)	18.3-23.4 (Algeria, Libya, Lebanon, Jordan) 8.2 (Iraq)	19.7-25.8 (Oman, UAE, Saudi Arabia, Kuwait) 9.3 (Bahrain) <0.1 (Qatar)
	3.C.1 Density of nursing and midwifery personnel (per 10,000 population), 2009-2018*	14.6 (Syria) 7.3 (Yemen) 0.6 (Somalia)	26.4 (Tunisia) 5.4-14 (others)	16.8-67.4	24.9-69.7
	3.C.1 Density of dentists (per 10 000 population), 2009-2018*	6.8 (Syria) 0.2 (Yemen) no data (Somalia)	0.2-3.1	2.5-11.1 no data (Algeria)	1-8.4
	3.C.1 Density of pharmacists (per 10 000 population), 2009-2018*	10.1 (Syria) 1 (Yemen) no data (Somalia)	0.2-4.4	2.9-16.1 no data (Algeria)	1.6-10.7
Target 3.D: Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.	3.D.1 Average of International Health Regulations (IHR) core capacity scores, 2018*	31-75	19-82	41-82	56-100

[1] LIC: Syria Arab Republic, Yemen, Somalia
[2] LMIC: Comoros, Mauritania, Tunisia, Djibouti, Egypt, Morocco, Sudan
[3] UMIC: Algeria, Iraq, Jordan, Lebanon, Libya
[4] HIC: Qatar, Bahrain, Saudi Arabia, Kuwait, United Arab Emirates, Oman
Data on Palestine is missing from the WHO report in 2019.
* Primary Data (not comparable estimates; data across countries may not be comparable because the data was compiled by international agencies from routine reporting by countries or publicly available sources such as demographic and health surveys)
Source of Data: World Health Statistics 2019 (WHO, 2019e)

In a 25 year study in the Arab world, maternal mortality showed a notable decrease in most countries, with the highest burden in Somalia versus the least burden in Gulf countries (4-17 per 100,000 live births) (Khachfe et al., 2019). Nevertheless, it is still relatively high in some LICs and LMICs, including in Somalia (732 per 100,000 live births), Mauritania (602 per 100,000 live births), and Yemen (385 per 100,000 live births). Some countries have also shown slight reductions in under-five mortality rates. Somalia, for example, showed a modest decrease in under-five mortality rates (per 1,000 live births) from 136.8 in 2016 to 127 in 2019. Similarly, neonatal mortality rates have also decreased in most countries, such as in Syria, from 12.9 in 2016 to 9 in 2019. Neonatal mortality rates range between 9-39 per 1,000 live births in LICs and 3-5 per 1,000 live births in HICs.

Tuberculosis incidence is relatively similar to the 2016 data, except in Djibouti (LMIC), where it has notably decreased from 619 to 269 per 100,000 population. Malaria incidence per 1,000 population at risk has also decreased in Somalia (36.7), Comoros (4), and is almost nil in HICs (0 - 0.1). Hepatitis B is more prevalent in most lower income countries, including Somalia (10.54 percent), compared to being less than 1 percent in UMICs and HICs. Overall, unintended poisoning mortality has decreased to a maximum of 4.6 per 100,000 population in Somalia.

BOX 1

RELATIONSHIP BETWEEN SDGS AND HEALTH (SDG 3)

Sustainable Development Goal	Relationship with Health (SDG 3)
SDG 1 – No Poverty	Poverty is recognized as one of the determinants of health (von dem Knesebeck et al., 2018; Yoshikawa et al., 2012). As poverty is eradicated, people would have more equitable access to resources, education, health services, food, and wealth. Living conditions would also be improved. This goal will also create a fairer world system in politics and economics, which would, as a result, alleviate poverty and improve the health of the poor.
SDG 2 – Zero Hunger	Ending hunger and improving nutrition is essential for improving health. Hunger and malnutrition are direct causes of a number of health ailments, including stunted growth in children, undernutrition, obesity, and diseases such as anemia, cardiovascular diseases, and diabetes (Mosby & Galloway, 2017). The statistics in Arab countries show that in the least developed countries, undernourishment rates are high, reaching 70 percent in Comoros, 39 percent in Sudan, and 26 percent in Yemen (ESCWA, 2017). Hence, progress on SDG 2 (Zero Hunger) improves child health and development and decrease the rates of malnutrition-related diseases.
SDG 4 - Quality Education	Education is essential to improve public health. It improves individuals' health literacy, enabling them to make healthy improvements in their households and communities. Knowledge is key to the prevention of disease (Fernandez, 2020). Education has also been shown to empower the most vulnerable populations, such as women in marginalized communities.
SDG 5 – Gender Equality	Achieving gender equality is directly linked with ensuring health for all. As a result of empowering women, improvements in access to health services, maternal health, non-communicable diseases, and sexual and reproductive health will occur. Females would also have access to education and labor markets, and exploitation and abuse of women would markedly decrease. According to the WHO (2019e), the Eastern Mediterranean region countries, most of which are Arab countries, have a high prevalence (37 percent) of intimate partner violence against women. Hence, SDG 5 is highly associated with the health of women and girls.
SDG 6 – Clean Water and Sanitation	Access to clean water and sanitation would notably reduce the prevalence of certain water-borne and communicable diseases and illnesses (Hall et al., 2016). WASH-related mortality is an essential indicator in SDG 3, with more females dying from unsafe WASH than males in most regions (except Africa) (WHO, 2019e). In fact, target 3.9 of SDG 3 includes reducing morbidity and mortality from water pollution and contamination, which is directly related to SDG 6.
SDG 7 – Affordable and Clean Energy	Providing clean and affordable energy is vital to improve health conditions. The WHO asserts that cooking, heating, and lighting using polluting fuels inside the household, contaminates the indoor air, and is associated with illnesses and mortality (WHO, 2016a). Using clean energy and reducing reliance on fossil fuels will protect human health. Renewable energy reduces emissions from burning fossil fuels, and improves outdoor air conditions, subsequently improving public health. In fact, the Eastern Mediterranean region countries are exposed to one of the highest concentrations of PM2.5, at 54.0 $\mu g/m^3$ (WHO, 2019e).
SDG 8 – Decent Work and Economic Growth	Providing decent work and ensuring economic growth impacts health. By reducing work-related injuries and deaths, and improving labor rights. Occupational health services are essential for the physical and mental health of workers and their families. Also, addressing child labor is advocated in this goal and implies the protection of children from hazardous working conditions at a young age (Habib et al., 2019b).

SDG 9 – Industry, Innovation, and Infrastructure	Building better infrastructure and powering innovation has an impact on health through the provision of affordable health interventions that can reach marginalized populations. Innovation in multiple areas, such as transportation, electricity, and technology may provide improved healthcare access and quality (Mead, 2017).
SDG 10 – Reduced Inequalities	Decreasing disparity across and within countries is vital to all SDGs. Reducing inequalities addresses poor and marginalized populations in urban and rural regions. It also allows equitable access to healthcare. The WHO affirms that equitable societies tend to be healthier and have higher life expectancy (WHO, 2019b).
SDG 11 – Sustainable Cities and Communities	Building sustainable cities provides open green spaces, appropriate and affordable housing, and safer roads. Road traffic injuries are one of the indicators in SDG 3, which is directly linked with SDG 11. According to the WHO (2019c), building safe and clean cities would reduce air pollution, combat NCDs, and improve sanitation and waste management, all targets of SDG 3.
SDG 12 – Responsible Consumption and Production	Responsible production processes reduce pollution, and coupled with responsible consumption, reduce the production of waste and the degradation of resources. Consequently, this would ensure the sustainability of resources and sustainable development necessary for a healthier environment and improved public health (Fernandez, 2020).
SDG 13 – Climate Action	Climate change has both direct and indirect consequences on health. Increases in extreme weather conditions, such as floods, droughts, hurricanes, and heatwaves are direct consequences of climate change, which lead to higher mortality rates. Indirectly, climate change leads to an increase in disease vectors and food insecurity. In the Eastern Mediterranean region, extreme weather events, air quality, infectious diseases, and malnutrition as a result of climate change are associated with morbidity and mortality (Habib et al., 2010).
SDG 14 – Life Below Water and SDG 15 – Life on Land	Humans are a vital component of the environment, and their health is dependent on the environment they live in, as shown in The Ecosystem Approach to Human Health (Lebel, 2003). Thus, establishing a balance in ecosystems is essential to ensure human health. For example, conserving biodiversity is necessary to maintain a stable food chain, which, if not protected, could affect food security as well as the potential medicinal value of certain species. Protecting both marine and terrestrial environments is important to prevent the disruption of the complex ecosystem processes, which are essential to sustain human health.
SDG 16 – Peace, Justice, and Strong Institutions	Eradicating armed conflicts and building peace is necessary for the achievement of the 2030 Agenda. War destroys infrastructure, undermines access to health services, and increases injury and mortality rates. SDG 16 is indirectly implicated in reducing the transmission of diseases, since conflict-driven migration has been associated with increased risks of infectious disease transmission and reduced ability to control infectious disease outbreaks (Stoett et al., 2016). This is relevant to the Arab world that has been plagued with wars and armed conflicts. Severe armed conflicts in Syria, Yemen, and Somalia have had disastrous impacts on the infrastructure and health in these countries and have also impacted the neighboring countries that have hosted large numbers of refugees.
SDG 17 – Partnerships for the Goals	Global partnerships and cooperation between countries, organizations, and institutions reduce inequality between communities, and support countries and vulnerable populations with poor resources. A dialogue in health entrepreneurship creates innovations and development in technology, policy, and research that improve the health status in the Arab world (Ramadi & Atun, 2019).

Water, sanitation and hygiene (WASH) mortality rates were variable between countries and were highest in Somalia (86.6 per 100,000 population). Tobacco smoking is relatively prevalent in the Arab world, with the highest prevalence in Lebanon (33.8 percent). Moreover, air pollution mortality rates per 100,000 population have markedly increased between 2016 and 2019 in most countries, including Iraq (from 32.2 to 50.9), Lebanon (from 29.7 to 51.4), Oman (from 13.5 to 53.9), and Qatar (from 9 to 47.4), among others. The relatively alarming increases in mortality from air pollution highlight the importance of safeguarding the environment, an essential aspect of improving health in the Arab world.

Although there have been improvements in a number of indicators, including malaria incidence and under-five and neonatal mortality rates, some have remained relatively unchanged (such as tuberculosis incidence), and few have worsened (such as air pollution mortality rate). This shows that health in the Arab world is modestly improving but that certain areas need to be addressed in order to succeed in achieving SDG 3.

Note: Based on 2020 World Bank classification, a few countries have been moved to a different class of income level. For example, due to war in Yemen and Syria the two countries that were previously classified under LMICs in 2016 were reclassified under LICs in 2019. On the other hand, Comoros was classified in the LICs group in the 2016 and was re-classified in the LMICs group in 2019.

V. PROGRESS TOWARDS OTHER SDGS RELATED TO HEALTH IN THE ARAB WORLD

SDG 3 is the main goal focused on achieving health for all. However, other goals of the 2030 Agenda are interconnected with SDG 3 and have a common ultimate aim: to foster and maintain human health. Progressing on these goals, including SDG 6 for clean water and sanitation, SDG 7 for affordable and clean energy, SDG 8 for decent work and economic growth, SDG 11 for sustainable cities and communities, and SDG 13 for climate action, is essential for achieving progress on SDG 3 targets (Acharya et al., 2018). Clean water and sanitation (SDG 6) is also highly interconnected with health. The relationship between SDGs of the 2030 Agenda and SDG 3 on health is explained in Box 1. The interconnectedness between the SDGs is naturally evident considering the dependence of 'health' on an array of sectors that affect health, including health care, transport, urban and rural infrastructure, work settings, housing and living conditions, as well as reducing pollution and climate change consequences. In fact, all the SDGs are directly or indirectly linked to ensuring health, since they address the various environmental, social, economic, and political determinants of health. This makes health an ultimate goal in the 2030 Agenda (Hall et al., 2016). Policies and interventions that protect public health and aim to meet the 2030 Agenda should be mindful of the interconnectedness between health and the other SDGs.

According to the Arab Region SDG Index and Dashboards Report (2019), there has been notable progress on SDG 6 and 13 related to water and climate change, respectively; however, the Arab world is still behind in achieving the 2030 Agenda (average SDG index: 58/100). Algeria, UAE, Morocco, Tunisia, and Jordan are performing better than other Arab countries on the 2030 Agenda (Total SDG index: ≥65), while countries in armed conflict are far from achieving the goals by 2030 (Luomi et al., 2019). The 2019 report also shows that most Arab countries still experience a wide range of challenges, which hinders their progress on most of the SDGs, including SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 16 (Peace, Justice and Strong Institutions), among others (Luomi et al., 2019). In fact, the report highlights that significant challenges remain for achieving SDG 3 for 16 Arab countries, that 14 countries are moderately progressing on SDG 3, 7 countries are stagnating, while only Oman is maintaining SDG 3 achievement (Luomi et al., 2019). All these SDGs will impact the health status of the Arab world, both directly and indirectly. Therefore, Arab countries need to ratchet up and coordinate their efforts towards sustainable development and find appropriate context-specific solutions to improve their performance on the SDGs and safeguard health in the region.

VI. CHALLENGES TOWARDS MEETING SDG 3 TARGETS

Countries of the Arab world face various challenges that hinder their ability to achieve the targets of SDG 3 and address "health for all". These challenges include political, and economical dimensions, and importantly armed conflicts in a number of countries that have had a widespread regional effect.

A. Armed Conflicts and Displacement

The Arab world has suffered from a number of protracted wars and armed conflicts. The Global Conflict Tracker by the Council on Foreign Relations (2020) that documents the conflict status of countries around the world, classified eight of the 22 Arab countries to be in conflict in 2020, namely: Yemen (with the war in Yemen marked as worsening), Syria, Libya, the Israeli-Palestinian conflict, Somalia, in addition to the political instability in Egypt, Iraq, and Lebanon (Council on Foreign Relations, 2020). In fact, Yemen (1st), Somalia (2nd), and Syria (4th) have also ranked as the most fragile states in the 2020 Fragile State Index (Fund For Peace [FFP], 2020).

Wars have had disastrous consequences in a number of these countries. Besides high rates of injuries and deaths, the effects of armed conflicts included environmental destruction, infrastructural damage, health systems deterioration, healthcare services disruptions, and the emergence of previously eradicated illnesses (Fares et al., 2020; Samman et al., 2018). The incidence rate of Cutaneous Leishmaniasis in Syria increased between 2010 (1 year before the onset of war) and 2018, from 20.08 to 44.99 per 10,000 population, respectively (Muhjazi et al., 2019). Leishmaniasis also spread in Lebanon in early 2013 among Syrian refugees, recording 1033 new cases in 2013 compared to 0-6 yearly cases in previous years (Alawieh et al., 2014). Polio, as well, reemerged in Syria in 2013 after being eliminated for over 15 years, and was attributed to the decrease in immunization from 75-91 percent in 2010 pre-war to 50-60 percent in 2012 after the war onset (Ozaras et al., 2016). Polio was also reported in Iraq in 2014, after being polio-free for 14 years (Arie, 2014), but the situation was controlled and a polio-immunization campaign for children took place, which led to removing Iraq from the list of polio-infected countries in 2015 (WHO, 2016b). Moreover, cholera and famine have hit Yemen since 2016, with an estimate of over 2.3 million suspected cases of cholera as of January 2020 and over 20 million food insecure people (World Food Programme [WFP], 2020; WHO, 2020a). These disease emergences are examples of the direct effects of armed conflict and embargo on countries, challenging fragile states in meeting the healthcare needs of their population.

One of the limitations of the 2030 Agenda is the assumption that individual countries can independently address the targets of the SDGs within their national borders and without the need for regional cooperation (El-Zein et al., 2016). In reality, this is not possible. For example, armed conflicts in Arab countries not only impact the geographical zone within national boarders of a country, but also affect the neighboring countries and the region. This fact pertains to the trickling political instability and the massive numbers of refugees that cross the national borders to seek refuge in neighboring countries. The Syrian war has led 6.7 million refugees to flee to neighboring countries, including Lebanon and Jordan, as well as countries in the wider region including Turkey and Europe (UNHCR, 2019). Poorly resourced host countries, like Lebanon, struggle to maintain their weak infrastructure, with limited abilities to serve both the local population and the incoming refugees (Dionigi, 2016; Fargues, 2014). The call for peace in goal 16 of the SDGs is extremely relevant for achieving health for all in SDG 3.

The health of refugees in host Arab countries, specifically Syrian refugees, has gained attention and has been the subject of a growing body of literature in the last five years. Research studies showed that refugees face precarious living conditions in Arab host countries (Habib, 2019; Habib et al., 2016; Habib et al., 2019a; Habib et al., 2020; Habib et al., 2019b). In Lebanon, the majority of Syrian refugees (69 percent) live in residential structures (e.g. concierge rooms or apartments), 20 percent in temporary shelters (e.g. tents), and 11 percent in non-residential structures (e.g. farms or factories), with over half of the refugees living in poor, overcrowded, below-standard, or dangerous shelters (UNHCR, UNICEF, & WFP, 2019). Refugees' poor living

conditions in Lebanon have been associated with poor health (Habib, 2019; Habib et al., 2016; Habib et al., 2019a; Habib et al., 2020; Habib et al., 2019b). Poverty and precarity have pushed Syrian refugee children into work and out of school (Habib, 2019). In a study of 4377 Syrian refugee children (between 4 to 18 years) living and working in the Bekaa Valley of Lebanon, 50 percent had to forgo school because of work.

Similarly, as of March 2018, Jordan hosted over 659 thousand registered Syrian refugees with about 140 thousand residing in camps, while an uncertain number of Syrians remain undocumented (Krafft et al., 2018). Syrian refugees in Jordan suffer from a range of health problems including communicable diseases, chronic illnesses, physical impairment, and mental health problems (Dator et al., 2018; Tiltnes et al., 2019). They also suffer from poor living conditions, financial issues and food insecurity, have limited access to health insurance, and most of them depend on charity to access health services (Krafft et al., 2018; Tiltnes et al., 2019). Moreover, they face gender-based challenges, whereby Syrian refugee girls face greater health risks and socio-economic challenges (Hattar-Pollara, 2019). Syrian refugees hosted in Turkey (3.6 million) have also experienced overcrowding with poor living conditions and health problems, including mental health problems, somatic distress, and NCDs (Eryurt & Menet, 2020; McGrath et al., 2020; Yıldız & Uzgören, 2016).

The associations between poor health amongst Palestinian refugees and poor living conditions in refugee camps in Arab countries has also been documented (Habib et al., 2014). Palestinian refugees living in Lebanon in poor households, such as with water leakage, were more likely to suffer from multi-morbidity (Habib et al., 2014), which shows how displacement due to conflicts is a major challenge to improving health in the Arab world.

B. The COVID-19 Pandemic

The COVID-19 pandemic has overburdened Arab countries, especially those with existing weak healthcare systems, those hosting refugees, and those that are economically reliant on migrant workers. The pandemic revealed the fragility of most Arab countries and their potential collapse against an emergent disease outbreak. The poor sanitation facilities and the crowded conditions in humanitarian settings allow for a quick spread of the virus (Walker, 2020). This is exacerbated by the absence of humanitarian aid workers as a result of the social distancing that has been adopted to reduce the spread of the virus (Walker, 2020).

The COVID-19 pandemic will adversely affect the progress towards achieving the SDGs in Arab countries by increasing morbidity and mortality and straining already poor healthcare systems and infrastructure. Arab countries, including high-income countries, tend to have a low number of physicians per capita, when compared with non-Arab countries of similar income levels (Abdellatif & Hsu, 2020). In addition, the capacity of hospitals and healthcare centers to admit COVID-19 patients is limited by low number of isolation chambers. Therefore, an existing weak system faces additional pressure during the pandemic, further challenging the capacity of less developed countries to improve public health.

The public health systems in the region's poor countries have been weakened by the scarcity of financial and human resources, and the frail capacity or will to accurately assess the burden of disease. In fact, this has been manifested during the COVID-19 pandemic, whereby the low numbers of reported laboratory confirmed cases in LICs and LMICs, compared to countries of higher income, is attributed to the lack of resources for testing and reporting, in addition to the limited laboratory capacity and weak surveillance systems (Mumtaz, 2020).

Within the region's HICs, where there is greater capacity for COVID-19 testing, migrant workers from non-Arab countries constitute a large portion of the positive COVID-19 cases. During a single week in May 2020, the Kingdom of Saudi Arabia's Ministry of Health reported that migrant workers made up more than 75 percent of all positive COVID-19 in the country (Sherlock, 2020).

The high rate of COVID-19 cases among migrant workers in Arab countries is due to both the large numbers of migrant workers in the region and the vulnerable nature of the migrant

worker populations. According to a 2019 estimate by the United Nations Department of Economic Affairs, Arab countries host over 35 million migrant workers (UNDESA, 2019). Most of those workers reside in the high-income Gulf Cooperation Council (GCC) countries, including Kuwait, Bahrain, and Qatar, where migrant workers make up the majority of the population, outnumbering national residents (International Labour Organization [ILO], 2019). Migrant workers in Arab countries work primarily in construction, manual labor, sanitation, and domestic labor (ILO, 2019). Since the onset of the COVID-19 pandemic, migrant workers (a low-income, vulnerable population) in the Gulf have had to bear a high burden, including high infection rates, living in crowded work camps, and enduring job loss (Chulov, 2020). Migrant workers typically reside in high-density housing where case-isolation (a critical, non-pharmaceutical intervention for controlling the spread of COVID-19) is not possible, creating a high chance of widespread infection (Babar, 2020). Given this context, the response to COVID-19 in Arab countries requires implementing policies that help reduce the vulnerabilities of the migrant community, in order to protect the health of both foreign and national residents and slow the spread of the disease (Babar, 2020). An example of such policies is the recent decision by the government of Qatar to offer worker-protection loans to businesses so that they could continue to pay workers under quarantine or isolation (Ataullah, 2020).

Standing as a counterweight to the health impacts of COVID-19 on migrant workers is the economic impact of COVID-19 on the foreign labor model in the Arab world (Barua, 2020). The COVID-19 pandemic has led countries around the world to enact public health mandates and travel restrictions, which have stagnated the movement of migrant workers and affected industries that rely heavily on foreign labor in Arab countries (Barua, 2020). National frameworks to address health and protections of migrant workers are therefore essential to protecting economic stability in HIC Arab countries in the face of COVID-19 (Babar, 2020) – a reality that illustrates again the relationship between SDG 3 (health) and others such as SDG 8 (economic development).

The economic impacts of COVID-19 will not be limited to Arab countries that rely on migrant labor. It is expected that the pandemic will result in a global economic depression, which will create further challenges for sustainable development and will hinder actions to achieve the SDGs (Abdellatif & Hsu, 2020). Projections suggest that the pandemic will increase poverty (SDG 1) and impact food security (SDG 2) (UN, 2020).

The necessary measures taken to control the COVID-19 pandemic, such as social distancing and closure of schools and businesses, has resulted in a burden on the economy of Arab countries (SDG 8), introducing fragility into the fairly wealthy countries and exacerbating it in those that were already vulnerable (Abdellatif & Hsu, 2020; UNDP Arabic, 2020). The UN ESCWA estimates that COVID-19 will result in a loss of USD42 billion and 1.7 million jobs in the Arab world, and that businesses in the Arab world have already lost around USD420 billion in market capital between January and mid-March 2020 (ESCWA, 2020). A marked reduction in the demand on oil and fuel due to the lockdown across the world has led to a dip in oil prices, which affected the economies of wealthy Gulf countries that are dependent on the petroleum sector. The UN ESCWA estimates that the Arab world has already experienced a loss of USD11 billion in net oil revenues between January and mid-March 2020 (ESCWA, 2020). These economic effects may also spread to other Arab countries since millions of Arab migrants working in the Gulf will not be able to send remittances back to their countries, resulting in a ripple effect that will spread from the Gulf to other remittance-dependent Arab countries (Abdellatif & Hsu, 2020).

C.Environmental Impacts on Health

Environmental crises are obstacles impeding progress in the Arab world. Extreme weather events, floods/droughts, air quality, infectious diseases, and malnutrition have been associated with climate change, morbidity, and mortality in the Eastern Mediterranean region (Habib et al., 2010). A recent systematic review on climate change and health in the Eastern Mediterranean region shows that researchers, health professionals, and policy makers should prioritize addressing the impact of climate change on health (Khader et al., 2015).

Environmental risks to health are included in SDG targets related to air pollution, water and sanitation, and poisoning (WHO, 2020d). In the Arab world, WHO estimates 24 million DALYs to be caused by environmental degradation (WHO, 2018). Air pollution is one of the most common environmental problems for Arab countries, where mortality attributed to low air quality is notably increasing (as shown in section IV, Table 4). Inadequate wastewater and solid waste management also creates an environmental burden in some Arab countries. For example, in Lebanon, aside from poor management of municipal solid waste and wastewater, there is no adequate treatment of hospital, industrial, and slaughterhouse waste (Abbas, 2017). These types of waste present biological and chemical hazards that would result in severe health outcomes.

Economic and political pressures have also burdened the environment in the Arab world. It is estimated that by 2030, 70 percent of the population living in Arab countries will reside in cities, increasing urbanization and overcrowding cities (El-Zein et al., 2014). Various Arab countries lack the resources and political interest to develop appropriate policies that protect the environment and public health. In contrast, the most wealthy Arab countries depend on the sale of oil and natural gas to sustain their economies (Zaidan et al., 2019). Also, the rapid increase in economic growth overtime in certain oil-producing Arab countries has created more demand and consumption, which in turn has stressed the natural resources and pressured the ecosystems' capacity to support life (Zaidan et al., 2019). This reliance on natural resource revenues may reflect the unwillingness to adopt environmentally sustainable strategies.

In addition, conflict and political issues stress the environmental health of populations. For example, droughts, water cuts, and destruction of

basic infrastructure have increased water insecurity and the associated illnesses in war-torn countries including Yemen, Syria, and the Palestinian territories (El-Zein et al., 2014; UNDP, 2020). These challenges, some unique to the Arab world, present obstacles that hinder the Arab countries' actions towards achieving the 2030 Agenda, and particularly SDG 3.

VII. NEED FOR NEW PERSPECTIVES: LOCAL AND REGIONAL EFFORTS

Evidently, with the current challenges, only some of the SDG 3 targets can be achieved. Unless a different approach is adopted, the Arab world will fail in achieving SDG 3 (El-Zein et al., 2016; Nuwayhid et al., 2016). Therefore, context-based local and regional efforts should be taken to create a suitable environment for succeeding in ensuring health for all (Bissat & Rihan, 2019; Katramiz et al., 2020). Health professionals should take on a more comprehensive integrated approach to achieving the targets. The following are measures that need to be pursued by Arab countries in their efforts to improve the health of their populations:

- **Country/Context-Specific Interventions**
  Each Arab country should plan interventions according to its health profile. As shown in this chapter, each country has a different burden of disease. Therefore, countries should prioritize their efforts to tackle the top causes and risk factors specific to their country. Most LICs and LMICs should focus on reducing neonatal disorders, diarrheal diseases, and lower respiratory tract infections, with efforts to tackle malnutrition, WASH, and air pollution. UMICs and HICs should focus more on reducing NCDs (e.g., diabetes and heart disease), congenital defects, road injuries, and drug use, with efforts to tackle BMI, blood pressure, dietary risks, and tobacco use. Such efforts can work on reducing the main risk factors for the top DALY causes in each country. In addition, almost all Arab countries should pursue efforts in peace building in order to stop ongoing conflicts and avoid future wars (SDG 16).

- **Cooperation for Health**
  Approaches to achieving health should consider cooperation between countries and between entities within a country (SDG 17). Arab countries should cooperate to overcome the challenges they face, since these challenges are not confined within one country, but disperse into the wider region, such as with migration, climate change, water scarcity and droughts, and air pollution. Cooperation between countries, organizations, and civil society can strengthen preparedness and response to disease epidemics as well (Schwartz & Yen, 2017). With all those hindrances, efforts for connection and communication should be fostered between Arab countries to achieve SDG 3 (Zaidan et al., 2019). However, actions for creating high-quality health systems should be tailored to the local context of each country rather than general to the entire region since each nation has different health priorities (Kruk et al., 2018). The health inequalities between Arab countries should be considered in the efforts undertaken to achieve SDG 3. Each nation must select the relevant targets to make progress on the goal, based on the assessment of its past, present, and future performance. Arab countries can exchange capacities and resources in a common trading zone based on their strengths. For example, Lebanon, with a strong medical educational system, could assist countries in the region in training healthcare workers. Wealthy Arab countries (e.g. Gulf countries) may be able to support other countries by investing in health-related technologies. National and regional working groups could coordinate the trade of financial and human resources to face the challenges and achieve SDG 3.

- **Efficient Data Collection**
  With regard to SDG targets, more efficient data collection is needed to ensure proper reporting of countries' progress. Some countries do not have data on all indicators, and therefore, should find alternative approaches and frameworks to collect data that show their progress towards the related target (Allen et al., 2017). Moreover, instead of national averages,

data should reflect more details, such as the regions within a country, gender, and age, which would help in determining the burden differences within the country. Nationality is of importance to collect as well, for countries hosting refugees and migrant workers. In addition, countries should work on increasing the financial, technical, and human resource capacity of healthcare facilities. This would help in accurately defining the status of a country with respect to certain diseases, especially with the recent COVID-19 pandemic.

- **Collaborations and Entrepreneurship**
  It is also important to form collaborations between both health and non-health fields for efforts on SDG 3. Unemployment is an ongoing and worsening situation in the Arab world; therefore, Arab World governments could incentivize health entrepreneurship, which can create public-private partnerships across various disciplines (SDG 17) and foster public health and biomedical research (Ramadi & Atun, 2019). This is important to improve health (SDG 3), to achieve economic growth while reducing unemployment (SDG 8) in the region, as well as to face the COVID-19 pandemic effectively.

- **Emergency Preparedness**
  There is an urgent need to pursue efforts in emergency preparedness against health-impacting problems. As mentioned previously, infectious disease outbreaks will constitute a major impact on health in countries with weak health systems. Investing in emergency planning is essential to mitigate the spread of those communicable diseases such as COVID-19, and reduce their effect on overall health in the Arab world. It is much more effective and essential for a country to prepare for an outbreak before it happens and not as a response to it (Perkins et al., 2017). Infectious disease outbreaks, such as COVID-19 and others, may recur in the future, which shows that emergency preparedness should be among the top priorities in the Arab world. In fact, such efforts should be part of the work to achieve Target 3.3 for combatting communicable diseases and Target 3.D for strengthening countries against national and global health risks.

- **Sustainable Development and Economic Progress**
  The Arab world is in need of strengthening the strategies to achieve sustainable development. Many Arab countries, particularly Gulf countries, have oil-based economies, which make them highly dependent on fuel commodities. Until ongoing plans to diversity income bear fruit, the instability of the petroleum sector revenues makes it an unsustainable economy and puts those countries at high risk of economic downfall. Therefore, Arab countries need to expedite economic diversification programs to include non-petroleum-based revenues that would sustain their financial status, an essential part of safeguarding health and achieving universal health coverage (Target 3.8). A good strategy would be to invest in environmentally friendly technologies, including energy efficiency and renewable energy. Some Arab countries, such as Egypt, Morocco, Jordan, UAE, Saudi Arabia, Tunisia, and Lebanon, have already initiated renewable energy alternatives (solar, wind, and hydropower), while others have the potential to implement renewable energy (International Renewable Energy Agency [IRENA], 2020). Researchers and policy makers should prioritize addressing environmental health issues, especially regarding the impact of climate change on health (Khader et al., 2015).

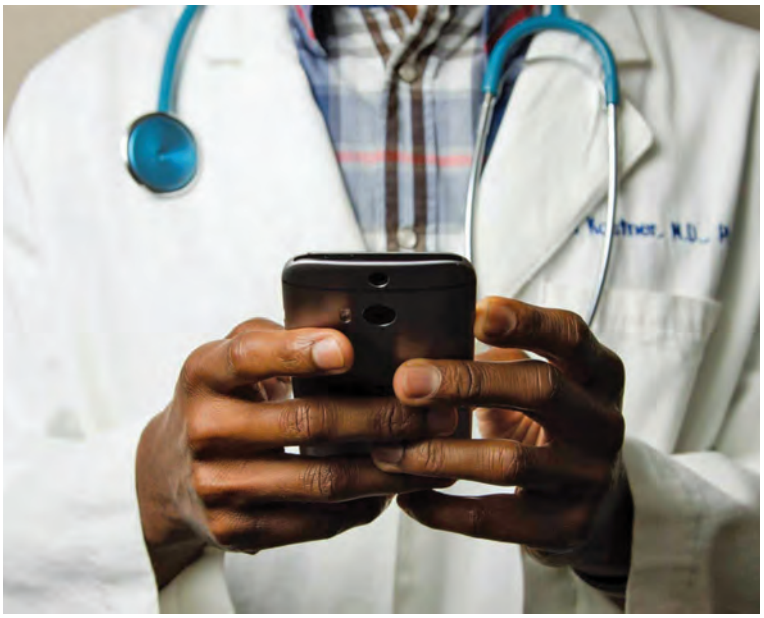
- **An integrated approach to achieve the SDG Agenda**
  Although SDG 3 targets (3.3, 3.B, and 3.D) include provisions for ending disease outbreaks and strengthening capacities to adopt necessary strategies, the tools and the plan for action to achieve those targets are not provided. It is important to note that the goals of the 2030 Agenda cannot be achieved as a piecemeal. Actions to progress on those goals will not be successful if countries address

only one goal at a time. For example, expanded and intensified agriculture to achieve SDG 2 alone would result in negative impacts on the environment and health, thus reducing progress on environmental, health-related goals (Di Marco et al., 2020). A similar issue is also reflected in the current COVID-19 pandemic, where countries, globally and in the Arab world, are struggling to deal with this public health outbreak without severely impacting their economies. Therefore, in order to achieve progress in the SDGs, especially those targets related to infectious diseases, countries should adopt an integrated approach that would safeguard people's livelihood, health, and the environment by addressing the relationships between the 17 SDG goals. An integrated approach would ensure that no SDG would be undermined during the process of achieving another.

- **Adopting a systems framework to achieve Universal Health Coverage (UHC)**

Universal health coverage (UHC) is the approach by which all citizens of a country are able to access health services (health promotion, prevention, treatment, rehabilitation, and palliative care) without financial hardships (WHO, 2019d). UHC reduces inequitable access to good-quality health services, reduces the risk of poverty associated with high health expenses, and helps achieve health-related SDG targets (Kutzin & Sparkes, 2016; WHO, 2019d). In fact, as shown in Figure 1 of this chapter, Target 3.8 of SDG 3 calls to achieve universal health coverage. Also, Targets 3.B, 3.C, and 3.D, as well as SDG Target 17.19 for 'statistical capacity-building', all relate to progress on improving the UHC process and health systems (WHO, 2019e). Given the health inequalities present within the Arab world, UHC is a necessity in Arab countries, as was evidenced by the new COVID-19 outbreak.

Achieving UHC requires strengthening the health systems (Kutzin & Sparkes, 2016) that are weak in most Arab countries.



Reducing out-of-pocket expenditures to a minimum, developing a basic healthcare package, having political stability, and increasing country income are also important features of a UHC (Jamal & El-Jardali, 2014; WHO, 2019d).

Given that many Arab countries are LICs and LMICs and that some have had prolonged armed conflicts, the challenges are numerous. In addition, most Arab countries, including those of high-income will face severe economic losses due to the COVID-19 outbreak. Therefore, adopting UHC to achieve health for all requires serious political commitment and diligent planning. The Systems Framework for Healthy Policy, which calls for the facilitation of global health security and focus on sustainable, fair health outcomes, can guide Arab countries to achieve UHC and health for all (Commonwealth Secretariat, 2016). The flexibility of this framework allows its implementation in a variety of contexts, be it with low, middle or high income.

VIII. CONCLUSION AND RECOMMENDATIONS

In brief, the Sustainable Development Goals, and particularly SDG 3, are more detailed than

the MDGs and provide a more holistic approach to sustainable development and health. Social, economic, and political development strategies are framed within this approach. Health (SDG 3) is at the center of all the efforts and is the overarching goal of the 2030 Agenda. Despite not being clearly shown in most UN documents, the interconnection between SDG 3 and the other SDGs should be considered by policy-makers and health professions.

The Arab world is still behind in achieving the 2030 Sustainable Development Goals. Although populations' health in the Arab world has modestly improved since 2016, more progress is still needed on SDG 3 and the other SDGs to succeed in the 2030 Agenda. The large discrepancies in the health profiles of the Arab countries are based on their economic and political situations. In order to achieve progress in health, Arab countries should face the challenges that hinder their efforts, including political, economic, and environmental factors, as well as armed conflicts and displacement. Addressing these challenges and mainstreaming the SDG 3 targets in the local and regional efforts will ensure progress in the 2030 Agenda. Arab countries should cooperate and trade resources to achieve the SDG 3 targets. Interdisciplinary agencies within a country should form partnerships to improve the health systems. More importantly, Arab countries should adopt a systems framework to achieve universal health coverage and reduce the health inequalities present in the Arab world. The COVID-19 outbreak has proved that the health of a nation cannot be sustained by targeting special groups that can afford to pay for healthcare services; "health for all" is a necessity.

Finally, the COVID-19 pandemic has exposed the weak healthcare systems in Arab countries and their limited capacity to cope with emergent health crises. More severe challenges are expected to test the health systems in Arab countries such as climate change, and the Arab world must learn from the experience of the COVID-19 outbreak in order to mitigate future threats. Regional cooperation between the Arab countries on environmental, political, and public health aspects is essential to achieve the SDG 3 targets and to ensure survival in the region.

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OPINION

HOW WILL THE CORONAVIRUS PANDEMIC INFLUENCE THE DEVELOPMENT GOALS?

Najib Saab

Can the UN Sustainable Development Goals (SDGs) still be achieved on time by the 2030 deadline? The apparent answer is no, not only because priorities have shifted and resources will be diverted towards addressing other urgent matters, but also because achieving the SDGs successfully now requires new rules and methods.

The impact of the coronavirus pandemic will not only affect the timing of implementation, but will also extend to the mechanism of action. High-level meetings scheduled for 2020 cannot take place as usual, according to plan. The decline in the work of governmental bodies and international organizations will lead to a delay in decision-making, with many heads of international organizations staying away from their headquarters for months. The direct negative outcome will affect all goals, beginning with SDG 3, which calls for ensuring healthy lives and promoting well-being for all.

Health has been the first victim of the pandemic, as the world has lost almost all progress made in recent years, after having to direct available resources to address the current crisis at the expense of universal healthcare. SDG 4, which calls for inclusive and equitable quality education, suffered a severe blow with more than one billion students under lockdown, a situation aggravated by a weak digital infrastructure in many poor countries that failed to secure online education. SDG 8, which is about promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, was also hit hard by an unprecedented economic collapse and the loss of tens of millions of jobs. SDGs 1 and 2, to end poverty and hunger, have also lost major ground, with tens of millions expected to join the growing club of the poor and hungry.

Whereas SDG 7 goal calls for ensuring access to affordable, reliable, sustainable and modern energy for all, a shortage in maintenance workers led to breakdowns in the existing electricity networks, and the decline in investments halted the construction of new production plants, whether they adopted traditional or renewable sources. According to the International Energy Agency (IEA), investments in energy in recent months have witnessed the largest decrease in history, and are expected to decline by 20 percent by the end of this year, compared to last year, at the equivalent of USD400 billion. The agency warned that this will affect energy supplies as well as hinder the shift to clean energy sources.

Whatever the hopes may be, the reality is that the current situation will negatively affect the commitments to curb climate change, as according to the Paris Agreement, developing countries were set this year to start receiving USD100 billion annually for climate action. In the absence of stable financing for practical and long-term measures, the expected funding delay will not be compensated by the temporary decrease in emissions from industry and transportation.

But not all bad news

On the other hand, some positive indicators have emerged, the most prominent of which is that achieving the SDGs, including environmental protection, is still on the national and international agendas, despite health and economic setbacks. The challenge has prompted all to acknowledge once again the imperativeness of international cooperation in addressing cross-border disasters, whether related to health or the environment.

Despite the isolationist tendencies of some governments, and populist movements that disregard environmental measures, including climate action, the European Union announced – when it recently allocated additional €750 billion for the EU Recovery Fund – that aid would be conditional on adopting green policies that would be reflected in both public and private sector spending, including efficient buildings, renewable energy and clean transport.

What about developing countries?

According to announced policies, the recovery funds allocated by developed countries will address environmental challenges alongside health, social and economic matters, which will boost achieving the SDGs

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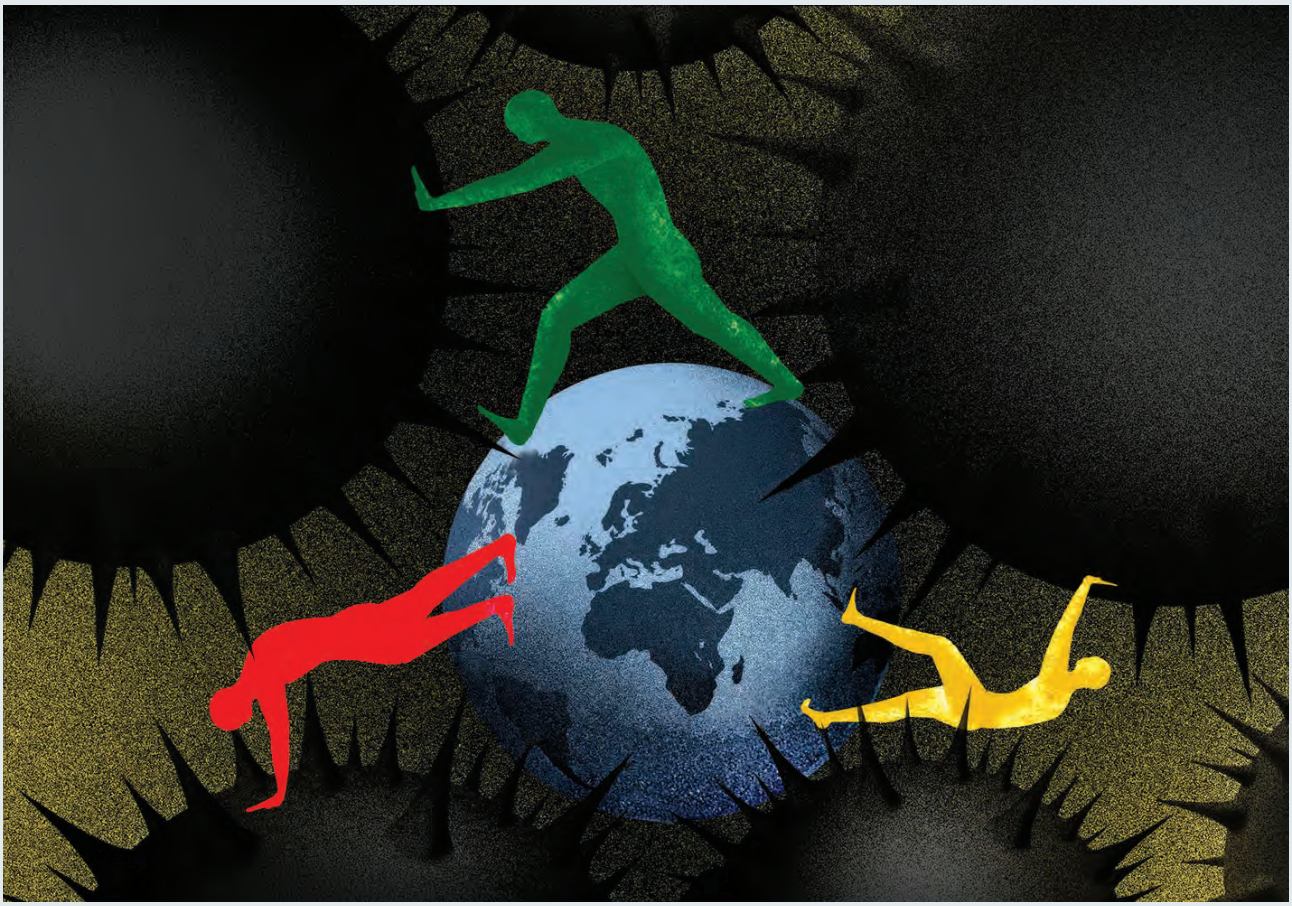


within national borders. But what about developing countries that need assistance to implement the required transformation? What are the implications of the global economic meltdown on donations, loans and investments in developing countries, whether they come from governments, development funds or the private sector? Here lies the big challenge.

The need of donor countries to pump massive funds to save their own economies will put pressure on funds earmarked for foreign aid. Country contributions to the budgets of international organizations and development funds will decrease. This compels a new approach, because attracting money and investments will become more difficult and subject to strict conditions, the most important of which are good governance, efficiency and the fight against corruption. Private investors will demand more guarantees, and aid agencies will ask for sterner assurances that soft loans and donations are well used and are not wasted to corruption.

Developing countries need to get their affairs in order, redefine their priorities, and invest their human and natural resources in a highly efficient manner, to show that they are worthy of external support. On the other hand, international organizations and development funds must adhere to strict efficiency standards, focusing on results and actual productivity, not on the number of projects or the size of loans and aid agreements.

Staying on track

There is no doubt that the global catastrophe we are going through will change the timetable for achieving the SDGs, including climate change and environmental protection, especially in developing countries. But we must admit that the failure to meet the conditions for achieving these goals is not solely the result of the new pandemic, as it preceded it. It should not be allowed to use the pandemic as an excuse for delay.

Changing the course was required long ago. Hopefully the shock caused by the pandemic will constitute an impetus for long-awaited new development policies, at the national, regional and international levels. Instead of the pandemic hindering sustainable development efforts, a successfully managed exit from the crisis may put them on the right track.

WATER AND SANITATION

Mey Jurdi, Joumana Nasr, Rola Ajib

I. INTRODUCTION

In July 2010, the United Nations General Assembly passed UN resolution 64/292 recognizing access to clean drinking water and sanitation as a basic human right. Likewise, the UN Human Rights Council adopted resolution 16/2 affirming that water and sanitation are inextricably related to the right to life and human dignity. The Millennium Development Goals (MDGs) addressed water and sanitation within MDG 7 on environmental sustainability. However, developing countries throughout the world were largely not able to fully meet the set MDG targets by 2015. Accordingly, Sustainable Development Goal 6 (SDG 6) was proposed to ensure the provision and sustainability of water and sanitation services for all. To achieve access to basic water and sanitation for all by 2030, countries should put efforts beyond households, to include institutional settings such as schools, healthcare facilities, public places, and workplaces.

In 2012, the League of Arab States (LAS) endorsed the Arab Water Security Strategy 2010-2030 to provide guidance for achieving sustainable development in their countries.

Recently, this strategy incorporated the SDG 6 agenda along with the new pillar of the water-energy-food security nexus. Further, the Arab Health and Environment Strategy 2017-2030 identifies water and sanitation as an integral component and calls on Arab countries to address the main challenges and risk factors relating to the provision of water and sanitation. Moreover, providing water, sanitation and hygiene (WASH) services is critical to help protect against major threatening infectious outbreaks such as the COVID-19 pandemic. Although mostly respiratory in nature, epidemiological and microbiological data provides evidence that contaminated hands can transmit the novel coronavirus when in contact with the mouth, nose or eyes and can transfer the virus from one surface to another. Therefore, maintaining recommended water and sanitation practices is key to reducing the spread of COVID-19. The WHO has thus called on practitioners to improve the provision of safe water by increasing access to sanitation services in order to promote and enable proper hygienic practices to help contain the spread of the COVID-19.

II. WATER AND SANITATION IN THE ARAB REGION: OVERVIEW

Diarrheal diseases are major contributors to global child mortality, causing 20 percent of all deaths in children under five years of age (WHO, 2015). Fecal pathogens cause diarrheal diseases and the main pathway is the direct fecal-oral route, in addition to contact with contaminated hands, surfaces and objects (Prüss-Üstün et al., 2016; Kotloff et al., 2013; Tate et al., 2012). Changes in climate also affect the transmission of diarrheal diseases due to major environmental impacts (WHO, 2014). Moreover, improvement in the access to water and sanitation and personal hygiene effectively reduce the exposure to diarrheal morbidity and mortality (Freeman et al., 2014; Wolf et al., 2014). Additional diarrheal disease burden is associated with food safety, as it relates to WASH services. In total, the World Health Organization estimated that around 58 percent (34-72 percent) of all cases of diarrhea in low and middle-income countries, or 57 percent worldwide, are attributable to the environment, resulting in 842,000 deaths annually. Water, sanitation and hygiene are major factors (Prüss-Üstün et al., 2014).

TABLE 1 **BURDEN OF DISEASE FROM DIARRHEA ATTRIBUTED TO EXPOSURE TO UNSAFE WASH SERVICES FOR THE YEAR 2016 (ADAPTED FROM WHO, 2016)**

Country	Number of Diarrheal Death from Inadequate Water, Sanitation and Hygiene	Diarrheal DALYs from Inadequate Water, Sanitation and Hygiene
Algeria	749	72,917
Bahrain	1	109
Comoros	386	22,103
Djibouti	281	16,115
Egypt	1854	175,169
Iraq	1109	114,169
Jordan	58	7104
Kuwait	1	316.4
Lebanon	47.2	3969
Libya	36	5398
Mauritania	1575	101,940
Morocco	661	57,280
Oman	2	494.9
Qatar	0	93.63
Saudi Arabia	29	3246
Somalia	11,756	886,677
Sudan	6637	551,580
Syria	669	67230
Tunisia	114.5	8665
United Arab Emirates	3	760.3
Yemen	2779	258,601

In the Arab region, the mortality rate of diarrhea attributed to unsafe WASH services was estimated to be close to 29,000 deaths in 2016, with an estimated 2,354,000 Disability Adjusted Life Years (DALYs). Table 1 presents the DALYs of diarrheal diseases attributed to unsafe water, sanitation and hygiene (WASH) services in Arab countries for the year 2016. Five countries belonging to the Gulf Cooperation Council sub region reported the lowest number of deaths and DALYs. These countries, Bahrain, Kuwait, Oman, Qatar, and the United Arab Emirates, are characterized by high coverage of safely managed drinking water and sanitation services (WHO/UNICEF, 2019; WHO, 2016).

On the other hand, most of the least developed countries in the region, specifically Mauritania, Yemen, Sudan and Somalia, along with Egypt reported the highest number of deaths and DALYs, with rates reaching 11,756 deaths in Somalia in 2016, as presented in Figure 1 (WHO, 2016; UNEP/WHOEMRO, 2015). As such, the provision of adequate water and sanitation remains a major challenge to be met mostly for Group 2 countries (Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Palestine, and Tunisia), and is highly health threatening for Group 3 countries (Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen).

Henceforth, the provision of sustainable access to sufficient drinking water and sanitation remains a major challenge that affects human health and aggravates the cost of environmental degradation. Studies of the World Health Organization for the

year 2016 indicate that environmental hazards are responsible for about 23 percent of the total burden of disease (including more than 628,000 deaths per year and 24 million DALYs, lost each year) (Prüss-Ustün et al., 2014; Prüss-Ustün et al., 2016; UNEP and WHOEMRO, 2015; WHO Stat, 2016; Wolf et al., 2014).

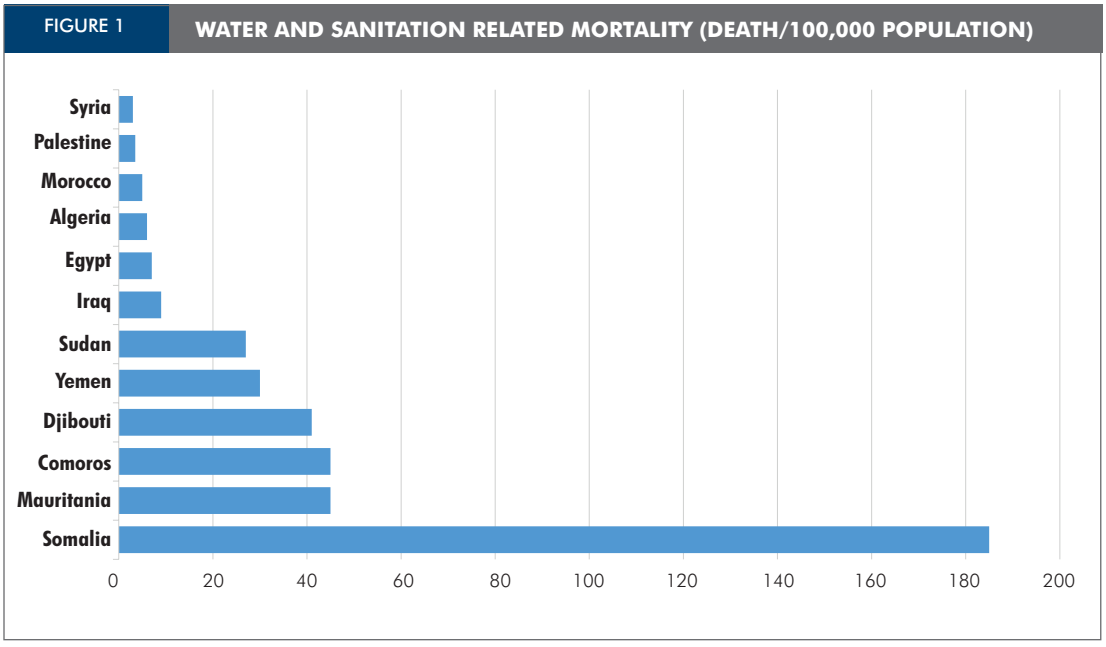
In the Arab region, in Group 1 countries (UAE, Bahrain, Kuwait, Saudi Arabia, Oman, Qatar), comprising 13 percent of the population, the annual environmental burden of disease is 25.4 DALYs per 1000 population (yearly overall cost of USD36.5 billion of the gross domestic product). The main environmental risk factors prevailing include air pollution, chemical exposure, housing and environmental determinants of injuries (Prüss-Üstün, 2014; Prüss-Üstün, 2016; WHO, 2016; UN and WHO, 2019; UNICEF and WHO, 2019; UNEP/WHOEMRO, 2015; Wolf et al., 2014). These contribute most significantly to the burden of non-communicable diseases.

For Group 2 countries (Jordan, Algeria, Syria, Iraq, Morocco, Tunisia, Palestine, Lebanon, Libya, Egypt), comprising 57 percent of the Arab population, the annual environmental burden of disease is 39.3 DALYs per 1000 population (yearly overall cost of USD60.5 billion of the gross domestic product). The major environmental risks prevailing are water and sanitation, air pollution, and exposures to chemicals, wastes and food contamination contributing to the burden of both communicable and non-communicable diseases (Prüss-Üstün, 2014; Prüss-Ustün, 2016; WHO, 2016 and Wolf et al., 2014).

For Group 3 countries (Sudan, Somalia, Yemen, Comoros, Djibouti, Mauritania) comprising 30 percent of the Arab population, the annual environmental burden of disease is 91.4 DALYs per 1000 population (yearly overall cost of USD14.0 billion of the gross domestic product). The main environmental risk factors prevailing are water and sanitation, indoor air pollution, and exposure to chemicals, wastes and food contamination that contribute significantly to the burden of communicable diseases, and to a lesser extent also non-communicable diseases (Prüss-Üstün, 2014; Prüss-Üstün, 2016; WHO, 2016; Wolf et al., 2014).

Moreover, the Arab region is one of the most water stressed regions of the world due to the limited renewable water resources and the over-exploitation of existing ones (Luomi et al., 2019; WWAP, 2019). In fact, the 14 most water stressed countries in the world belong to the Arab region (AFED, 2016). Water scarcity in the region is mostly aggravated by climate change, progressive population growth, dependency on shared/transboundary water sources, and poor water governance (ESCWA, 2015a,b; Luomi et al., 2019; Jurdi, 2015; Mediterranean Wetland Initiative, 2016; Middle East Institute; WWAP, 2019). This

FIGURE 1 WATER AND SANITATION RELATED MORTALITY (DEATH/100,000 POPULATION)



is a major critical challenge that further reflects on poor water resource management, and further challenges the development and sustainability of water and sanitation services.

Water management is not comprehensive, nor cohesive; it is highly fragmented and mostly driven by competitive demands among various sectors. In fact, what drives the management of water resources is the inefficient and ineffective water consumption/production patterns, and the unlimited surface and ground water extraction (AFED, 2016). Likewise, the policies relating to the agricultural sector, which is a major water-consuming sector, overlook sustainable water use and the need to enhance water productivity, which has contributed highly to the escalation of the problem. Moreover, deficient wastewater treatment and reuse further challenges water availability in terms of both water quantity and quality. Subsequently, excessive exposure to pollution results in degraded water quality and mainly pollution resulting from the discharge of inefficiently treated wastewater in natural water bodies. The published water quality reports are mostly based on testing few quality indicators such as: (a) electrical conductivity and pH for both surface and groundwater; (b) nitrogen, orthophosphates, and dissolved oxygen for surface water; and (c) nitrates for groundwater (UNEP, 2018). This further confirms deficient water resource assessment that is critical to enhance water availability in terms of quantities needed to meet the basic water needs, and to insure the provision of safe water supply.

III. PROVISION OF WATER AND SANITATION IN THE ARAB REGION

To evaluate the provision of water and sanitation services provided in the Arab region, the indicators presented in tables 2 and 3 will be used (Guppy et al., 2019; WHO/UNICEF, 2017; WHO/UNICEF, 2019; UN, 2018). These indicators directly relate to the provision of water and sanitation services but do not cover all nine targets of SDG 6 (Guppy et al, 2019; UN, 2018) Based on the scope of the presented work, and in line with data availability, the presentation addresses, mostly, these indicators. Moreover, it is important to understand the level of the service tracked by each indicator, which is crucial to follow up on the progress in countries. Meeting all the set targets by 2030 does not mean that populations will have sustainable access to adequate and safe drinking water and proper sanitation. It is the first milestone towards developing an infrastructure for water and sanitation services. The target for now, as explicit with the definitions, is basic levels of services still; the major challenge facing countries is to develop sustainable WASH systems. As such, it is critical to continuously develop and upgrade the system based on health needs and in line with socioeconomic development. Therefore, the ultimate universal goal is to provide all populations with sustainable access to adequate safe drinking water and proper sanitation. This was the driving motto of the water and sanitation target of MDG7 on environmental sustainability.

A. Proportion of Population Using Safely Managed and Basic Drinking Water Services

In 2017, 89 percent of the population in the Arab region used basic drinking water services – close to the global average, which was estimated at 90 percent – whereas the remaining 13 percent lacked access to basic services (LAS, 2020). It was difficult to calculate the regional figures for the year 2017 on the proportion of people who used safely managed drinking water due to a major limitation in the number of countries with adequate data (WHO/UNICEF, 2019; UN Stat, 2019). However, the 2016 estimates showed that 90 percent of the population in the Arab region had access to safe drinking water. This is close to the global average, which was then at 91 percent. At the country level, Kuwait was the only country in the Arab region with a 100 percent coverage of safely managed drinking water services. The coverage rates of other countries such as Jordan, Oman, Bahrain, Qatar and Tunisia ranged between 90.28 to 98.98 percent, while Iraq and Lebanon had the lowest coverage rates of 58.83 and 47.70 percent, respectively. Given that this indicator reflects on the "percentage of people using drinking water from an improved source that is accessible on premises, available when needed and free from fecal and priority chemical contamination" (Mohieldin, 2018), it is critical to develop and sustain comprehensive water quality monitoring programs as direct indicators to insure the physical, chemical and microbiological water safety. We cannot just depend on the

proxy indicator of improved water sources that can range from piped water, boreholes or tube wells, protected dug wells, protected springs to packaged or delivered water. This is also crucial to be able determine that the amounts in terms of basic water requirements (BWR) to sustain human health as recommended by the World Health Organization (50L/capita/day), are being met (Gleik, 2014).

B. Proportion of Population Using Safely Managed and Basic Sanitation Services

In 2017, only 29 percent of the Arab countries had access to safely managed sanitation services, recording lower rates than the global average estimated at 45 percent (WHO/UNICEF, 2017, 2018). Moreover, the proportion of people in the region with access to at least basic sanitation services was 81 percent (Table 3). This level exceeded that of the global average recorded at 68 percent (Mohieldin, 2018). Kuwait also recorded the highest coverage of safely managed sanitation services (100 percent), while Algeria, Lebanon, Libya, Djibouti, Morocco and Iraq had the lowest coverages, ranging between 17.69 and 41.07 percent. Egypt, State of Palestine, Saudi Arabia, Tunisia, Jordan, Bahrain, Qatar and United Arab Emirates, all reported a coverage rate of more than 50 percent, ranging from 60.74 to 96.03 percent. In low-income countries such as Somalia, Comoros, Sudan, Mauritania, Djibouti and Yemen, more than 40 percent of the population did not have access to basic sanitation services (WHO/UNICEF, 2018). In fact, overall estimates show that 19 percent of the total Arab population lacks access to basic sanitation services (Mohieldin, 2018).

Disparities are also recorded between rural and urban areas, with rural areas having poorer access to sanitation and water services (AMWC, 2012; ESCWA, 2015a). Furthermore, in 2017, the proportion of the population practicing open defecation was null in less than half (9)

TABLE 2 **DESCRIPTION OF THE SDG 6 INDICATORS (ADAPTED FROM WHO/UNICEF JMP, 2019)**

SDG 6 Indicators	Description as defined by the WHO/UNICEF Joint Monitoring Program
People using safely managed drinking water services (% of population)	The percentage of people using drinking water from an improved source that is accessible on premises, available when needed and free from fecal and priority chemical contamination. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.
People using at least basic drinking water services (% of population)	The percentage of people using at least basic water services, including people using basic water services as well as those using safely managed water services. Basic drinking water services is defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip.
People using safely managed sanitation services (% of population)	The percentage of people using improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines: ventilated improved pit latrines, compositing toilets or pit latrines with slabs.
People using at least basic sanitation services (% of population)	The percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services.
People with basic handwashing facilities on premises (% of population)	The percentage of people living in households that have a handwashing facility with soap and water available on the premises. Handwashing facilities may be fixed or mobile and include a sink with tap water, buckets with taps, tippy-taps, and jugs or basins designated for handwashing. Soap includes bar soap, liquid soap, powder detergent, and soapy water but does not include ash, soil, sand or other handwashing agents.
Proportion of safely treated domestic wastewater (%)	The percentage of wastewater flows from households, services and industrial premises that are treated in compliance with national or local standards.
Total official development assistance (gross disbursement) for water supply and sanitation (USD millions)	The total official development assistance (ODA) allocated to water- and sanitation-related programs. ODA is reported as the total per recipient country in constant 2015 USD per year.

of the Arab countries, namely: Oman, Bahrain, Tunisia, Egypt, Kuwait, Qatar, Saudi Arabia, Lebanon and Libya (JMP WHO/EMRO, 2019; UN, 2019). In the same year, the global average for open defecation was at 9 percent, with some Arab countries including Djibouti, Yemen, Sudan, Somalia, and Mauritania exceeding this average with percentages ranging from 17 to 32 percent. It is worth noting, though, that Sudan was among the 16 countries at a global level that significantly reduced this percentage by more than 20 percent between 2000 and 2017 (UNICEF/WHO, 2019). It is also important to note that improved sanitation facilities include "flush/pour flush to piped sewer systems, septic tanks or pit latrines: ventilated improved pit latrines, compositing toilets or pit latrines with slabs" (Worldbank, 2020) and that the transitional goal is basic sanitation, whereas the ultimate goal is proper treatment and further reclamation and reuse. This is critical for a region suffering from utmost water scarcity and degraded water quality, as indicated before (Aleisa and Zubari, 2017; ESCWA, 2017; WHO/UNICEF, 2019; UN Stat, 2019; ESCWA, 2016; ESCWA, 2017).

TABLE 3 SDG 6 INDICATORS REPORTED BY ARAB COUNTRIES (ADAPTED FROM UN STATS, 2019 AND WHO/UNICEF JMP, 2019)

Service	Year	SDG 6 Indicator	Country	Value (%)
Proportion of population using safely managed drinking water services	2017	6.1.1	Lebanon	47.70
			Iraq	58.83
			Morocco	70.27
			Oman	90.28
			Tunisia	92.66
			Jordan	93.82
			Bahrain	98.98
			Qatar	96.18
			Kuwait	100.00
Proportion of population using safely managed sanitation services	2017	6.2.1a	Algeria	17.69
			Lebanon	21.76
			Libya	26.11
			Djibouti	36.44
			Morocco	38.75
			Iraq	41.07
			Egypt	60.74
			State of Palestine	61.24
			Saudi Arabia	77.75
			Tunisia	78.12
			Jordan	80.55
			Bahrain	96.00
			Qatar	96.03
			United Arab Emirates	96.28
			Kuwait	100.00
Proportion of population with basic handwashing facilities on premises	2017	6.2.1b	Somalia	9.83
			Mauritania	15.95
			Sudan	23.44
			Yemen	49.54
			Syria	70.60
			Tunisia	78.69
			Algeria	83.74
			Egypt	89.83
			Iraq	94.58
			Oman	97.40

C. Proportion of Population with Basic Handwashing Facilities on Premises

As for basic handwashing facilities (Table 3), Oman had the highest coverage with 97.4 percent, followed by Iraq with 94.58 percent. Syria, Tunisia, Algeria and Egypt also recorded high coverage rates, ranging from 70.6 to 89.83 percent. Somalia recorded the lowest coverage

TABLE 3 CONT. **SDG 6 INDICATORS REPORTED BY ARAB COUNTRIES (ADAPTED FROM UN STATS, 2019 AND WHO/UNICEF JMP, 2019)**

Service	Year	SDG 6 Indicator	Country	Value (%)
Proportion of safely treated domestic wastewater flows	2018	6.3.1	Somalia	0.70
			Lebanon	13.44
			Libya	15.25
			Algeria	17.75
			Iraq	18.57
			Morocco	42.96
			Egypt	57.61
			Palestine	68.65
			Tunisia	70.57
			Saudi Arabia	70.78
			Qatar	76.90
			Jordan	82.91
			United Arab Emirates	98.62
			Kuwait	100.00
Total official development assistance (gross disbursement) for water supply and sanitation (USD millions)	2017	6.a.1	Libya	2.27
			Algeria	3.79
			Comoros	4.12
			Syria	8.35
			Somalia	20.23
			Sudan	20.74
			Djibouti	20.94
			Yemen	35.31
			Mauritania	57.62
			Lebanon	99.55
			Palestine	102.91
			Egypt	148.44
			Morocco	156.50
			Tunisia	165.38
			Iraq	208.19
			Jordan	522.18

rate, at 9.83 percent, followed by Mauritania and Sudan with 15.95 and 23.44 percent, respectively (WHO/UNICEF, 2019; UN, 2019; WHO and UNICEF 2019; UNICEF, 2020; World Bank, 2020). The COVID-19 pandemic has taught us that hygiene is beyond "the percentage of people living in households that have a handwashing facility with soap and water available on the premises" (WHO/UNICEF, 2019). The provision of sufficient safe water supply, proper sanitation and handwashing facilities with enhanced awareness is necessary to stop propagation of the pandemic. In addition, the importance of proper handwashing is beyond the handwashing facilities that may be "fixed or mobile and should include a sink with tap water, buckets with taps, tippy-taps, and jugs or basins designated for handwashing" (WHO/UNICEF, 2019). Further, the use of soap is detrimental (WHO/UNICEF, 2019).

D. Proportion of Safely Treated Domestic Wastewater

Kuwait and Mauritania recorded the highest and lowest coverage of safely treated domestic wastewater flows with 100 and 0.7 percent, respectively (Figure 2). The United Arab Emirates had a coverage rate of 98.62 percent. Lebanon, Libya, Algeria, Iraq and Morocco recorded a coverage rate of less than fifty percent, ranging from 13.44 to 42.96 percent. As for Egypt, State of Palestine, Tunisia, Saudi Arabia, Qatar, and Jordan, the coverage rates ranged between 57.61 to 82.91 percent (Table 3). As such, wastewater collection, treatment, reclamation, and reuse remain major challenging factors that affect water quality and availability.

Wastewater collection, treatment and the levels of treatment vary widely between the Arab countries. Data from countries shows that collected wastewater undergoes secondary treatment (45 percent) and tertiary treatment (23 percent), as presented in Tables 4 and 5 (ESCWA, 2016). For, the GCC countries (Bahrain, Oman, Qatar, Saudi Arabia and the United Arab Emirates), as well as Jordan, Tunisia and Mauritania, the majority (more than 90 percent) of the collected wastewater undergoes treatment, and the treatment is up to the tertiary level for the GCC countries (Table 4). When it comes to other countries as Egypt, Iraq, Yemen, Algeria, Morocco, Libya, and State of Palestine the treated wastewater out of the collected wastewater varies between 67 percent and 1 percent (ESCWA, 2016). For these countries, the treatment is mainly secondary and in few cases primary, as presented in Table 5 (keeping in mind that for some countries, like Mauritania, the collected wastewater is minimal to start with) (Aleisa and Zubari, 2017; ESCWA, 2016; ESCWA, 2017). This wide variability in range of treatment wastewater treatment further highlights the challenge of wastewater management in Arab countries.

As for the reuse of treated wastewater, wide variation also exists between countries of the region, as presented in Figure 2 and Table

5. Many countries highly reuse the treated wastewater, while others do not, for several reasons. Few countries, like Palestine and Oman, use the treated wastewater for groundwater recharge (Freeman et al., 2014). Many countries reuse most of its treated wastewater for irrigation or directly discharge it in freshwater bodies (Freeman et al., 2014; Gleik, 2014). Moreover, some countries still treat wastewater partially and discharge it in an unsafe manner in watercourses (UN, 2018). In countries where the reuse rates are low, several factors like the fluctuation in the effluent quality, the absence of sufficient distribution infrastructure, restrictive reuse standards as well as the public's psychological acceptance relating to the reuse of wastewater, even if treated, among others are major limiting factors (Karnib, 2016). For most of the Arab countries, wastewater treatment and reuse is becoming necessary for water supply, especially with climate change and the increase in demand because of population growth. In GCC countries specifically, wastewater treatment and reuse is proving to be indispensable for the provision of water as a means to alleviate the financial and ecological burden of desalination (Aleisa and Zubari, 2017).

E. Development Assistance for Water and Sanitation

Table 3 presents the total official development assistance (gross disbursement) for water supply and sanitation. In 2017, 136 developing countries received a total of USD 8.8 billion as official development assistance (ODA) for water and sanitation related activities. Seventeen Arab countries got USD1.6 billion of this assistance (WHO, 2019). Funds to Arab countries varied significantly, ranging from USD2.27 million for Libya to USD522.18 million for Jordan (WHO/UNICEF, 2019). These official development funds exhibited an upward trend from 2015 to 2017, and countries used them for water and sanitation related projects. Such projects focused on water sector policy and administrative management, water resources conservation, river basin development and wastewater management and disposal (WHO, 2017, 2019).

Even though the external development funds represent only a small portion of the global

expenditure in the water and sanitation sector, the amount received by some countries was significant (Sachs et al., 2019). For instance, Mauritania received USD 57.62 million as ODA, which accounted for almost 60 percent of the national expenditure on the water and sanitation sector (WHO, 2017). Still, the UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) 2019 Report showed that global financing assistance of 2017 was not sufficient to meet national targets for SDG 6. Looking at the few Arab countries who did report on funding gaps between identified WASH needs and available funding to meet national targets, Lebanon reported a 68 percent funding gap for the year 2017, and the State of Palestine reported a 47 percent gap, whereas Mauritania was one of the countries that reported a 0 percent gap (WHO, 2019).

Further, Table 6 presents water and sanitation reported data based on grouping countries by the levels of socioeconomic development (Groups 1, 2 and 3). According to the Sustainable Development Goal 2019 Progress Report, only 9 Arab countries are on track to achieve SDG 6. The remaining countries in the region exhibit either stagnating or moderate increasing trends (Sachs et al., 2019).

The discrepancies among countries are highly evident, confirming the need for focused WASH efforts. Additionally, the data is mostly unavailable or not reported – even the quality of the reported data is poor. This further

emphasizes the importance of water resources assessments as an essential component of integrated water resources management based on continuous monitoring. This is a priority to enhance water supply, manage water demand, and develop and recommend environmental interventions for protecting natural water resources.

IV. CHALLENGES TO MEETING SDG 6 WATER AND SANITATION PROVISION TARGETS BY 2030

The provision of safe water supply and sanitation with the ultimate goal of instating sustainable processes for integrated water resources management (SDG 6) are, currently, among the highest-priority challenges facing most of the Arab countries (Goll, et al., 2019; UN, 2019). Yet many aspects hinder the region's progress toward achieving the targets set by the SDG 6 Agenda. Even though the local context struggles, priorities and progress of the Arab countries significantly vary, some of the challenges that hinder the achievement of the SDGs are nonetheless common (AFED, 2016; UN, 2019). Subsections 3.4.1-3.4.7 describe some of these major challenges.

A. Poverty and Development

Globally, WASH poverty diagnostic studies are on the increase to better understand the linkages between monetary poverty and WASH services. Questions raised relate to defining poverty, identifying the constraints to service and recommending the potential solutions to providing universal access to safely managed water supply and sanitation. Poverty and low

FIGURE 2 TREATED AND UNTREATED WASTEWATER USE (UN, 2018)

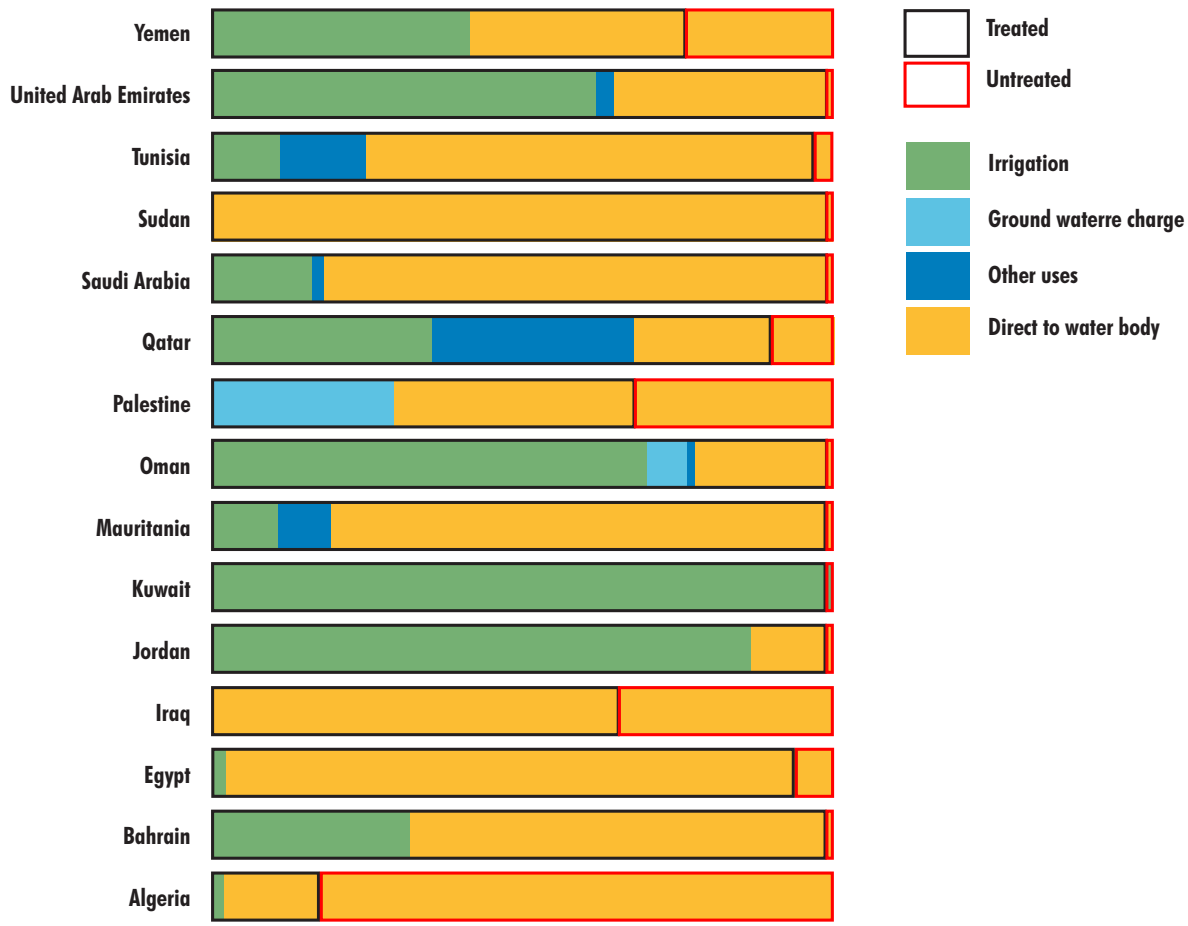


TABLE 4 WASTEWATER COLLECTION AND TREATMENT IN ARAB COUNTRIES FOR THE YEAR 2013 (ADAPTED FROM ESCWA ET AL., 2016)

Country	Volume of Collected Wastewater (Mm^3/yr)	Primary Treatment (Mm^3/yr)	Secondary Treatment (Mm^3/yr)	Tertiary Treatment (Mm^3/yr)
GCC Countries				
Bahrain	122.8	0	0	122.8
Kuwait	-	-	58.0	250.3
Oman	26.2	0	0	26.2
Qatar	176.8	0	0	158.7
Saudi Arabia	1,317.2	0	580.2	736.9
United Arab Emirates	615.7	0.3	11.7	593.6
Mashreq Countries				
Egypt	3,030.4	724.3	2,054.8	57.1
Iraq	620.4	0	415.7	0
Jordan	130.8	0	130.8	0
Lebanon	-	-	-	-
Palestine	30.8	20.7	0.45	0
Maghreb Countries				
Algeria	1570.4	0	275.2	0
Libya	291.1	0	45.8	0
Morocco	144.2	38.2	0.1	6.1
Tunisia	235	0	222	6.6
Least Developed Countries				
Mauritania	0.65	0	0.65	0
Sudan	18	18	0	0
Yemen	159.4	58.13	42.24	22.02
Region	8,489.9	858.6	3,837.6	1,980.3

development in the southern Arab countries such as Comoros, Somalia, Sudan, and Yemen hinder the countries' progress towards achieving the sustainable development of water resources, and specifically, the provision of water and sanitation services provision of water (UN ESCWA, 2019). The United Nations Development Program (UNDP) and other organizations co-designed an international comparable measure for poverty, which is the Global Multidimensional Poverty Index (MPI). This index mainly tracks progress toward SDG 1 (to end poverty in all its forms) and encompasses various factors, including dimensions related to health, education, and standard of living. As shown in Figure 3, countries such as Somalia, Sudan, Mauritania, Yemen, Comoros and Djibouti recorded the highest values of poverty when compared to other countries in the region.

As presented before, these countries are lagging behind in terms of the provision of WASH services. Accordingly, they carry a very high burden of diarrheal diseases. Further, poverty can

TABLE 5 WASTEWATER REUSE IN ARAB COUNTRIES FOR THE YEAR 2013 (ADAPTED FROM UNESCWA, 2016)

Country	Volume of Safely Treated Wastewater (Mm^3/yr)	Safely Treated Wastewater to Total Collected (%)	Volume of Safely Treated Wastewater Reused (Mm^3/yr)	Treated Wastewater Reused to Total Collected (%)	Treated Wastewater used in Irrigation (%)
GCC Countries					
Bahrain	122.8	100	38.1	31	31
Kuwait	308.3	-	308.3	100	100
Oman	26.2	100	20.4	78	71
Qatar	158.7	90	115.9	73	35
Saudi Arabia	1317.2	100	237.1	18	16
United Arab Emirates	605.3	98	397.2	66	46
Mashreq Countries					
Egypt	2111.9	67	50.2	2	2
Iraq	415.7	67	0	0	
Jordan	130.8	100	113.3	87	86
Lebanon	-	-	-	-	-
Palestine	0.5	1	0.5	100	0
Maghreb Countries					
Algeria	275.2	18	19.3	7	72
Libya	45.8	16	14.7	32	32
Morocco	6.2	4	-	-	
Tunisia	228.6	97	60.0	26	10
Least Developed Countries					
Mauritania	0.7	100	0.1	18	9
Sudan	0	0	0	0	
Yemen	64.3	40	36.0	56	29
Region	5818.1	51	1411.1	24	

be the result of political instability, corruption, ethnic conflicts, climate change and other manmade causes.

B. Conflicts and Regional Political Instability

Conflicts and instability, which are constant in some of the countries in the region, are also exerting extra tension on water management systems. Water infrastructures have become targets of destruction during conflicts and wars. In Iraq, Libya, State of Palestine, Somalia, Sudan, Syria and Yemen water reservoirs, pumps, water and wastewater treatment facilities have been highly damaged. Wars and conflicts also limit the operation and the improvement of water services during periods of instability Moreover, the huge influx of refugees in the Arab region increases the vulnerability of the already-scarce water resources. Inadequate water and sanitation infrastructures in countries such as Jordan and Lebanon, who are receiving huge influxes of refugees from Iraq, Syria, and the State of Palestine, already led to major detrimental effects (WWAP, 2019). Table 7 displays the number of refugees in Arab countries for the year 2018,

TABLE 6 **INDICATORS GROUPED BY CATEGORIES BASED ON HIGH, MIDDLE AND LOW SOCIOECONOMIC STATUS (EXTRACTED FROM COUNTRY PROFILES, JMP WHO/UNICEF, 2018)**

Group	Countries	A (%)	B (%)	C (%)	D (%)	E (%)	K($)
		Drinking Water	Sanitation	Hygiene	Wastewater	Water Quality	Cooperation
1	United Arab Emirates	/	96	/	99	/	n/a
	Bahrain	99	96	/	/	/	n/a
	Kuwait	100	100	/	100	/	n/a
	Saudi Arabia	/	78	/	71	/	n/a
	Oman	90	/	/	/	/	n/a
	Qatar	96	96	/	77	/	n/a
	RANGE	90-100	78-100	/	71-100	/	n/a
2	Algeria	/	18	84	18	/	$ 4 M
	Syria	/	/	71	/	/	$ 8 M
	Jordan	94	81	/	83	/	$522M
	Morocco	70	39	/	43	79	$156M
	Egypt	/	61	90	58	/	$148M
	Iraq	59	41	95	19	/	$208M
	Libya	/	26	/	15	/	$2M
	Palestine	/	61	/	69	/	n/a
	Lebanon	48	22	/	13	50	$100M
	Tunisia	93	78	79	71	/	$165M
	RANGE	48-93	18-81	71-95	13-83	50-79	$ 2–522M
3	Somalia	/	/	10	1	/	$ 20M
	Djibouti	/	36	/	/	/	$ 21M
	Comoros	/	/	/	/	/	$ 4M
	Sudan	/	/	23	/	86	$ 21M
	Mauritania	/	/	43	/	/	$ 58M
	Yemen	/	/	50	/	/	$ 35M
	RANGE	/	36	10 - 50	1	86	$ 4–58M

A: Percentage of the population using a safely managed drinking water service (SDG indicator 6.1.1)
B: Percentage of the population using a safely managed sanitation service (SDG indicator 6.2.1)
C: Percentage of the population with access to a basic handwashing facility (SDG indicator 6.2.1b)
D: Percentage of safely treated household wastewater (SDG indicator 6.3.1)
E: Percentage of water bodies with good ambient water quality (SDG indicator 6.3.2)
K: Amount (USD) of water- and sanitation-related official development assistance disbursed (SDG indicator 6.a.1)

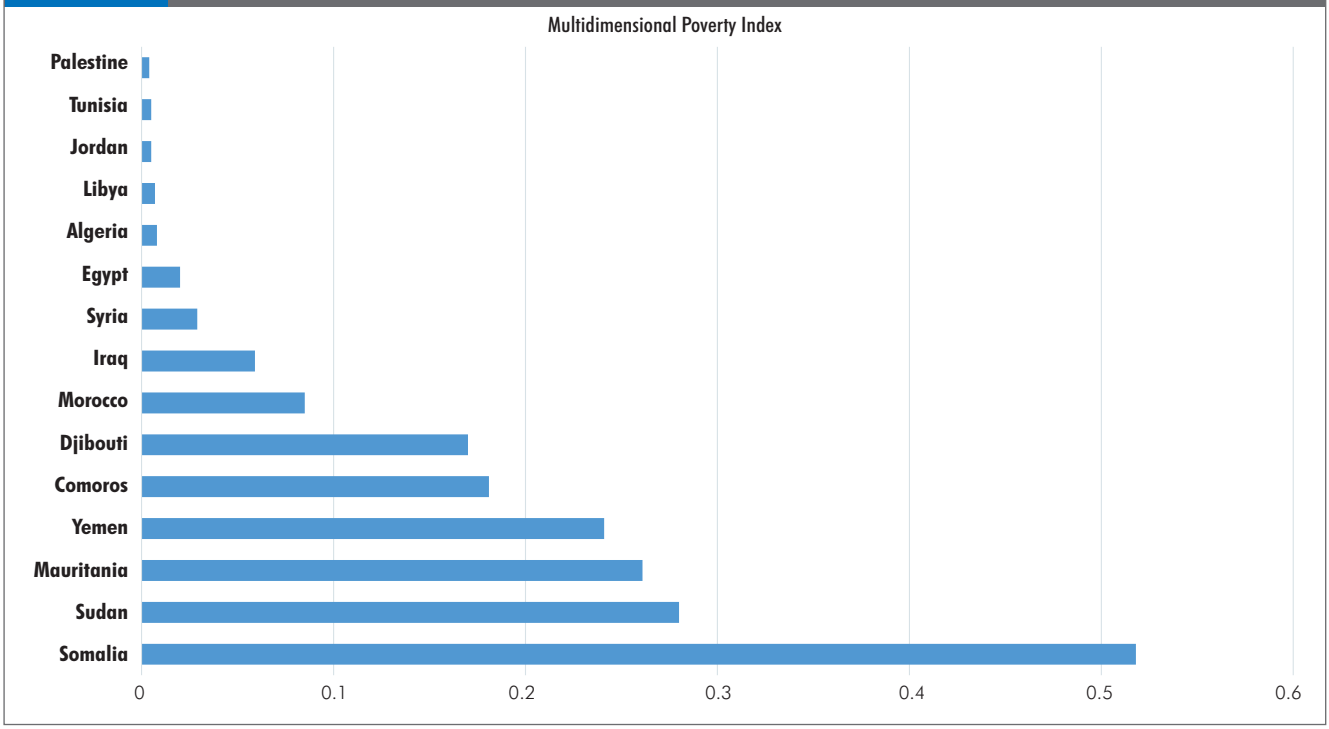
adding up to around 5 million (UNHCR, 2018). This is an added pressure to the provision and sustainability of water and sanitation services and has major environmental impacts mostly in terms of water quantities provided and degraded water quality. Poverty and limited resources in the various countries, as indicated before, further challenges services and increases the cost of operation and maintenance.

C. Water Scarcity

The challenge of providing clean drinking water to the population of the region is not just a matter of supply but also of quality, with water pollution posing a major threat in countries with scarce water resources. The Arab region, as reported in 2019, has an average of 736 m^3 total renewable water resources per person per year, compared to a global average of 7,453 m^3 (WWAP, 2019). Figure 4 maps the levels of water stress in the Arab countries. The calculated scores for countries are a measure of the ratio of total water withdrawals (domestic, industrial, irrigation and livestock uses) to available renewable surface and groundwater supplies, and the higher the score displayed, the greater the competition is among water users in the country (World Resources Institute, 2019).

Rapid urbanization and population growth adds severe strain on the region's water security and challenges the implementation of sustainable management of water resources strategies (AMWC, 2012; ESCWA, 2015a). The effects of climate change, experienced by all Arab countries, will further increase temperatures and reduce precipitation levels, thus intensifying the region's water scarcity (UNDP, 2013; UNESCWA, 2019a). Water scarcity forces many countries in the Arab region to resort to non-conventional water resources such as water desalination at high production costs, and with significant environmental impacts. Heavy subsidies for water services has led to excessive use and reduced incentive to conserve water, especially in the Gulf Cooperation Council (GCC) countries (AFED, 2016; AMWC/ACSAD, 2014). Because of this, GCC countries also face challenges related to demand management, the lack of signaling pricing, and a shift in focus on water production from aquifers and desalination plants. This shift in GCC countries has led to the over-exploitation of their groundwater aquifers (UNDP, 2013). Similarly, some countries in the Arabian Peninsula and the Maghreb regions rely mainly on their groundwater sources, such as

FIGURE 3 MULTIDIMENSIONAL POVERTY INDEX FOR SELECTED ARAB COUNTRIES (ADAPTED FROM HRO AND UNDP, 2019)



Libya and Djibouti, leading to over-exploitation of aquifers as the demand increases and the quality of available surface water deteriorates (UNESCWA, 2019a).

D. Water Governance and Integrated Water Resources Management (IWRM)

Weak research and development capabilities, inadequate institutional infrastructure and policymaking capacities are all factors that hinder the achievement of SDG targets (Goll et al., 2019). The non-existence of national water strategies and policies in some countries such as Comoros, and their weakness in other countries such as Somalia, Egypt and Lebanon, also add major constrains on the implementation of integrated and sustainable water management. Moreover, monitoring systems, which are crucial for ensuring sustainable water management, require major improvements and development in many countries of the region. In addition, gender objective, a major pillar in IWRM, is also lacking in many countries due to gender mainstreaming and traditional roles and customs that favor men. As such, in Egypt, Mauritania, Lebanon, Somalia, Sudan, Saudi Arabia, United Arab Emirates, and Tunisia, women often have less access to natural resources including water (UNESCWA, 2019a,b).

Table 8 displays the IWRM implementation score of each country. Three countries, Qatar, Kuwait and the United Arab Emirates, scored the highest in the region, generally meeting the IWRM objectives with good geographical coverage and stakeholder engagement and high potential of achieving targets set by 2030 (HDRO/UNDP, 2019; Jurdi, 2015). Morocco, Jordan, Saudi Arabia, and Tunisia scored between 55 and 64 percent, signifying that these countries have implemented most of the IWRM elements in their long-term programs and have potential to achieve set goals (UNEP, 2018; UNESCWA, 2019a,b). Nine countries: Algeria, Libya, Mauritania, Egypt, Sudan, Bahrain, Yemen, Oman, and Lebanon scored less than 50 percent, indicating that they have adopted most of the IWRM elements but implementation is in-progress. In Iraq, and Comoros, scores ranged between 25 and 26 percent, indicating that they have started developing IWRM elements, but that the coverage and stakeholder participation

TABLE 7 **NUMBER OF REFUGEES IN ARAB COUNTRIES IN THE YEAR 2018 (ADAPTED FROM UNHCR, 2018)**

Country	Number of Refugees
Algeria	94,350
Bahrain	-
Djibouti	18,295
Egypt	246,749
Iraq	283,022
Jordan	715,312
Kuwait	673
Lebanon	949,666
Libya	8,794
Mauritania	93,191
Morocco	5,940
Oman	308
Qatar	190
Saudi Arabia	266
Somalia	16,741
Palestine	-
Sudan	1,078,287
Syria	18,817
Tunisia	1,066
United Arab Emirates	1,164
Yemen	264,369
Total	**3,797,200**

is still low (UNEP, 2018; UNESCWA, 2019a,b; UNDP, 2013). Somalia is the only country with a very low score of 10 percent, suggesting that the development of IWRM has yet to be started. Countries with scores lower than 50 percent are unlikely to meet the targets unless they record significant improvements in development and implementation (UNEP, 2018; UNESCWA, 2019a,b).

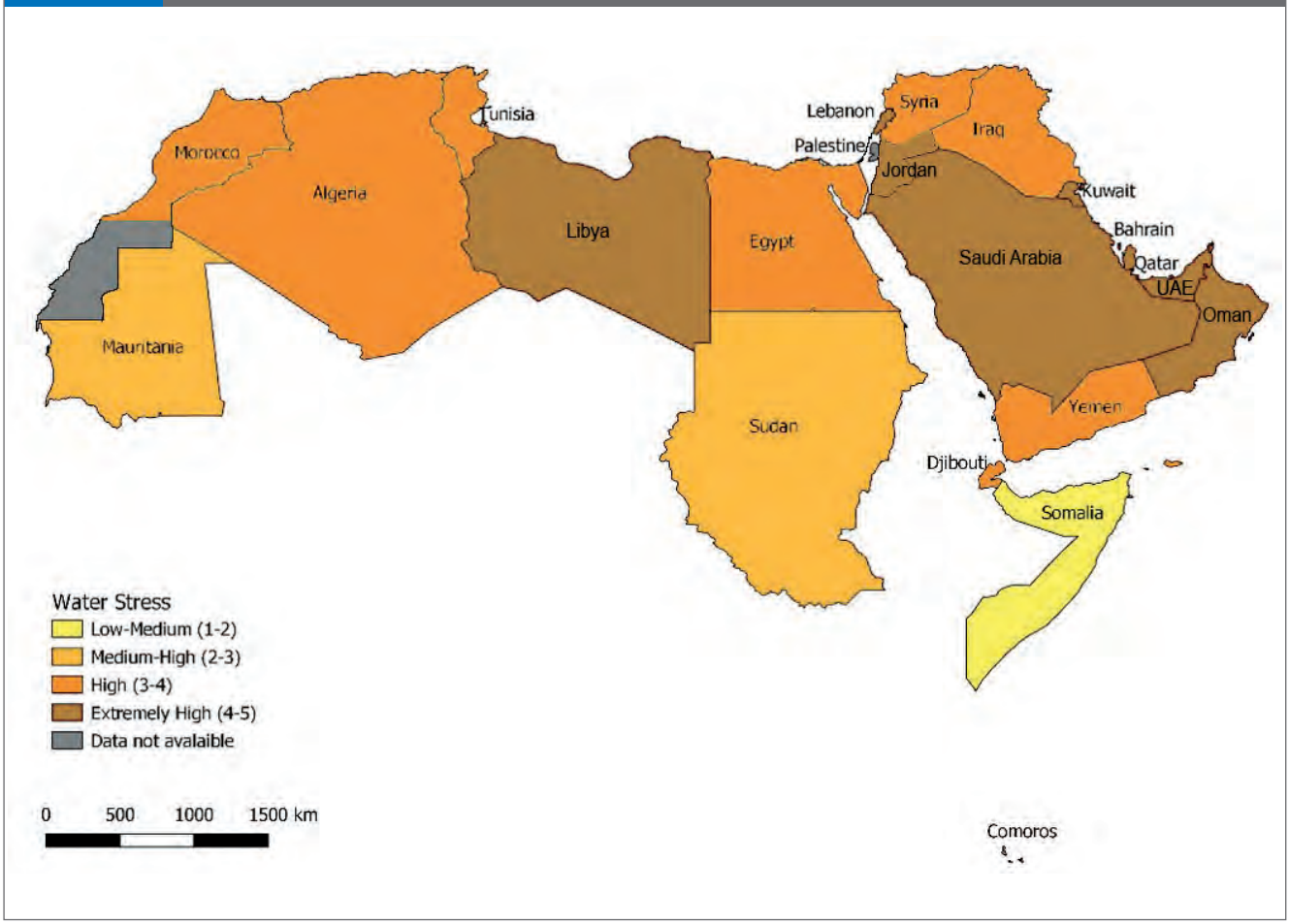
To conclude, 16 out of 19 countries have at least institutionalized most elements of IWRM (medium-low implementation and above). The challenge lies in increasing capacity, financing and coordinating across sectors, particularly for the nine countries reporting medium-low implementation. In addition, almost half of the countries (8 out of 19) have generally met IWRM objectives of policies, laws and plans with good geographic coverage and stakeholder engagement. Still, overall, only 7 countries (32 percent) have partially, mostly or fully implemented IWRM strategies, policies and frameworks, whereas 11 countries (50 percent) are still in the development phase. Further, examining the four dimensions of IWRM implementation shows the highest-level performance is for the management instruments, institutions, and participation (medium-high category). The lowest scores are for financing and the enabling environment (medium-low category), which is highly critical and challenges the majority of the least developing countries in the region (UNEP, 2018). In addition, while the overall socio- economic development appears to affect the degree of implementation, it is not the only factor – political will and prioritization are crucial.

E. Integrating Water, Sanitation and Hygiene for Health

To present, many of the water and sanitation approaches employed in international development focus on providing either improved water, improved sanitation or improved hygiene. Global monitoring programs such as the Joint Monitoring Program of UNICEF and the WHO count access to each of the three separately. Alternatively, the vision is to implement all three concurrently. Organizations struggle to do so when faced with field challenges, as settings vary among developing and developed countries, and rural and urban areas. To have a sustained health impact, water, sanitation and hygiene should be intertwined (EstevesMills and Cumming, 2016; PMNCH, 2014). As a first step, the Arab Health and Environment Strategy 2017-2030 defines the two major strategic initiatives of (a) monitoring and assessing the performance of the sector in health protection, and (b) updating of national regulations and management practices, to address priority challenges and risk factors relating to the provision of water and sanitation. As summarized by UNEP and WHOEMRO (2015), all Arab countries have to:

a. Present biannual analysis and evaluation on the performance of the sector,
b. Activate public health surveillance to ensure the provision of adequate and safe water supplies and address health impacts of wastewater reuse in agriculture and other sectors,

FIGURE 4 LEVELS OF WATER STRESS IN ARAB COUNTRIES (WORLD RESOURCES INSTITUTE, 2019)



c. Expand water and sanitation services to address all disadvantaged groups,
d. Develop national policies on requirements that meet at least the minimum level of safe water supply required to protect health,
e. Update drinking water standards and insure development of preventive water safety plans, and
f. Update and activate the national standards for water reuse.

Five indicators mostly addressing health safety issues (water safety plans, drinking water standards, wastewater reuse standards) and the contribution to the global water and sanitation monitoring programs such as the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene will be tracked to evaluate progress of countries by 2020, 2025, and 2030 (UNEP and WHOEMRO, 2015).

F. Stakeholders' Participation and Mobilization

The absence of business and public participation and private sector involvement in the water sector are also limiting factors that delay the improvement of water management in countries such as Comoros, Iraq and Yemen. In addition, poor coordination between concerned parties such as water authorities, ministries, the private sector and research institutes is a major obstacle in Lebanon. Important hindering factors cited for Sudan are fragmented management and contradictory sectoral policies (UNESCWA, 2019).

V. POLITICAL AND FINANCIAL COMMITMENT

Major hindrances in Somalia, Iraq, Lebanon, and Mauritania include inadequate budget allocation

TABLE 8 DEGREE OF INTEGRATED WATER RESOURCE MANAGEMENT IMPLEMENTATION IN ARAB COUNTRIES (ADAPTED FROM UNEP, 2018)

Country	Score on Section 1: Enabling environment	Score on Section 2: Institutions & participation	Score on Section 3: Management instruments	Score on Section 4: Financing	Final score on degree of IWRM
Algeria	40	42	51	60	48
Bahrain	28	48	43	40	40
Comoros	27	35	14	28	26
Iraq	24	22	42	12	25
Jordan	68	57	70	58	63
Kuwait	84	82	80	80	82
Lebanon	37	40	40	12	32
Libya	57	45	53	32	47
Mauritania	65	63	60	70	45
Morocco	68	69	64	55	64
Oman	33	18	57	24	33
Qatar	55	100	89	85	82
Saudi Arabia	42	68	71	46	57
Somalia	13	13	11	4	10
Sudan	37	44	44	34	40
United Arab Emirates	59	90	71	80	75
Tunisia	67	53	58	40	55
Egypt	47	42	49	24	40
Yemen	50	51	36	20	39

*All Scores are out of 100

for water infrastructure and the implementation of IWRM elements. Financing transboundary arrangements is also a major constrain in countries such as Lebanon, Bahrain, Iraq and Somalia (UNESCWA, 2019). As presented before (Table 3), official development assistance (ODA) varied highly and was relatively minimal. Moreover, committing financial resources in the region is highly linked to priority setting that is further challenged by the conditions of safety and security.

Faced with all indicated challenges, work is still in progress. Table 9 presents the overall achievements and trends for SDG 6 targets. Information presented confirms the challenges and highlights deficient areas that have to be aggressively addressed.

The Sustainable Development Goal Progress Report of 2019 showed that only 9 Arab countries are on track to achieve SDG 6 while all remaining countries in the region exhibit either stagnating or moderate increasing trends (Sachs et al., 2019). The report provided an analysis of the current situation of each country in relation to the SDG achievements. All countries in the Arab region still face challenges to meet the targets set by SDG 6, with more than half (60 percent - 13 countries) facing major challenges. Still, despite the fact that major challenges remain in achieving SDG 6 in the six GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates), they are still on track to achieving the targets (Luomi et al., 2019; Sachs et al., 2019).

Most of the North African Arab countries – Algeria, Egypt, Morocco, Libya and Tunisia – have significant to major challenges to overcome before achieving SDG 6. Among these countries, only Tunisia is on track to achieving SDG 6 (Sachs et al., 2019). Jordan, Lebanon, State of

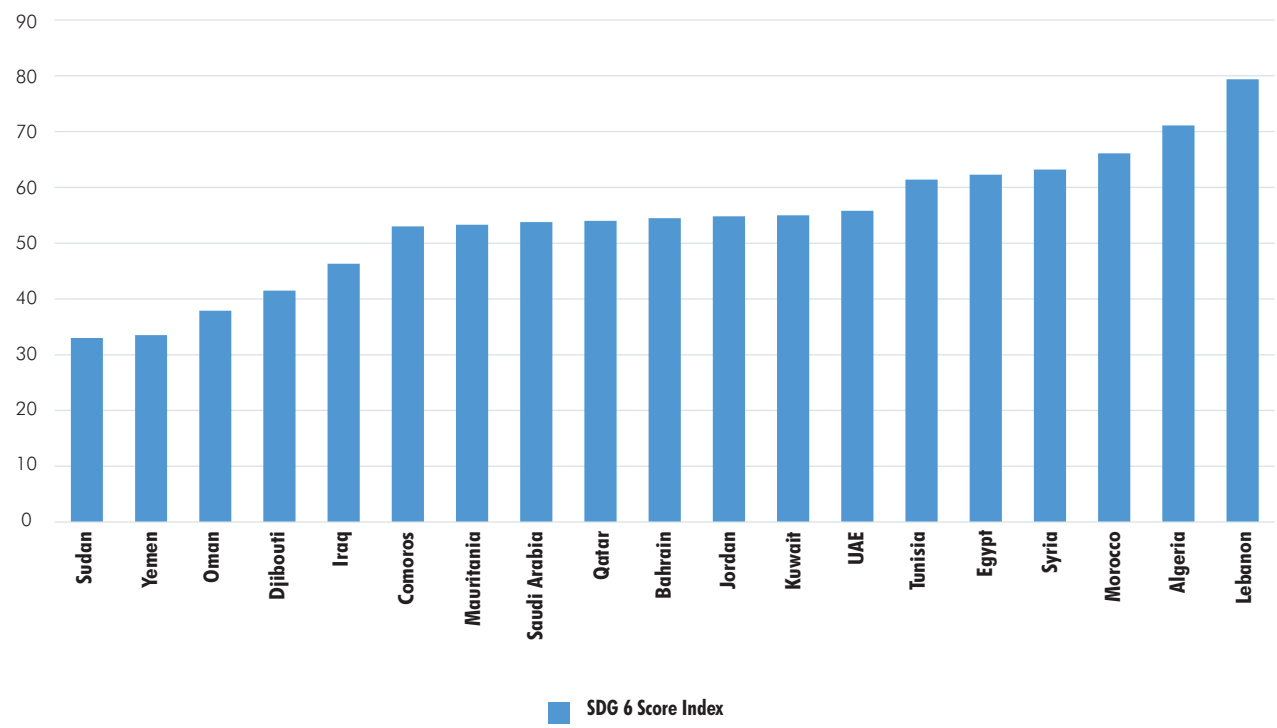
TABLE 9 **ACHIEVEMENTS AND TRENDS FOR SDG 6 INDICATORS FOR ARAB COUNTRIES (EXTRACTED FROM LUOMI ET AL., 2019)**

Country	Population using at least basic drinking water services	and Trends	Population using at least basic sanitation services	and Trends	Wastewater that receives treatment	and Trends	Degree of IWRM implementation	and Trends	Freshwater withdrawal	and Trends	Imported groundwater depletion	and Trends	WASH related mortality rate	and Trends	Over all Performance on SDG6	and Trends
Algeria	●	↗	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	↗
Bahrain	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Comoros	●	↓	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	↓
Djibouti	●	→	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	→
Egypt	●	↑	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	↗
Iraq	●	↗	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	↗
Jordan	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Kuwait	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Lebanon	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Libya	●	→	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↗
Mauritania	●	↗	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	↗
Morocco	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Oman	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Palestine	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	→
Qatar	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Saudi Arabia	●	→	●	↓	●●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Somalia	●	↓	●	↑	●●	●●	●	●●	●	●●	●	●●	●	●●	●	↓
Sudan	●	↗	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	→
Syria	●	→	●	→	●	●●	●	●●	●	●●	●	●●	●	●●	●	→
Tunisia	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
United Arab Emirates	●	↑	●	↑	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑
Yemen	●	↑	●	↗	●	●●	●	●●	●	●●	●	●●	●	●●	●	↑

● SDG achieved
● Challenges remain
● Significant challenges remain
● Major challenges remain
● Data unavailable

↑ On track / maintaining SDG achievement
↗ Moderately improving
→ Stagnating
↓ Decreasing
●● Data unavailable

FIGURE 5 SDG 6 SCORE INDEX FOR ARAB COUNTRIES (ADAPTED FROM SACHS ET AL., 2019)



Palestine, and Syria all face significant challenges in achieving SDG 6 as well, with only Jordan and Lebanon being on track to achieve it. Iraq also has major challenges remaining with a moderate increasing trend towards achieving SDG 6. Additionally, the least developed countries of the Arab region, which include Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen, all have major significant challenges remaining before achieving SDG 6. Among these countries, only Yemen is showing a moderate increasing trend, while the rest show stagnation (Luomi et al., 2019; Sachs, et al., 2019).

The 2019 SDG Report also estimated the percentage of achievement of each country towards all targets of the SDGs, as well as for each SDG separately. The SDG 6 Index Score for countries in the Arab region ranged from 33 to 79.4 percent, with Sudan and Lebanon scoring the lowest and highest scores, respectively, as presented in Figure 5. State of Palestine was not included in the global SDG Progress Report, while Libya and Somalia did not have sufficient data to compute the SDG Score Index (Luomi et al., 2019; Sachs, et al., 2019).

Sudan had the highest share (86.05 percent) of water bodies with good ambient water quality, followed by Morocco and Lebanon, with 79.15 and 50 percent respectively. Tunisia, Somalia, Qatar and Morocco recorded a 0 percent coverage of transboundary basins with an operational arrangement for water cooperation. Jordan and Iraq recorded a 21.91 and 13.55 percent coverage rate. Data on the total extent of open water bodies and wetlands was available for only Lebanon, with a value of 6289.25 km^2 (Luomi et al., 2019; Sachs et al., 2019).

Syria and Morocco exhibited a high level of participation of users/communities in water resources planning and management. Sudan, Oman, Mauritania, Lebanon, Jordan, and State of Palestine showed moderate levels of participation, while Comoros and Tunisia presented low and null levels of participation, respectively. Moreover, Sudan, Oman, Morocco, Mauritania, Lebanon, Jordan and State of Palestine had clearly defined procedures in laws or policies for participation by service users/communities in water resources planning and management. Comoros and Syria's definitions

were not clear, and Tunisia provided no definition (Luomi et al., 2019; Sachs et al., 2019).

VI. CONCLUSION AND RECOMMENDATIONS

Meeting the basic SDG 6 targets for the provision of water and sanitation is not just a benefit. It is a milestone towards developing environmental infrastructures and systems responsive to health needs and development. The entire Arab region should focus action to achieve targets by 2030. Countries should develop and implement water and sanitation programs in line with the Arab Health and Environment 2017-2030, strategic initiatives. Strengthening of national financial systems to support decision-making is necessary, and the use of performance indicators on expenditure and cost-effectiveness should be an integrative component. At the national level, commitment of financial and human resources is critical and regional collaboration is a major supportive factor. Additionally, there is need to increase the provided Official Development Assistance (ODA) to countries. Moreover, while most countries do have national drinking water standards and sanitation guidelines, regulatory authorities should take corrective actions against non-compliers. Development of water safety plans, coupled with the comprehensive monitoring of the quantities and the quality of the provided supply, is necessary.

Beyond achieving this milestone, the sustainability of water and sanitation infrastructures, programs and activities remains the outstanding challenge. To address this challenge sustainably, it should be an integrative output of the IWRM process. This process is the key to optimize the performance of the water and sanitation sector in the region. Arab countries still have a long way to advance the enabling environment (e.g., policies, laws, and plans), strengthen institutional arrangement and stakeholder participation, manage the instruments that facilitate decision-making (monitoring systems and pollution control), and commit to financing. Moreover, although the overall socio-economic development is a major factor to the degree of implementation, political will and prioritization remain essential drivers.

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IMPACT OF COVID-19 PANDEMIC ON WATER SUPPLY AND SANITATION IN THE GCC COUNTRIES: CHALLENGES AND LESSONS LEARNED

Waleed K Al-Zubari and Mohammed F. Al-Rashidi

INTRODUCTION

On January 30, 2020, the WHO declared the novel coronavirus outbreak COVID-19 (aka SARS-CoV-19) a public health emergency of international concern (PHEIC)1. As early as mid-February several COVID-19 cases started to appear in some of the Gulf Cooperation Council (GCC) countries and continued to rise with time. To control the spread of the virus, the GCC countries took immediate and stringent measures including suspending flights, restricting economic and educational activities, partial and complete curfews, and closing borders.

Like other service sectors, the COVID-19 pandemic has affected the water supply and wastewater sectors in an unprecedented way. In order to identify the main challenges and risks associated with the COVID-19 pandemic and exchange the best practices in overcoming these challenges and mitigating associated risks, the Electricity and Water Department in the GCC Secretariat General conducted a number of virtual online workshops for GCC water supply and sanitation professionals in May and June 2020. These workshops discussed the main challenges faced during the pandemic, the most important lessons learned, and the main recommendations for enhancing the resilience of the water supply and sanitation system in the GCC countries when faced with similar disruptive situations in the future. The following is a summary of main results of these workshops.

CHALLENGES

Human Resources

The general practice in designing drinking water supply plans under emergencies is to assess the risks of damage to and disruption of the stable and continuous operation of the water supply system and its infrastructure. The methodology is typically a "risk assessment and management" procedure, which consists of assessing the relationship between "risk", "probability" and "impacts" for possible hazards. As the drinking water supply systems in the GCC countries depend heavily on desalination plants (average regional dependency is more than 75%), the focus has been placed on hazards related to the disruption of desalination plants, such as maritime contamination to their feed water. Other relevant hazards to the drinking water supply system are power outage and problems with Supervisory Control and Data Acquisition (SCADA) software. In the case of the wastewater system, risks are related to failure of the operation of the treatment plant, electrical power outage, workers' exposure to a variety of hazardous chemical and biological materials contained in the influent and effluent, and the environmental and health risks related to treated wastewater reuse.

Based on the evaluation of these hazards, contingency plans are designed to deal with these conditions and to mitigate their impacts. Examples of risk management measures in the case of drinking water supply are increasing strategic reserves, internal national gridding and transmission, and reliance on groundwater. In the case of wastewater treatment, overdosing disinfection and restricting/banning the reuse of treated wastewater are measures that can be implemented.

However, the COVID-19 pandemic has highlighted a novel risk in the GCC countries: shortage in human resources, or the "ultrastructure" in the water supply and

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sanitation sectors. The pandemic has raised this issue to high levels in terms of risk of disruption to the water supply systems. Shortage in human resources in the GCC countries during the pandemic had several causes including staff movement restrictions due to curfews (partial and complete), flight suspension and borders closing, and a 14-day self-isolation (for those arriving from countries affected by COVID-19 or those who have been in close contact with a probable or confirmed COVID-19 case).

To address this challenge, the GCC countries have taken several actions to ensure that drinking water and wastewater services are fully operational, which is critical to containing COVID-19 and protecting the population from other public health risks. The most important of these actions is considering the workers in the water supply and wastewater sectors as "essential" workers, like health workers, the police, army, and other workers whose physical presence in their working place even during curfew hours is crucial. Another action that has been taken by all GCC countries is to have the staff of the water supply and sanitation sectors physically present at work places for only the most critical jobs (approximately 20% of work force), and have

the rest perform their work remotely from home by relying on virtual electronic communication channels.

Water Safety

An important concern related to water safety during the pandemic is whether the COVID-19 virus can be transmitted in the drinking water supply network. In addition, recent studies have suggested that the virus may be excreted in the feces of people infected throughout their illness and after recovery2,3, which raised the concern of the safety of the workers in the wastewater treatment plants and those involved in the reuse of treated wastewater. In a report published in April 2020 by the WHO and UNICEF4 on how to protect against viruses in sewage and drinking water, it is indicated that water disinfection and sanitation treatment can reduce viruses and that COVID-19 has not been detected in drinking water supplies. The report notes that COVID-19 is highly sensitive to disinfection by chlorine, ultraviolet light and ozonation, and that conventional, centralized drinking water supply treatment methods that utilize filtration and disinfection should deactivate the virus.

Furthermore, the report indicates that as viral fragments have been found in excreta and because of other potential infectious disease risks from excreta, wastewater should be treated in well-designed and well-managed centralized wastewater treatment works. It should be noted also that COVID-19 virus concentration is expected to be high in wastewater generated from hospitals and quarantine facilities. However, each stage of treatment (as well as retention time and dilution) results in a further reduction of the potential risk. A final disinfection step is capable of removing viruses and making the produced treated wastewater suitable for reuse. On the other hand, the safety of the workers in the wastewater treatment plants has also been of a concern. The above indicated guidance has put specific precautionary and risk mitigation measures for the workers: workers should wear appropriate personal protection equipment (PPE), which includes protective outerwear, heavy-duty gloves, boots, goggles or a face shield, and a mask; they should perform hand hygiene frequently; they should avoid touching their eyes, nose or mouth with unwashed hands; and they should practice social distancing while working.

The concern of transmitting the COVID-19 virus in drinking water supply network and during the reuse of treated wastewater is considered very low to none since drinking water supply in all GCC countries is disinfected before it reaches the tap of the consumers, and wastewater is treated at the tertiary level which includes multiple disinfection procedures. Furthermore, workers' use of PPE has been a standard practice in wastewater treatment plants in the GCC counties.

Spare Parts and Consumables

The desalination and wastewater treatment industries have not matured yet in the region and are still dependent on imported technology. Large percentages of key spare parts, chemical additives, and consumable reagents, for example, are being imported. Under the COVID-19 pandemic, a major concern has been the shortage of these essential imported goods, due to a number of reasons including: low stockpiles, border closing, and closure of factories in exporting countries due to the pandemic. The shortage in critical spare parts, chemical additives, and consumable reagents have direct impact on the operation and maintenance of the water supply and wastewater systems in terms of capacities and quality. In response, some GCC countries have started to increase their reliance on consumables produced locally or produced in other GCC countries. While significant disruption in key spare parts and consumables has not been experienced, shortage remains a concern with the protraction of the COVID-19 pandemic.

Balancing Supply and Demand

To combat the COVID-19 virus and limit its spread through human contacts, all the GCC countries have resorted to the implementation of partial and/or complete curfews, closed many sectors including governmental, educational, industrial, and commercial, or at least restricted their operations. These curfews and restrictions have resulted in most of the population being confined at home. These conditions have impacted drinking water supply, the volume of generated wastewater and has altered the peak periods of both. A concern has been if these changes would overwhelm the current water supply and sanitation systems and whether the

current operational rules and capacities of these two systems would be able to handle such changes. While analysis of these changes will require more data and time, early observations indicate that many cities in the GCC countries have witnessed an increase in the domestic water consumption and changes in the periods of the peak demands. These changes vary from negligible to very high (3%-16%). Similar observations have been detected in the wastewater sector. However, no shortages in water supply have been reported yet. This is due to the preparation in all the GCC countries for emergency conditions by continuously having higher production capacities of desalination than drinking water demand, and relatively large drinking water strategic reserves.

LESSONS LEARNED

The GCC experience of the COVID-19 pandemic has so far resulted in a number of lessons that need to be taken into account in the formulation of future plans aimed at increasing the resilience of the water supply and sanitation. These lessons will better prepare the countries for similar situations but will also enhance the overall water security in these countries. The following are the main operational and long-term strategic recommendations that have been generated from these lessons.

Operational Recommendations

- Periodically review and update current emergency plans with emerging hazards and risks to water security and include the risks related to shortage in human resources during pandemics or other similar conditions. It is also important to conduct water emergency training and drills simulating human resources shortages on a regular basis.
- Analyze changes in the demand of drinking water and wastewater generation patterns (volumetric rates and peak periods) during the current pandemic due to curfews, revise the operations of water supply and sanitation based on these patterns, and include these patterns in future plans for drinking water supply and sanitation.
- Invest in IT smart systems and networks in the water supply and sanitation sectors and enhance cyber security, to enhance management and expedite response.

Strategic Recommendations

Develop professional and technical capacities of local human resources and establish an expat substitution plan in the municipal water system in the GCC countries (i.e., water supply, desalination, wastewater treatment, and reuse) and establish human resources succession plans.

Invest in localizing the manufacturing of vital spare parts, chemical additives and consumable reagents in the water supply and sanitation sectors to increase the resilience of the municipal water system during emergency conditions similar to pandemics.

Complement the supply-side engineering measures undertaken by the GCC countries with efficiency and demand-side management measures to alleviate the pressure on water supply and treatment systems during emergencies as well as under normal conditions.

Notes

1. A PHEIC is a formal declaration by WHO of "an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease and to potentially require a coordinated international response", formulated when a situation arises that is "serious, sudden, unusual or unexpected", which "carries implications for public health beyond the affected state's national border" and "may require immediate international action". Source: https://www.who.int/news-room/q-a-detail/what-are-the-international-health-regulations-and-emergency-committees.

2. Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H. Evidence for gastrointestinal infection of SARS-CoV-2. Gastroenterology. 2020. doi: 10.1053/j.gastro.2020.02.055.

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HEALTH IMPACT OF AIR POLLUTION

Hassan R. Dhaini, Charbel Afif

I. INTRODUCTION

Air pollution is considered one of the world's most challenging environmental and health problems. The Industrial Revolution in the 18th century marked the beginning of a new era related to air quality (Akhtar & Palagiano, 2018). Industrialization and rapid growth of the global population led to increased combustion of fossil fuels in order to meet increasing energy demands, augmented agricultural activity in order to meet global food security requirements, and increased generation of wastes, hence affecting air quality and the environment as a whole. Currently, anthropogenic air emissions may be released from mobile or stationary sources (Figure 1), from a point source such as a stack, or an area source such as a landfill, or a volume source such as highways and conveyors, or an open pit such as a mine, or from both buoyant and non-buoyant line sources, which applies to many industries. Different sources can release distinct types of pollutants that can vary widely in terms of their chemical and physical properties (Chandrappa & Chandra Kulshrestha, 2016). On the other hand, ambient air pollution may also be caused by natural sources, such as windblown dust, pollen, erupting volcanoes, and wildfires (IARC, 2016). Once in the atmosphere, a pollutant is dispersed by wind, eventually depositing on surfaces such as land and water bodies (Amodio et al., 2014).

Air pollution may also occur indoors, within confined structures. Common sources of indoor pollution include appliances with combustion processes, heating and cooling systems, humidification devices, smoking of tobacco products, building and furnishing materials, in addition to personal care, cleaning, and maintenance products (Franklin, 2007; WHO, 2006b) (Figure 2). Furthermore, old appliances, and malfunctioning or poorly maintained ones

FIGURE 1 **ANTHROPOGENIC AND NATURAL SOURCES OF AMBIENT AIR POLLUTION ADOPTED FROM THE US NATIONAL PARKS SERVICES ON AIR QUALITY (HTTPS://WWW.NPS.GOV/)**

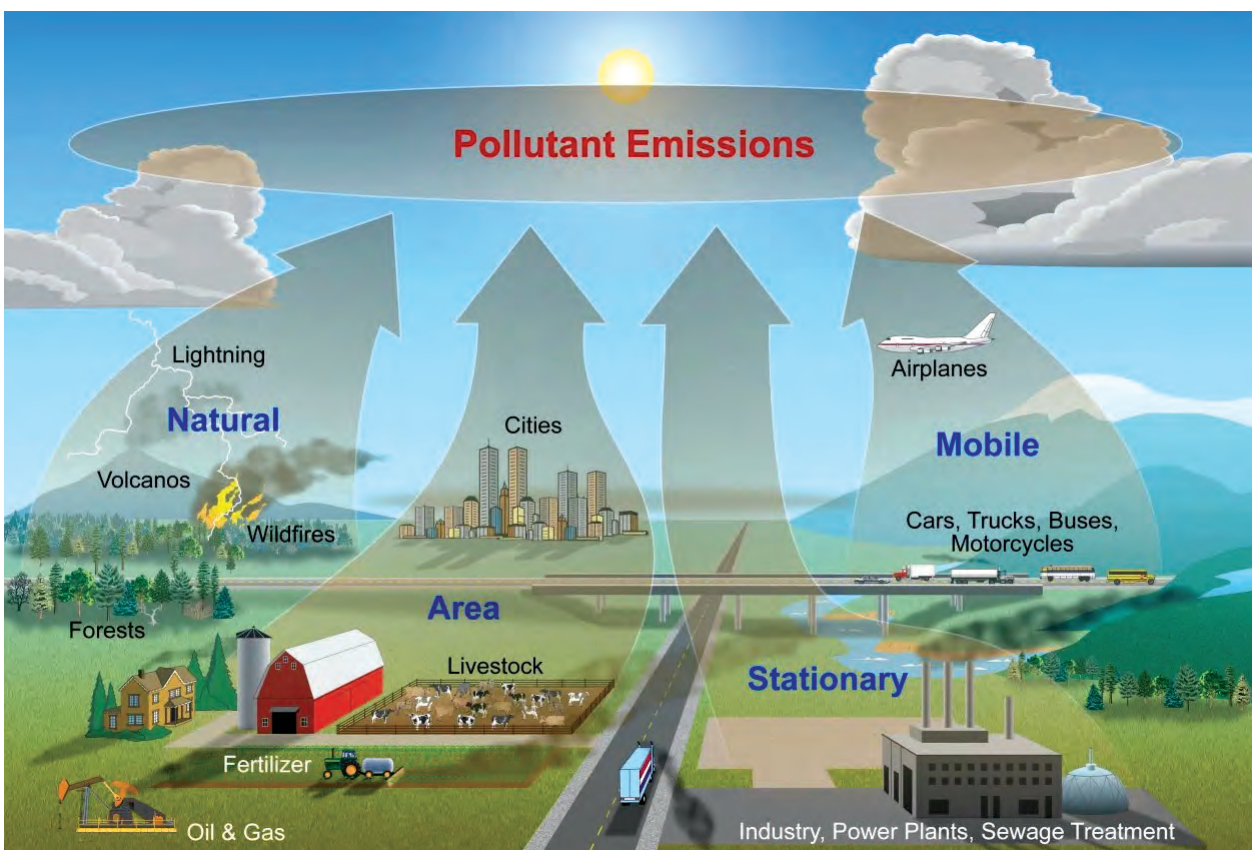
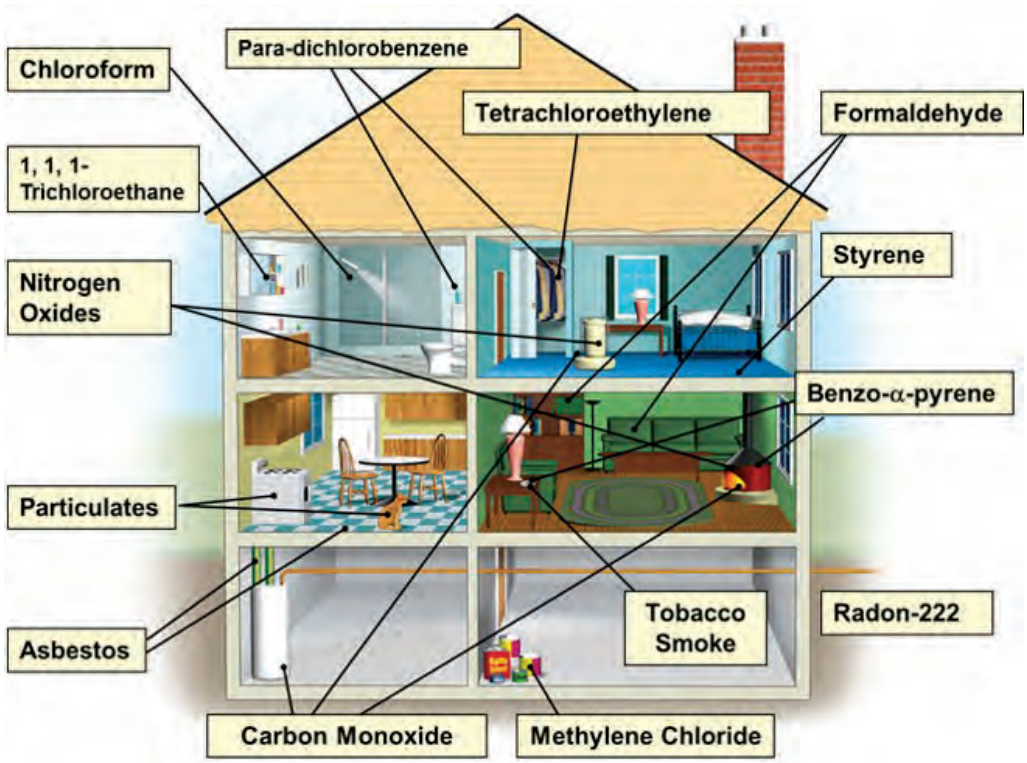


FIGURE 2 SOURCES OF INDOOR AIR POLLUTION (MATYSSEK ET AL., 2013)



can release higher levels of air pollutants (USEPA, 2020b; WHO, 2006b). At the same time, outdoor air can also penetrate indoors and affect the quality of indoor air.

Exposure to both indoor and outdoor polluted air has been associated with a wide range of acute and chronic health effects including cardiopulmonary diseases and cancers (The World Bank, 2016; West et al., 2016). Apart from its health effects, air pollution can also cause acid rain, visual impairment, and damage to vegetation and property (USEPA, 2020a). In September 2015, more than 190 industrial and developing countries adopted 17 Sustainable Development Goals (SDGs) (UN, 2015). In particular, air pollution was recognized as a pressing challenge, clearly figuring in two SDG targets: in SDG 3.9 on substantial reduction of deaths and illnesses from hazardous substances in polluted air, water, and soil, and in SDG 11.6 on reduction of the adverse per capita environmental impact of cities, by paying special attention to air quality.

II. AIR QUALITY REGULATIONS

Pollutants released into the atmosphere from various sources normally disperse, undergo chemical reactions, and may deposit on dry and wet surfaces. Exposure limits are established by regulatory agencies around the world in order to prevent adverse effects of air pollutants when human exposure occurs. However, given that levels of pollutants can only be controlled at source, regulation usually targets emission limit values.

The witnessed sociodemographic and economic growth in the Arab world has increased the demand on energy and motor vehicles in recent years. According to the Arab Forum on Environment and Development (AFED) 2017 report, there is an overall increase in fuel combustion and greenhouse gases (GHGs) emission in most Arab countries, hence the call for a swift action to address air pollution challenges (Chaaban, 2017). As a league, the Arab states do not have

THE EUROPEAN ON-ROAD TRANSPORT EMISSIONS STANDARDS

The EU regulates the emissions of passenger cars and light duty vehicles running on gasoline among distinct categories like heavy-duty vehicles, off-road vehicles, and others through the introduction of new standards, namely ECE and Euro, based on the production year of the vehicle:

- Pre-ECE vehicles up to 1971
- ECE-15.00 and ECE 15.01 1972 to 1977
- ECE-15.02 1978 to 1980
- ECE-15.03 1981 to 1985
- ECE-15.04 1985 to 1992

After 1992, Euro-standards became mandatory in all EU member states, and a new type of approval test was introduced. The following is a summary of the various stages and the associated vehicle technology:

- *Euro 1*: new vehicles were officially introduced by Directive 91/441/EEC in July 1992, and were the first to be equipped with a closed-loop, three-way catalyst.
- *Euro 2*: new vehicles had improved, with closed-loop, three-way catalyst control, and complied with lower emission limits compared with Euro 1. They were introduced by Directive 94/12/EC in all EU member states in 1996.
- *Euro 3*: a new emission standard was implemented with Directive 98/69/EC in January 2000, and introduced a new approval test reducing emission levels compared with Euro 2
- *Euro 4*: this was introduced by Directive 98/69/EC in January 2005. It required additional reductions for CO, NOx, and hydrocarbons compared with Euro 3.
- *Euro 5* & 6: the European Council adopted new emission standards proposed by the European Commission in May 2007. Euro 5 came into effect in January 2010. No further reductions for gasoline vehicles have been proposed for the Euro 6 legislation so far.

harmonized standards for air quality yet. However, most countries have their own national air quality standards, often in conformity with international guideline values and standards, mainly the World Health Organization (WHO), the EU, and the US (UNEP et al., 2006). Some Arab countries are continuously updating their regulations, either completely or by amending new sections.

At the level of mobile sources, Arab countries are amongst the highest global contributors of carbon monoxide (CO) and nitrogen oxide (NOx) emissions, with high on-road emissions attributed to older on-road vehicles, inefficient fuel usage, and unregulated control of exhaust emissions (Waked & Afif, 2012). Proper regulations for on-road transport vehicles do not exist or are incomplete in most Arab countries. For instance, in Lebanon only CO is regulated, whereas no regulations exist in KSA. A few Arab countries like Kuwait have regulations that are more complete. At the same time, the average emission per driven kilometer is decreasing due to continuous renewal of the fleet, and new vehicles adhering to higher emission standards joining the fleet (Abdallah et al., 2020). Another reason for this decrease is the evolution of the European emission standards (Euro-standards) into tighter restrictions and values over the last two decades.

The US Environmental Protection Agency (USEPA) divides ambient air pollutants (AAP) into two categories: criteria air pollutants (CAPs) that generally have higher concentrations, and hazardous air pollutants (HAPs) that are more toxic pollutants yet usually have lower concentrations (USEPA, 2020a). The USEPA sets permissible limits for CAPs (NAAQS), where primary standards are designed to protect human health, while secondary standards aim to protect properties (USEPA, 2016). On the other hand, the WHO classified air pollutants as "classical", "organic", or "inorganic", whereas the EU does not distinguish between "classical" (or CAPs) and organic/inorganic (or HAPs) air pollutants (EU Directive 2008/50/EC). As for indoor air pollutants (IAPs), these are not identical to AAPs in many cases: e.g., ozone (O_3) and sulfur dioxide (SO_2) are not considered IAPs whereas formaldehyde is. The list of IAPs differs from country to country. Table 1 summarizes classical/CAPs and IAP sources, in addition to WHO, USEPA, and EU permissible limits.

The WHO "classical pollutants" consist of particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ozone (O_3). The USEPA considers additionally lead (Pb) and carbon monoxide (CO) as CAPs. Both WHO classical

TABLE 1 SOURCES AND PERMISSIBLE LIMITS FOR CRITERIA AIR POLLUTANTS

Pollutant	Outdoor Sources	Indoor Sources	USEPA	EU	WHO	
			Ambient Primary AQS	Ambient AQS	Ambient AQ Guidelines	Indoor AQ Guidelines
Carbon Monoxide (CO)	Vehicular exhaust Industrial processes Burning of coal for power generation Waste incineration	• Stoves, ovens, space and water heaters and fireplaces • Tobacco smoking	• 35 ppm (40 mg/m^3)- 1 hour • 9 ppm (10 mg/m^3) - 8 hours	• 10 mg/m^3 - 8 hours	• 100 mg/m^3 - 15 min • 60 mg/m^3 - 30 min • 30 mg/m^3 - 1 hour • 10 mg/m^3 - 8 hours	• 100 mg/m3 - 15 min • 35 mg/m^3 - 1 hour • 10 mg/m^3 - 8 hours • 7 mg/m^3 - 24 hours
Lead (Pb)	• Motor fuels • Coal combustion • Lead smelters • Waste incineration • Iron and steel production	• Lead-containing paint • Water pipes • Lead-containing dust	• 0.15 μg/m^3- 3 months	• 0.5 μg/m^3 - 1 year	• 0.5 μg/m^3 - 1 year	No limit available
Nitrogen Dioxide (NO_2)	• Combustion processes • Fossil fuel-based engines • Heat and power generation	• Tobacco smoking • Stoves, ovens, space and water heaters and fireplaces	• 100 ppb (188 μg/m^3) - 1 hour • 53 ppb (100 μg/m^3) - 1 year	• 200 μg/m3 - 1 hour • 40 μg/m3 - 1 year	• 200 μg/m^3 - 1 hour • 40 μg/m^3 - 1 year	• 200 μg/m^3 - 1 hour • 40 μg/m^3 - 1 year
Ozone (O_3)	• Vehicular exhaust • Industrial emissions • Solvents	• Photocopying and laser printing • Air purifying and disinfecting devices	• 70 ppb (137 μg/m^3) - 8 hours	• 120 μg/m^3 - 8 hours	• 100 μg/m^3 - 8 hours	No limit available
$PM_{2.5}$	• Combustion processes	• Stoves, heaters, fireplaces • Tobacco smoking	• 35 μg/m^3 - 24 hours • 12 μg/m^3 - 1 year	• 25 μg/m^3 - 1 year	• 25 μg/m^3 - 24 hours • 10 μg/m^3 - 1 year	No limit available
PM_{10}	• Construction activities • Road dust resuspension	• Stoves, heaters, fireplaces • Tobacco smoking	• 150 μg/m^3 - 24 hours	• 50 μg/m^3 - 24 hours • 40 μg/m^3 - 1 year	• 50 μg/m^3 - 24 hours • 20 μg/m^3 - 1 year	No limit available
Sulfur Dioxide (SO_2)	• Power generation • Motor vehicles	• Heat generation	• 75 ppb (196 μg/m^3) - 1 hour	• 350 μg/m^3 – 1 hour • 125 μg/m^3 - 24 hours	• 500 μg/m^3 - 10 min • 20 μg/m^3 - 24 hours	No limit available

(USEPA, 2016; WHO, 2001, 2006a, 2006b, 2010)

pollutants and USEPA CAPs, in addition to benzene, arsenic, cadmium, nickel, and benzo[a] pyrene, constitute one list of EU AAP standards.

Particulate matter (PM) may be composed of both organic and inorganic solid and liquid particles suspended in air and can vary in composition and shape. Those with a diameter of less than 10 µm (PM_{10}) can actually penetrate to the respiratory tract. Anthropogenic sources of PM_{10} are mainly construction activities and road dust re-suspensions (WHO, 2006a). PM with a diameter of less than 2.5 µm ($PM_{2.5}$) can penetrate the lung barrier and may reach the blood stream, hence posing a much higher health risk. $PM_{2.5}$ is mainly released from combustion activities, including burning of fossil fuels, both oil and coal-based, for power and heat generation, and vehicular exhausts (WHO, 2006a).

Classical pollutants and CAPs may also be found indoors, within households, buildings and other structures. For instance, tobacco smoking and appliances with combustion processes are major sources of PM_{10}, $PM_{2.5}$, NO_2, and CO, indoors (WHO, 2001, 2006b, 2010). O_3 may also be present indoors, due to photocopying and laser printing, air purifiers, and disinfecting devices (Huang et al., 2019; Seow et al., 2016), while Pb may originate from paint (WHO, 2010).

On the other hand, HAPs are also associated with serious health risks. Currently, the USEPA recognizes 187 HAPs, most of which are a result of combustion activities (Miller, 2015). Similar to CAPs, HAPs can also originate from indoor sources, such as building materials and cleaning supplies (Miller, 2015). Examples of HAPs include volatile organic compounds (VOCs) such as benzene and formaldehyde, semi-volatile organic compounds (SVOCs), dioxins, and heavy metals. Table 2 describes selected HAPs, their outdoor and indoor sources, and relevant WHO guideline values. The USEPA does not set permissible limits for HAPs; instead, the agency publishes the National Emission Standards for Hazardous Air Pollutants (NESHAP), mainly consisting of a list of standards specific for stationary industrial sources (US Environmental Protection Agency, 2020). The USEPA HAPs list includes both the WHO Organic and Inorganic pollutants categories, in addition to the EU list of benzene, arsenic, cadmium, nickel, and benzo[a] pyrene (Table 2).

III. REGIONAL TRENDS IN AIR POLLUTION & HUMAN EXPOSURE

With rapid urbanization and economic growth, air pollution in the Arab world has climbed to alarming levels in recent years. Ambient air quality shows a trend of high levels of NO_x, SO_x, and CO_2 emissions over the Arabian Peninsula (Farahat, 2016). According to the WHO, air quality indicators in the Arab countries often exceed the WHO guideline values reaching 5-10 folds higher in certain areas (Saade, 2019). This deterioration in air quality is attributed to both natural and anthropogenic factors. On the one hand, ambient air quality is negatively affected by sea-salt particles and dust, and on the other hand, it is influenced by human activity in urbanized regions where emissions concentrate. Human activities that affect air quality range from industries, road transport emissions, operating power plants, to oil and agricultural production (Abdallah et al., 2020; Aina et al., 2014). Abbas et al. (2018) report that emissions in the MENA region increased by almost five times over the past three decades due to the increase in demand on water, energy, and transportation. In KSA, Bahrain, Kuwait, and the UAE, CO_2 emissions increased by 6 percent annually on average between 2005 and 2014, going hand-in-hand with elevation in GDP and energy consumption (Lelieveld et al., 2015). NO_2 also increased by about 5 percent per year until 2010, and then decreased afterwards (Lelieveld et al., 2015). In addition, the motor vehicle fleet is dominated by passenger cars in most of these countries, and consequently this low utilization of public

TABLE 2 SOURCES AND PERMISSIBLE LIMITS FOR SELECTED HAZARDOUS AIR POLLUTANTS - ADOPTED FROM VARIOUS SOURCES

Pollutant	Outdoor Sources	Indoor Sources	EU	WHO	
			Ambient AQ Standards	Ambient AQ Guidelines	Indoor AQ Guidelines
Benzene	▪ Vehicular exhaustion ▪ Evaporation from gasoline products ▪ Burning of coal and oil	▪ Tobacco smoking ▪ Paint, glue, wax, detergents ▪ Building material	▪ 5 $\mu g/m^3$ - 1 year	▪ No safe level of exposure can be recommended.	▪ No safe level of exposure can be recommended.
Formal-dehyde	▪ Vehicular exhaust from engines not fitted with catalytic converters	▪ Building materials and insulation ▪ Consumer products such as resin and glue ▪ Combustion activi-ties such heating and cooking practices ▪ Tobacco smoking	No limit available	▪ 100 $\mu g/m^3$ - 30 min	▪ 100 $\mu g/m^3$ - 30 min
Mercury (Hg) Com-pounds	▪ Burning of oil, coal and wood ▪ Power plant emissions ▪ Burning of electronic waste	▪ Household products and appliances such as thermostats and stoves	No limit avail-able	▪ 1 $\mu g/m^3$ - 1 year	▪ 1 $\mu g/m^3$ - 1 year
Cadmi-um (Cd) Com-pounds	▪ Mining and smelting activi-ties ▪ Manufacturing of batteries, pigments and plastics ▪ Use of phosphate fertilizers in agricultural activities ▪ Waste incineration	▪ Cadmium-containing dust ▪ Tobacco smoking	▪ 5 ng/m^3 - 1 year	▪ 5 ng/m^3 - 1 year	No limit available

(ATSDR, 1998; Carpi & Chen, 2001; Council, 1997; Driscoll et al., 2013; Medicine, 2003; WHO, 2017)

transport contributes to traffic congestion and concentrates emissions (Abbas et al., 2018). Road vehicles underlie 59 percent of NOx emissions in most MENA countries, in addition to 90 percent of CO, and 75 percent of NMVOC (non-methane volatile organic compounds) (Abbas et al., 2018; Waked & Afif, 2012).

A. CRITERIA AIR POLLUTANTS (CAPs) PATTERNS

The Arab region showed an increase in air pollution in recent years, notably in particulate matter (PM) levels (Table 3) (World Bank, 2020). PM levels may vary between countries due to differences in natural and anthropogenic sources. In Kuwait, annual average PM_{10} levels were 8 times higher than the 20 $\mu g/m^3$ WHO air quality standard between 2014 and 2016, (Al-Hemoud et al., 2018). Similarly, the annual average concentration of PM_{10} in a residential area in Jeddah was shown to be 65 $\mu g/m^3$, more than 3-fold the WHO standard (Alghamdi, 2016). Further, a review of data from several countries in the region, including Egypt, Jordan, Kuwait, Syria, Qatar, U.A.E, and Lebanon, shows that PM concentrations often exceed the $PM_{2.5}$ WHO annual guidelines value of 10 $\mu g/m^3$ (Z. Nasser et al., 2015). In Egypt for instance, on-road traffic accounts for 36 percent of atmospheric $PM_{2.5}$. In parallel, up to 54 percent of $PM_{2.5}$ levels are attributed to dust and sand storms, and oil combustion in power plants of GCC countries. However, in non-oil producing countries like Lebanon, other anthropogenic activities such as industries, road transport, and construction sites are a significant source of both PM_{10} and $PM_{2.5}$ (Z. Nasser et al., 2015; Waked et al., 2012). According to the World Bank, the mean annual exposure in Arab countries exceeds the WHO $PM_{2.5}$ threshold of 10 $\mu g/m^3$ by 80-100 percent (Figure 3) (Ritchie, 2019; World Bank, 2020). Annual $PM_{2.5}$ concentrations in the Arab world exceed the WHO guideline value

TABLE 3 ANNUAL PM CONCENTRATIONS IN ARAB COUNTRIES IN THE LAST TEN YEARS

Country	$PM_{2.5}$			PM_{10}		
	Concentration ($\mu g/m^3$) - 2015	Concentration ($\mu g/m^3$) - 2016	Concentration ($\mu g/m^3$) - 2017	Concentration ($\mu g/m^3$)	City	Year
UAE	42	41	41	150	Abu Dhabi	2015
Bahrain	73	70	71	250	Ras Hayan	2012
Comoros	21	20	21	-	-	-
Djibouti	46	46	46	-	-	-
Algeria	36	40	39	-	-	-
Egypt	88	88	87	284	Cairo	2015
Iraq	66	64	62	179	Baghdad	2016
Jordan	34	33	33	68	Amman	2017
Kuwait	65	61	61	130	Al-Jahra	2015
Lebanon	31	30	31	41	Beirut	2014
Libya	52	52	54	-	-	-
Morocco	31	33	33	43	Casablanca	2016
Mauritania	49	47	47	-	-	-
Oman	43	42	41	82	Muscat	2009
Qatar	94	88	91	-	-	-
Saudi Arabia	97	84	88	161	Dammam	2016
Sudan	59	54	55	-	-	-
Syria	44	44	44	-	-	-
Tunisia	36	38	38	90	Tunis	2010
Yemen	54	50	50	-	-	-

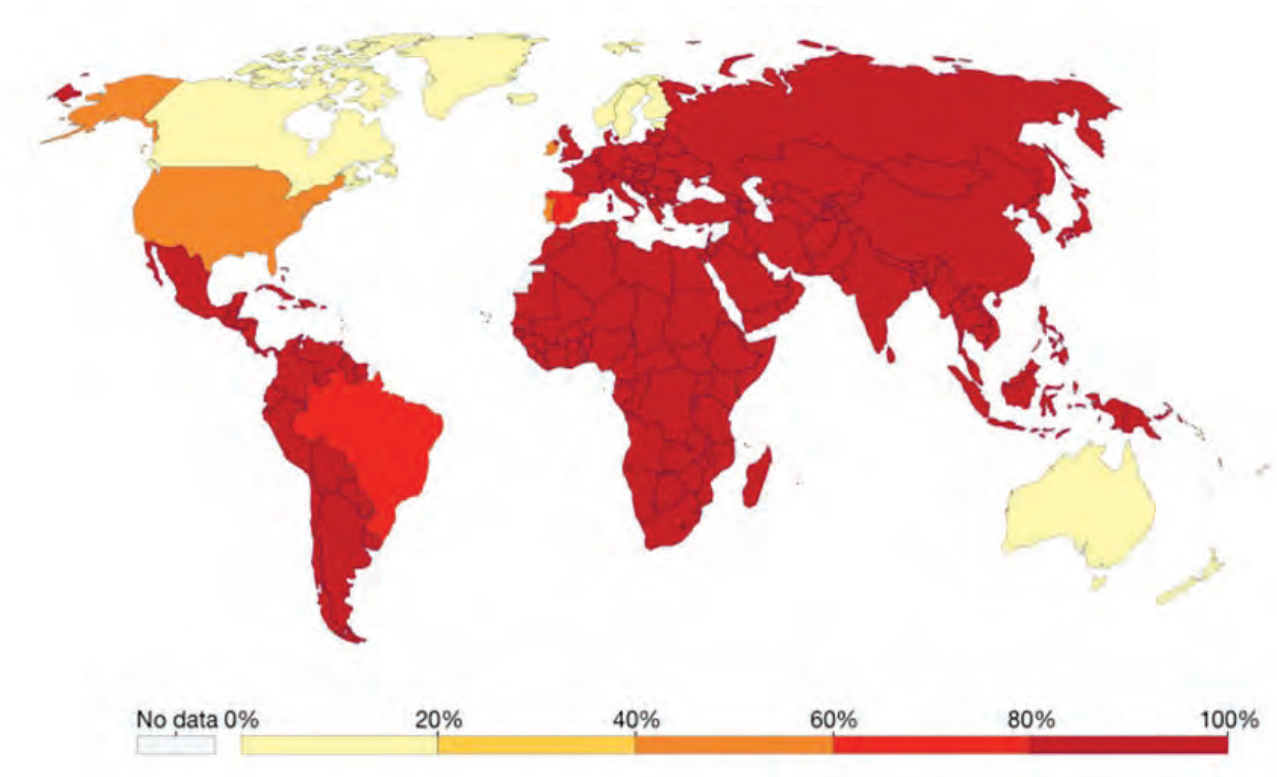
(WHO, 2020; World Bank, 2020)

by up to five folds with significantly excessive exposures in Egypt and Saudi Arabia (World Bank, 2020) (Figure 4). The high PM_{10} and $PM_{2.5}$ concentrations encountered in these two countries are caused by frequent dust storms that push the averages up.

On the other hand, trends of other criteria air pollutants seem to have also increased over the past years. Air quality monitoring through the international Ozone Monitoring Instrument (OMI) showed a linear increase over Arab urban centers between 2005 and 2014 for NO_2 (3-12 percent), HCHO (2–7 percent), and SO_2 (60-120 percent) (Barkley et al., 2017). The highest air pollution levels were seen over oil ports and refineries, and urban settlements in Bahrain, Kuwait, Qatar, and the UAE. In KSA, the air concentrations of SO_2, NO_2, O_3, as well as PM_{10} in Makkah, showed a climbing trend from 1997 to 2012 (Munir et al., 2013). The distribution of NO_2 in Riyadh and Jeddah may be attributed to vehicle emissions and urban activities (Al-Ahmadi & Al-Zahrani, 2013a). Pollution was shown to peak during the holy month of Ramadan and Hajj seasons, mainly due to increased road traffic and human activities (Al-Jeelani, 2012). Moreover, the massive motor vehicle traffic on highways in Iraq burdens air with high concentrations of CO, H_2S, and SO_2 (Chaichan et al., 2018).

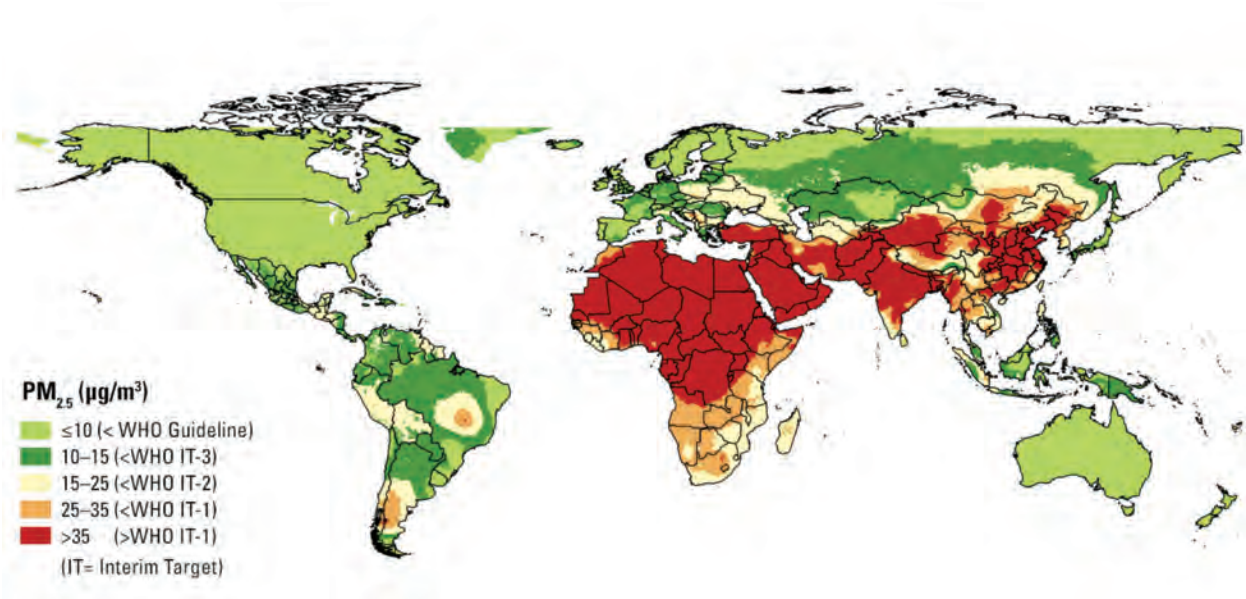
Since the global phase-out of leaded gasoline, more than 175 countries became lead-free, representing near-global eradication (Al-Dosky et al., 2012). However, according to the United Nations Environment Program (UNEP) leaded gasoline is still being used in some Arab countries like Iraq, Algeria, and Yemen, hence posing a major health risk. In a cross-sectional study conducted amongst healthy Iraqis, blood lead

FIGURE 3 **SHARE OF THE GLOBAL POPULATION EXPOSED TO $PM_{2.5}$ LEVELS THAT EXCEED THE WHO GUIDELINE VALUE OF 10 μG/M3**



Source: World Bank, 2020

FIGURE 4 **ANNUAL AVERAGE PM2.5 CONCENTRATIONS IN 2017 RELATIVE TO THE WHO AIR QUALITY GUIDELINE**



Source :State of Global Air 2019

levels (BLL) were 8.6 µg/dl and 5.4 µg/dl in adults and children, respectively (Al-Dosky et al., 2012).

In summary, CAP emissions in the Arab world are attributed to fossil-fuel addicted societies, high population density, and absence of proper public transportation systems. In addition, countries with frequent dust storms are generally prone to higher CAP pollution, notably PM_{10} (Tsiouri et al., 2015).

B. HAZARDOUS AIR POLLUTANT PATTERNS

Hazardous air pollutants (HAPs) measured in Arab states include non-methane hydrocarbons (NMHCs) and polyaromatic polycyclic hydrocarbons (PAHs). Studied NMHCs generally focus on benzene, toluene, ethylbenzene, and xylenes (BTEX) (Borgie et al., 2014; Habeebullah & Hassanien, 2012) while others extend to a broader list (Salameh et al., 2015). In Beirut, the main identified compounds were toluene, isopentane, butane, m,p-xylenes, propane, and ethylene, with 51 percent and 74 percent contribution from mobile traffic and gasoline evaporation sources in winter and summer, respectively (Salameh et al., 2015; Salameh et al., 2016). Concentrations of NMHCs in Beirut exceeded those measured in megacities such as Paris and Los Angeles with a total of around 30 ppb in summer (Salameh et al., 2015). Benzene levels were 6.5 µg/m^3 and 5.6 µg/m^3 in summer 2011 and winter 2012, respectively. Similarly, areas near oil fields and refineries in Kuwait show higher levels of NMHCs (Al-Awadhi, 2011). Processing of fuel oils also produces PAHs. A study in Jeddah, found that air quality around schools located near a refinery was richer in PAHs (36.7 µg/m^3) as compared to schools near a ring road (30.3 µg/m^3) and those distant from vehicle traffic (12.3 µg/m^3) (Trasande et al., 2015). In addition, PM-bound PAHs measured in winter in a Beirut suburb (Lebanon) was in the order of 33.5 µg/m^3 (Waked et al., 2013). On the other hand, the concentration of heavy metals in Giza in Egypt was equal to 3.2 µg/m^3 during regular days and 3.8 µg/m^3 during the straw rice combustion period in winter (Hassan & Khoder, 2017).

C. INDOOR AIR POLLUTION

Indoors, a body of evidence from studies conducted in Arab countries indicates significant indoor air pollution. Arab countries in the Gulf Cooperation Council (GCC) are highly exposed to indoor air pollutants, owed to spending more time indoors, emissions from air-conditionings'

TABLE 4 **INDOOR AIR POLLUTION LEVELS IN THE DIFFERENT ARAB COUNTRIES**

Countries	Study Environment	Average Concentration of Pollutants	Latest Reference
Bahrain	Homes	NO_2 29.8 $\mu g/m^3$	Madany & Danish, 1992
Egypt	Indoor smoking area	$PM_{2.5}$ 478 $\mu g/m^3$	Loffredo et al., 2016
KSA	Restaurants	PM_{10} 78.2 $\mu g/m^3$ $PM_{2.5}$ 38.1 $\mu g/m^3$ CO 5.4 mg/m^3 CO2 2360 mg/m^3 VOCs 0.4 ppm NO_2 608 $\mu g/m^3$ SO_2 0.2 mg/m^3	El Sharkawy & Javed, 2018
	Mosques Carpet Dust	PAHs 4.09 $\mu g/g$	
Kuwait	Elementary Schools	SO_2 7.7 $\mu g/m^3$ NO_2 29.8 $\mu g/m^3$ H_2S 6.3 $\mu g/m^3$	Al-Hemoud et al., 2017
Oman	Residential Homes	O_3 159 $\mu g/m^3$ NO_2 20.3 $\mu g/m^3$ CO_2 1170 mg/m^3 CO 321 $\mu g/m^3$ VOCs 689 ppm	Abdul-Wahab, 2017
Palestine	Schools	CO 0.8 ppm	Elbayoumi et al., 2014
Qatar	University	CO_2 1938 mg/m^3 CO 1.2 mg/m^3 O_3 424 $\mu g/m^3$	Benammar et al., 2018
UAE	Homes	$PM_{2.5}$ 206 $\mu g/m^3$ CO 5.5 mg/m^3	Weitzman et al., 2017

(AC) long operating hours, smoking indoors, and overcrowding (Amoatey et al., 2018). Data on indoor air pollution in the different Arab countries is summarized in Table 4. Indoor air quality is also affected by tobacco smoking, particularly the widespread smoking of waterpipe among Arab populations. For instance, the mean $PM_{2.5}$ level in coffee shops in Doha, Qatar was found to be 476 $\mu g/m^3$, which is 13 times greater than ambient air in the same location (35 $\mu g/m^3$) and 19 times higher than the WHO's air quality guideline (Al Mulla et al., 2015). Similar findings and identical levels were also reported in coffee shops in Cairo, Egypt (Loffredo et al., 2016).

Children are more vulnerable to indoor pollution, and they spend relatively more time in closed environments. In a study targeting 15 schools in Jeddah, KSA, average PM levels indoors were found to be 45.3 $\mu g/m^3$, 25.4 $\mu g/m^3$, and 13.5 $\mu g/m^3$ for PM_{10}, $PM_{2.5}$, and PM_1, respectively (Alghamdi, 2013). All sampled elementary schools exceeded either the maximum daily or the annual mean limits for PM as set by the WHO (Alghamdi, 2013). In addition, in two large school-based cross sectional studies very recently conducted in Kuwait, 45 percent and 51 percent of enrolled middle school and high school students were exposed to secondhand household smoking, respectively (Ziyab et al., 2020). On the other hand, in schools with inappropriate heating installations, other hazardous air pollutants were detected indoors. For instance, in Palestine, the mean CO levels in schools was 0.79 ppm, with a higher average of CO in winter than during fall and spring (Elbayoumi et al., 2014).

Hazardous air pollutants may also be emitted from microenvironments such as AC unit filters. PAHs were detected in dust samples collected from AC filters and household floor dust in Jeddah, KSA, and in Kuwait (Ali, 2019; Ali et al., 2016; Gevao et al., 2007), and in Qatar (Mahfouz et al., 2019). On the other hand, PAHs were also

found in mosques in the city of Riyadh – 14 types of PAHs were present in the samples of mosque carpet dust with a mean concentration of 4.09 µg per gram of dust (El-Mubarak et al., 2016). At the same time, BTEX levels were found to be higher indoors – in office and copy center spaces – compared to outdoors in KSA (El-Hashemy & Ali, 2018). In addition, elevated VOC levels indoors of up to 77.3 µg/m^3 were reported in residence in Helwan, Egypt (Abd El-Shakour et al., 2015).

In summary, evidence of air pollution of ambient areas, workplaces, residential areas, households and public and educational spaces indicates that the high levels of CAPs and HAPs represent a significant level of risk to Arab populations. A thorough understanding of the regional air pollution exposure and trends is essential to investigate the impact of air pollutants on public health.

D.Impact of Conflicts and Wars on Air Quality

Very few studies have focused on the impact of armed conflicts on air quality in Arab countries, although NO_2 has been analyzed over several years by satellite (Lelieveld et al., 2015). Results show that NO_2 in Syrian cities, namely Damascus and Aleppo, decreased by about 30-40 percent during the armed conflict in 2014 compared to 2011 (prior to conflict), which is attributed to lower human activity for residents inside Syria during the armed conflict, and also due to displacement of the Syrian population to neighboring countries. This displacement was massive, mainly towards Lebanon, which led to an increase in emissions and air pollution (Abdallah et al., 2018). The burden of this massive displacement on Lebanon was mainly on road transport, residential heating, solid waste, and electricity production with a total national increase of 18 percent for CO, 20 percent for NOx, 4 percent for SO_2, 11 percent for PM_{10}, and 13 percent for $PM_{2.5}$, compared to the pre-displacement era in 2010 (Waked et al., 2012).

IV. IMPACT ON HEALTH

Ambient and indoor air pollution are significant risk factors in many countries, particularly in developing cities. Mounting evidence indicates that exposure to air pollution is associated with increased health risks, particularly premature death, cardiopulmonary diseases, and cancer, across Arab countries. The disability-adjusted life year (DALY) attributable to air pollution varies among countries, as described in Table 5 (Abouzaid, 2008). DALY is the summary measure used to give an indication of overall burden of disease. One DALY represents the loss of the equivalent of one year of full health. Using DALYs, the burden of diseases that cause premature death but little disability (such as drowning or measles) can be compared to that of diseases that do not

IMPACT OF COVID-19 CRISIS ON AIR QUALITY IN ARAB COUNTRIES

The global response to the COVID-19 pandemic has resulted in unprecedented reductions in economic activity. No studies have focused on the impact of COVID-19 lockdowns in Arab countries, and very few have explored the impact on a global scale and in countries with weak air quality monitoring infrastructure. Venter et al. (2020) examined levels of NO_2, $PM_{2.5}$, and O_3 before and during the lockdown across 27 countries worldwide using remote sensing and air quality monitoring stations. Results showed that NO2 levels declined on average by 29 percent, O_3 by 11 percent, and $PM_{2.5}$ by 9 percent. The reduced air pollution levels come with a substantial health co-benefit in terms of avoided premature deaths and pediatric asthma cases that accompanied the COVID-19 containment measures. Venter et al. (2020) estimated that a total of 7400 premature deaths and 6600 pediatric asthma cases were avoided during the first two weeks of lockdown. On the other hand, Wu et al. (2020) showed that long-term $PM_{2.5}$ concentrations in the US were associated with higher death rates from the disease.

Sources:

Venter, Z., Aunan, K., Chowdhury, S., Lelieveld, J. (2020). COVID-19 lockdowns cause global air pollution declines with 1 implications for public health risk. Submitted, medRxiv preprint; doi: https://doi.org/10.1101/2020.04.10.20060673.

Wu, X., Nethery, R., Sabath, B., Braun, D., Dominici, F. (2020). Exposure to air pollution and COVID-19 mortality in the United States. medRxiv 2020.04.05.20054502; doi: https://doi.org/10.1101/2020.04.05.20054502

cause death but do cause disability (such as cataract causing blindness) (See Annex 1).

A. ASSOCIATION WITH PREMATURE MORTALITY

Premature deaths attributable to environmental factors in the Arab world are estimated to be between 13 percent and 30 percent (Abouzaid, 2008). The number of deaths from ambient air pollution (AAP) increased significantly since 1990. Exposure to excessive levels of PM and NO_2 are associated with higher mortality rates in many Arab countries such as in Kuwait, Egypt, Lebanon, and UAE. (Al-Hemoud et al., 2018; Amini et al., 2019).These rates tend to vary across middle-income countries. For instance, in 2017, Egypt showed an almost 3-fold higher death rate attributed to AAP, as compared to higher-income countries such as KSA and UAE (Ritchie & Roser, 2017). In Kuwait, long-term exposure to anthropogenic sources of $PM_{2.5}$ at a mean level of 87.9 µg/m^3 over 10 years, are estimated to increase the years of life lost (YLL) for all age groups, from 252 to 8487 YLL in 2025 (Al-Hemoud et al., 2018). In contrast, air pollution from dust storms in Kuwait had a negligible effect on mortality rates (Al-Taiar & Thalib, 2014). In Lebanon, the average attributable number of deaths (AD) and years of life lost associated with $PM_{2.5}$ in the capital city Beirut were found to be 257-327 and 3,086-3,923, respectively (Dhaini et al., 2017) (Table 6). Similarly, in an older study in UAE, 545 (7 percent) and 62 (1 percent) premature excess deaths were attributable to ambient air PM and O_3, respectively, in 2007 (Li et al., 2010). A more recent study conducted in UAE found that outdoor air pollution is the leading contributor to mortality, with 651 attributable deaths, which makes 7.3 percent of all deaths. In the same study, indoor air pollution and occupational exposures were the second and third leading contributors to mortality, with 153 and 46 attributable deaths, respectively (MacDonald Gibson et al., 2013).

In summary, air pollution significantly contributes to premature death in Arab countries. These death rates may be mitigated by reducing emissions. For instance, life expectancy would increase by 0.4 and 2.6 years for people aged 30-65 years and for newborns, respectively, if PM levels are reduced to WHO-recommended interim targets in Kuwait (Al-Hemoud et al., 2018). Similarly, in the city of Bejaia in Algeria, 55 deaths are projected to be prevented if PM_{10} mean level would be decreased to 20 µg/m^3 (the WHO annual air quality guideline) (Benaissa et al., 2016).

TABLE 5 ENVIRONMENTAL BURDEN OF DISEASE IN THE ARAB WORLD (2008)

Country	Risk factors (DALYs/ 1000 capita, per year)	
	Ambient Air Pollution	Indoor Air Pollution
Algeria	-	-
Bahrain	-	0.4
Comoros	-	-
Djibouti	3	3
Egypt	0.2	2
Iraq	0.8	5
Jordan	-	0.8
Kuwait	-	1.1
Lebanon	-	1.4
Libya	0.2	3
Mauritania	-	-
Morocco	-	0.2
Oman	-	1.1
Palestine	-	-
Qatar	-	0.6
Saudi Arabia	-	1.1
Somalia	-	0.4
Sudan	2.4	1
Syria	0.6	0.9
Tunisia	0.3	0.6
U.A.E	-	1.8
Yemen	13	0.7

B. ASSOCIATION WITH CARDIOPULMONARY DISEASES

Air pollution is also strongly associated with cardiopulmonary health effects. Most respiratory diseases are caused by airborne agents such as bacteria, viruses, chemicals, allergens, gases, and dust particles. With increasing urbanization in recent years, the prevalence of asthma is generally increasing in the Arab world (El margoushy et al., 2013). A systematic review targeting respiratory

outcomes associated with air pollution in the Eastern Mediterranean region (EMR) reports increased wheezing among children attributable to air pollution in each of Egypt, Kuwait, Oman, Qatar, and Morocco (Abdo et al., 2016). In addition, studies on populations in UAE, Kuwait, Syria, Qatar, and Egypt report an association between PM from dust storms and increased asthma attacks in adults and children (Abdo et al., 2016; Moussa et al., 2016; Teather et al., 2013a). On the other hand, rates of respiratory hospital admissions are significantly higher in areas where concentrations of SO_2 and CO were the highest in Bahrain (Hamadeh & Al-Roomi, 2014). Similarly, in Beirut, incremental increase in PM_{10} concentration by 10 µg/m^3 were found to increase the total respiratory admissions by 1.2 percent (Nakhle et al., 2015). A strong correlation was also found between CO levels and both asthma and chronic obstructive pulmonary disease, among a population residing in northern Algeria (Benaissa et al., 2014).

In addition, in many Arab countries residing near a source of air pollution was found to be a risk factor for cardiopulmonary disease (Table 7). For instance, in Oman, living closer to the industrial park showed a 2-fold higher risk of ER visits due to adverse respiratory conditions (Al-Wahaibi & Zeka, 2015; Alwahaibi & Zeka, 2016). Moreover, residents living close to a busy road, and/or a local power plant in Lebanon had a higher risk of chronic bronchitis (Salameh et al., 2012). Similarly, in UAE, residing near industrial plants, gas stations, dumpsites, or construction sites, was associated with higher risk of respiratory diseases, such as asthma, wheezing, and dry cough (Barakat-Haddad et al., 2015). A cross-sectional study based on data from six hospitals in Lebanon, showed that people living near busy highways and near local diesel generators had a 4-5 times higher risk of cardiovascular diseases (Z. Nasser et al., 2015). Another study in Lebanon showed that living near a busy road or a power plant increases the risk of hypertension (Salameh et al., 2018; Salameh et al., 2019). In Kuwait, attributable proportions of ischemic heart disease and stroke in 2017 were 70 percent (Al-Hemoud et al., 2019). On the other hand, Saudi children attending schools near oil refineries in Jeddah had 4-fold higher prehypertension (Trasande et al., 2015). In summary, both short-term and chronic air pollution exposure in many Arab countries are significantly contributing to cardiopulmonary disease incidence.

TABLE 6 **PREMATURE MORTALITY ATTRIBUTABLE TO AIR POLLUTION IN CERTAIN ARAB COUNTRIES**

Country	Premature Mortality Indicators	Attributable Pollutant(s)
Egypt	114 deaths/100,000	PM NO_2
Kuwait	YLL Projections (2015-2025): 252.18 to 8487.28	$PM_{2.5}$
Lebanon	AD: 257-327 YLL: 3,086-3,923	$PM_{2.5}$
UAE	Premature excess deaths: 545 (7 percent of all deaths) 62 (1 percent of all deaths)	 PM O_3

Abbreviations: YLL: Years of Life Lost; AD: Attributable Deaths

C. ASSOCIATION WITH CANCER INCIDENCE

According to the Global Health Observatory, the WHO estimates that air pollution contributes globally to 29 percent of lung cancer deaths yearly (WHO, 2019). Studies in various Arab populations have concluded that long-term exposure to air pollution increases the risk of cancer (Table 8). Furthermore, studies report that The Eastern Mediterranean region (EMR) has a large disease burden, including cancer, from air pollution, and that ambient particulate matters are the fifth leading DALYs risk (Cohen et al., 2017). A recent study in Beirut showed that the average cumulative cancer risk attributable to NMHCs exceeds the USEPA acceptable risk of 10^{-6}, by 30-40 fold (Dhaini et al., 2017). Another study showed that exposure to $PM_{2.5}$ and PM_{10} contributed to 13 percent of total lung cancer cases in 2018 (Charafeddine et al., 2017). In addition, in a case-control study also conducted in Lebanon, living in urban areas near road traffic and near a generator, was associated with lung cancer (Aoun et al., 2013).

Evidence of cancer burden also exists in GCC and North African countries. In Jeddah, an excess cancer risk of 108-fold was found to be associated with exposure to PM_{10} heavy metals components (Alghamdi, 2016). In addition, exposure to urban air pollution, mainly NO_2, was significantly associated with different types

TABLE 7 AIR POLLUTANTS AND/OR SOURCES ASSOCIATED WITH CARDIOPULMONARY DISEASES IN ARAB COUNTRIES

Country	Type and/or Source of Air Pollutant(s)	Associated Outcomes
Algeria	CO	Asthma & Chronic obstructive pulmonary disease (COPD)
Bahrain	SO_2, CO	Respiratory hospital admissions
Egypt	NO_2, SO_2, H_2S, dust storms	Asthma-related symptoms
Kuwait	$PM_{2.5}$ NO_2, SO_2, H_2S, dust storms	Ischemic heart disease and stroke Asthma-related symptoms
Lebanon	PM_{10} $PM_{2.5,}$ busy road, local diesel generators, local power plant	Total respiratory admissions Hypertension, cardiovascular diseases, chronic bronchitis
Morocco	NO_2, SO_2, H_2S, dust storms	Asthma-related symptoms
Oman	NO_2, SO_2, H_2S, dust storms Industrial park	Asthma-related symptoms Adverse respiratory conditions ER visits
Qatar	NO_2, SO_2, H_2S, CO, NO, O_3, SO_2, PM_{10}, dust storms	Ischemic heart disease & asthma-related symptoms
Saudi Arabia	PAHs, PM_{10}, $PM_{2.}5$, oil refiner	Prehypertension
Syria	Dust storms	Asthma-related symptoms
Tunis	Biomass	Cardiopulmonary diseases
UAE	Industrial plant, gas station, dumpsite, or construction	Asthma, wheezing, and dry cough

of cancer in urban Saudi areas (Al-Ahmadi & Al-Zahrani, 2013a, 2013b). Exposure to PAHs from street dusts of Jeddah was associated with increased cancer risk in children (8.3×10^{-6}), and adults (7.4×10^{-6}), with higher incremental lifetime cancer risks in various other cities (Shabbaj et al., 2018). PAH levels indicate high potential carcinogenic health risks in other Arab countries as well. In Alexandria, Egypt, the incremental lifetime cancer risks were 6.6×10^{-6} as a result of the exposure to PAHs through inhalation, ingestion, and dermal contact (Khairy & Lohmann, 2013).

On the other hand, it is woth noting that Arab populations living abroad are also showing excessive cancer risk associated with air pollution. In the US, Arab-American enclaves show a significantly higher cancer risk score as compared to non-enclave tracts (Grineski et al., 2019). Moroccan enclaves show the highest cancer risk score (46.93), followed by Egyptian (45.33), Iraqi (43.13), Jordanian (41.67), and Lebanese (40.65). Even after adjusting for geographic clustering and other covariates, Arab enclaves show significantly higher cancer risks due to HAPs than non-enclaves ($p < 0.001$).

In summary, it is reasonable to conclude that exposure to air pollutants is contributing to the cancer burden in Arab populations.

D. HEALTH IMPACT OF GLOBAL WARMING AND OZONE DEPLETION

Climate change is causing significant disruptions in the agricultural sector in many Arab countries, which threatens food security and exacerbates the spread of malnutrition, hence severely impacting public health (ESCWA, 2017; ESCWA & FAO, 2017; Verner, 2012). An increase in the incidence of droughts and floods in Comoros, Mauritania, Somalia and Yemen, where subsistence agriculture is highly prevalent, was found to be associated with major public health challenges including malnutrition, famine, and starvation (Ahmadalipour & Moradkhani, 2018). Climate change is also aggravating the pre-existing water scarcity problem in the region, which negatively compromises water, sanitation and hygiene (WASH) efforts to improve human health.

The Intergovernmental Panel on Climate Change (IPCC) predicts an increase in the number of warm days and nights in the Arab region,

TABLE 8 CONTRIBUTION OF AIR POLLUTION TO CANCER RISK IN SELECT ARAB POPULATIONS

Country	Pollutant(s)	Excess Cancer Risk (x 10^{-6})
KSA	Heavy metals of PM_{10}	108
	PAHs	8.3 (children); 7.4 (adults)
Lebanon	NMHCs	30-40
Egypt	PAHs	6.64
Arab-Americans (USA)	HAPs	40.6

Abbreviation: NMHCs: Non-methane hydrocarbons; PAHs: Polycyclic polyaromatic hydrocarbons; HAPs: Hazardous air pollutants

accompanied by an increase in heat-related mortality rates and hospitalization (ESCWA, 2017; Hewitson, 2014). A study conducted in the MENA region found a substantial increase in mortality risk attributed to excessive heat stress among people aged over 65 years in the coastal regions of the Red Sea, Arabian Gulf, and Mediterranean Sea (Ahmadalipour & Moradkhani, 2018). A recent study targeting construction workers in Qatar reported an increase in cardiovascular disease mortality rates during hot periods of the year (Pradhan et al., 2019). Another study estimates that 0.1 percent and 0.2 percent of cardiovascular disease deaths and hospital admissions, respectively, are attributed to a rise in temperatures in the UAE (MacDonald Gibson et al., 2013).

Global warming also disrupts zoonotic ecosystems and promotes the transmission of infectious and food-borne diseases, particularly malaria, dengue, leishmaniosis, and schistosomiasis, which constitute a major rising public health problem in the region (ESCWA, 2017; Haines et al., 2014; Smith et al., 2014; Verner, 2012). One study found that Egypt and Yemen have the highest prevalence rates of neglected tropical diseases (NTDs), followed by Algeria, Libya, Morocco and Syria. Prevalent NTDs included soil-transmitted nematode infections, filarial infections, schistosomiasis, fascioliasis, leprosy, and trachoma (Hotez et al., 2012). The same study found that Leishmaniosis is endemic in Syria, Iraq, Libya and Morocco, while Dengue is endemic in KSA (Hotez et al., 2012). Another study showed a correlation between increasing temperatures and morbidity rates associated with water and food-borne illnesses in Beirut (El-Fadel et al., 2012). Furthermore, the region has witnessed several disease outbreaks due to climate change in the past 10 years, including yellow fever outbreak in Sudan (2012), sporadic dengue outbreaks in KSA and Egypt (2015), and other outbreaks in Yemen, Djibouti, and Somalia (Amarasinghe & Letson, 2012). Other infectious diseases reported in the region and attributed to climate change include the Middle East Respiratory Syndrome in Bahrain, Oman, Qatar, Saudi Arabia, UAE, and Yemen (2013-2015), and cholera in Iraq (2015) (ESCWA, 2017).

Air quality is also influenced by global warming. Air pollutants released from natural and anthropogenic sources can be affected by changes in weather parameters including temperature, humidity and wind variations. As such, dust storms released from large deserts in the Arabic peninsula have increased in frequency and intensity over the past years, and are estimated to increase mortality and morbidity rates attributed to asthma and other respiratory conditions (Jish Prakash et al., 2015; Namdari et al., 2018; Teather et al., 2013b). Studies have linked global warming to the global rise in asthma, with the highest incidence rates observed in Middle Eastern countries with higher dust storms frequency (Portier CJ & Scheraga J, 2010; Schweitzer et al., 2018; Teather et al., 2013b). At the same time, the rising levels of atmospheric CO_2 can also influence the distribution and allergenicity of certain air pollutants.

In parallel, ozone layer depletion can also result in adverse health effects due to excessive exposure to ultraviolet B-radiation (UVB). Exposure to UVB is associated with eye cataracts and skin cancers (NOAA et al., 2014; WHO et al., 2002). However, a recent review, conducted in 2018,

identifies a gap in high quality population-based research on skin cancer incidence in Arab countries (Bais et al., 2018).

V. CONCLUSION AND RECOMMENDATIONS

Pollution levels in the Arab world are showing an increasing pattern, especially in urban areas. The observed trends are mainly due to fossil fuel burning owing to increasing population density, road transport, industrial activities, the oil and gas sector, aggravated by sand storms. Outdated regulations, lack of law enforcement and absence of sustainable air quality monitoring are all challenges currently facing Arab countries towards improving air quality.

A recent global-burden-of-disease study focusing on the Eastern Mediterranean region, and using data between 1990-and 2015, reports a 42 percent increase in respiratory diseases, and highlights ischemic heart diseases as the leading cause of death in the region (Collaborators, 2018). Examined air pollutant levels have been found to contribute to the overall disease burden, particularly by increasing premature death rates and elevating acute and chronic morbidity, especially cardiopulmonary disease and cancer incidence. However, large data gaps in Arab countries still exist that prevent an accurate assessment of the impact of air pollution on human health.

Many steps need to be implemented in order to manage properly air quality, which may be summarized as follows:

- Update the regulatory framework in order to reflect the best performance of technology for stationary sources, mobile sources, air quality standards.
- Enforce the law in an efficient manner and penalize non-compliance.
- Sustain air quality monitoring through existing networks while conducting quality assurance.
- Establish highly resolved nationwide emission inventories, and employ high-resolution air quality modeling systems.
- Develop priority lists for health risk assessments based on air monitoring and modeling studies.
- Derive concentration-response (C-R) functions for every country, in order to be able to relate accurately concentrations of air pollutants to health risks.

Overall, conducting health risk assessment based on accurate air pollution data and C-R functions is fundamental to a comprehensive risk management program. Risk management, in turn, would provide Arab policy-makers with the right tools to control health risks, allocate resources, and rank remediation alternatives, ultimately reducing the public health impact of air pollution.

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HEALTH IMPLICATIONS OF SOLID WASTE MANAGEMENT

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I. INTRODUCTION

Solid wastes can be classified based on a number of criteria such as the source of their generation (industrial, municipal, residential, healthcare) or their potential to harm public health and the environment (hazardous and non-hazardous). Solid waste management (SWM) is considered a major responsibility on the road to sustainability as it has the potential to have a cascading effect on all of the three founding principles of sustainable development (economy, society, and the environment) and can alter the trajectory of implemented initiatives. Different methods of waste management contribute significantly to all types of pollution including air, soil, and water. Potential adverse health effects of various waste management options can be direct or indirect because of broader environmental impact such as water and soil pollution and global warming. The environmental contamination caused by the uncontrolled accumulation of wastes has continuous and serious effects on nearby ecological systems. This in turn decreases the productivity of nearby agricultural lands and impacts the health and standards of living of local populations, especially if they suffer from pre-existing medical conditions including respiratory illnesses such as asthma, as well as skin conditions and allergies.

Therefore, the proper management of waste is not only important for environmental and aesthetic reasons, but also because of its implications on the health of the public. There is extensive literature available on the potential adverse health effects of different types of waste and their management. Exposure to a wide range of toxins and substances emanating from various forms of waste management, such as open dumpsites, open burning, incineration of mixed waste, burning of plastic and healthcare waste, can cause various health impacts among the general population ranging from acute health effects such nuisance from foul odors, headaches, allergies, and skin rashes, to more serious and chronic conditions such as respiratory problems, congenital and developmental disorders and cancer. Moreover, waste management workers handling various types of waste are often exposed to harmful substances, chemicals, microorganisms, and pathogens. These occupational exposures lead to increased rates of respiratory problems and gastrointestinal problems among this working population. This chapter aims to (1) elucidate and appraise the current waste management practices in the Arab countries, (2) assess potential health and environmental impacts of the various types of solid waste and (3) examine alternatives for sustainable and integrated solid waste management.

II.WASTE MANAGEMENT PRACTICES IN THE ARAB COUNTRIES: HEALTH AND ENVIRONMENTAL RISKS

Globally, solid waste generation has been increasing at an alarming rate, with the situation in the Arab region being no different (Kaza et al., 2018). Factors such as population growth, urbanization, increasing living standards, and changes in consumption patterns have driven applied waste systems to the brink. These underlying circumstances are noticeable in the Arab world. Waste generation rates increased exponentially in certain countries such as Oman, where the per capita generation rate rose from 0.79 kg to 1.3 kg between 2002 and 2014 (Aljuboury et al., 2019). The total population of the Arab region increased by 3.7 times between the years 1950 and 2000, from 100 to 380 million (Hussein, 2008). The problem is further exacerbated in some Middle East and North Africa (MENA) countries as political unrest and continuous instability have heaped more pressure on the already fragile solid waste systems in place and contributed to degrading existing infrastructure (Knowles, 2009; Zwijnenburg and

Te Pas, 2015). Such factors have hindered the establishment and implementation of effective and proper SWM systems as environmental issues tend to lose priority in times of turmoil, leading to the adoption of inferior methods for waste disposal such as open dumping and burning. The open dumping of wastes is highly prevalent in the Arab world with 53 percent of all generated wastes being indiscriminately disposed of in an unsanitary manner (Kaza et al., 2018). This has led to a salient lack of progress on the solid waste front in the Arab world with SWM systems predominantly characterized by low rates of resource recovery, being financially unsustainable, and having large ecological footprints (El-Sherbiny et al., 2011).

A. Municipal solid waste

The quantity of municipal solid waste (MSW- everyday items that are discarded by the public) produced in the Arab region is set to surpass 200 million tons per year in 2020 (Abou-Elseoud, 2008; Zyoud et al., 2015), with an annual rate of increase of around 3.3 percent (Elmabrouk, 2009). In addition to the aforementioned factors that are increasing the generation of solid waste, rates are also heavily tied to the economic status of each country in the region (Palanivel and Sulaiman, 2014). The high levels of income and living standards in The Gulf Cooperation Council (GCC) countries such as Saudi Arabia (KSA), the United Arab Emirates (UAE), and Qatar, have driven these nations into ranking amongst the top 10 percent of waste producers per capita, worldwide. Hence, the average generation is 1.5 kg/person/day (Hahladakis and Aljabri, 2019), with the figure exceeding 1.8 kg/person/day in certain contexts (Ahmad, 2016). Despite sanitary landfills becoming more commonly operated in the region, especially in the GCC (Abou-Elseoud, 2008; El-Sherbiny et al., 2011), most countries rely on uncontrolled dumping, and consequently open burning, as the main method of MSW disposal (El-Sherbiny et al., 2011; Zyoud et al., 2015). The implications of such treatment and disposal methods are amplified by the fact that hazardous wastes, including medical and industrial wastes, are often commingled with the municipal waste stream (Sweepnet, 2014a). This may increase the potency of the generated emissions and leachate, and could in turn increase the costs associated with remediating and rehabilitating the polluted dumpsites (El-Sherbiny et al., 2011).

To complicate matters further, the threats and implications posed by dumpsites is heightened by the fact that they tend to be situated near

residential areas, primarily in small countries where limited amount of land is available (Zafar, 2018). Furthermore, the accumulation of waste in urban areas can attract disease vectors and result in odor nuisance to local residents, such as the case of the landfills in Lebanon (Omran et al., 2018). Leachate collected from a number of regulated and unregulated municipal dumpsites in Lebanon showed high cytotoxic and genotoxic risks to human health (Khalil et al., 2018). Many studies also found occupational health hazards associated with waste picking (Nyathi et al., 2018). Uncontrolled open burning, which is practiced in most of the open dumpsites, also poses major public health concerns. Burning of waste has been linked to heart disease, cancer, skin conditions, and respiratory illnesses due to the release of carbon oxides, nitrogen oxides, particulate matter as well as dioxins (International Labor Organization, 2011; Wiedinmyer et al., 2014).

B. Hazardous wastes

1.Industrial waste

Hazardous and special wastes comprise a sizable portion of the generated wastes within the region, with 18 percent and 7 percent of the overall wastes in the GCC being industrial and hazardous, respectively (Ouda et al., 2018). Generally, the recycling and reuse of industrial waste in the Arab region is minimal, despite its recycling potential. The management of industrial waste differs among countries, but most industrial waste is disposed of in MSW dumpsites and landfills due to the lack of hazardous waste treatment facilities (Nassour et al., 2016). Furthermore, legislation that governs and standardizes the treatment and disposal of certain hazardous wastes is lacking at times (Daou et al, 2015), which allows such haphazard practices to manifest without the responsible parties being reprimanded. For instance, in the Occupied Palestinian Territories, almost all hazardous waste is mixed with MSW at either the collection or disposal stage (Sweepnet, 2014b).

On the other hand, in high income countries such as Bahrain and Kuwait, hazardous wastes are disposed in specifically designed landfill sites that are engineered to prevent migration and percolation of leachate (Alhumoud and Al-Kandari, 2008). Moreover, some Arab countries, such as the KSA and the UAE operate treatment facilities that neutralize hazardous wastes by converting them into less or non-hazardous

waste before their final disposal in MSW landfills (Alkurdi, 2018). Similarly, in Jordan 50 percent of hazardous waste is treated and dumped safely in sanitary landfills, while only 7 percent is treated and safely disposed of in Egypt (Allen, 2017). Moreover, Qatar reached a recycling rate of 36 percent of its hazardous waste in 2013 by capacity building, workshops, incentivization and multi-stakeholder engagement (Clarke et al., 2017). Residing in close proximity to hazardous landfills, common in several countries, has been associated with an increased risk of a number of diseases and conditions including certain types of cancers such as leukemia, and respiratory, circulatory, and neurological illnesses (WHO, 2016).

2. Healthcare waste

The healthcare sector is a major contributor to the hazardous waste stream, given that approximately 15 percent of medical wastes are hazardous (El-Salam, 2010). Medical waste generation is rapidly increasing due to the expansion of the healthcare sector in the Arab region (Zafar, 2018). Estimates show that 150 tons of medical waste is produced every day in the GCC countries alone (Zafar, 2018). Medical waste refers to all types of solid wastes produced by facilities such as hospitals, pharmacies, clinics, and laboratories. The wastes typically include needles, syringes, plastics, biological fluids, chemicals, and radioactive material (Alagha et al., 2018). The management of medical waste in the Arab region is considered a major challenge, with regional research on its handling and management being limited (Al-Emad, 2011; Sweepnet, 2014a). Medical wastes are often not separated from the general waste stream in low-income countries, where regulations that govern this form of waste are weak and hardly enforced (El-Salam 2010; World Health Organization, 2018). For instance, in Lebanon, more than 50 percent of the country's medical wastes are disposed without treatment (Daou et al, 2015), while in the Occupied Palestinian Territories, medical waste handling often involves uncontrolled incineration and sterilization using autoclave – procedures that have been shown to be ineffective (Sweepnet, 2014a).

The design and implementation of medical waste incinerators in the region has been problematic (Sweepnet, 2014a). In Tunisia and Morocco, limited progress has been made with regards to handling medical waste, even with adequate infrastructure to implement effective policies and practices (Sweepnet, 2014a; Alkurdi, 2018). Moreover, some of the medical waste treatment facilities established in Tunisia and Jordan do not meet international standards (Alkurdi, 2018; Sweepnet, 2014a). Some countries such as Bahrain and Kuwait, however, have made improvements in medical waste management through the passage of legislation, source segregation and the establishment of a centrally controlled incinerator with proper disposal of the generated ash (Alhumoud and Alhumoud, 2007; Mohamed et al., 2009).

Wastes generated by the healthcare sector that contain both hazardous and non-hazardous components, have been gaining more attention due to the COVID-19 pandemic, which has exponentially increased the volume of generated healthcare wastes. The World Health Organization (WHO) classifies all healthcare waste produced from patient care, which includes waste from COVID-19 infected patients, to be infectious. Thus, the introduction of medical waste into the general municipal waste stream increases the potential for these solid wastes to cause harm as medical wastes can contain pathogenic, genotoxic, radioactive, infectious, and heavy metal containing material, in addition to the fact that certain medical wastes are ranked amongst the most threating community wastes (Alagha et al, 2018). What distinguishes this category of wastes is its ability to cause a more acute and rapid impact on human health and the environment than municipal or non-hazardous wastes. This is attributed to the pathological and

infectious nature of some components within this stream, as cholera and hepatitis for example can spread due to the mismanagement of medical wastes (Hossain et al., 2011).

Similar to other forms of refuse, medical wastes can impact human health directly, given that some of these wastes could act as vectors of disease-carrying microbiological and virulent agents such as the hepatitis B virus, or could introduce contaminants and toxins into the environment that alter baseline conditions. Moreover, the improper handling, collection, and treatment of hazardous wastes can pose serious environmental and health risks. The uncontrolled burning of medical wastes can result in the release of dangerous carcinogenic emissions such as dioxins, which is likely occurring as a result of the ill-equipped incinerators that are being operated and as a consequence of the open burning of wastes at dumpsites (El-Salam, 2010). The pollutants released by wastes, in general, can impact public health since these toxins can enter the human body through multiple routes including:

- Ingestion, given that pollutants such as dioxins and mercury can enter the food chain (Azar and Azar, 2016).
- Inhalation, as roughly 40 percent of waste generated globally is openly burnt (Wiedinmyer et al., 2014), which leads to the release of carcinogenic chemicals such as polycyclic aromatic hydrocarbons (PAH) (Baalbaki et al., 2016).
- Absorption, as some hydrophobic agents can enter the body through the skin.

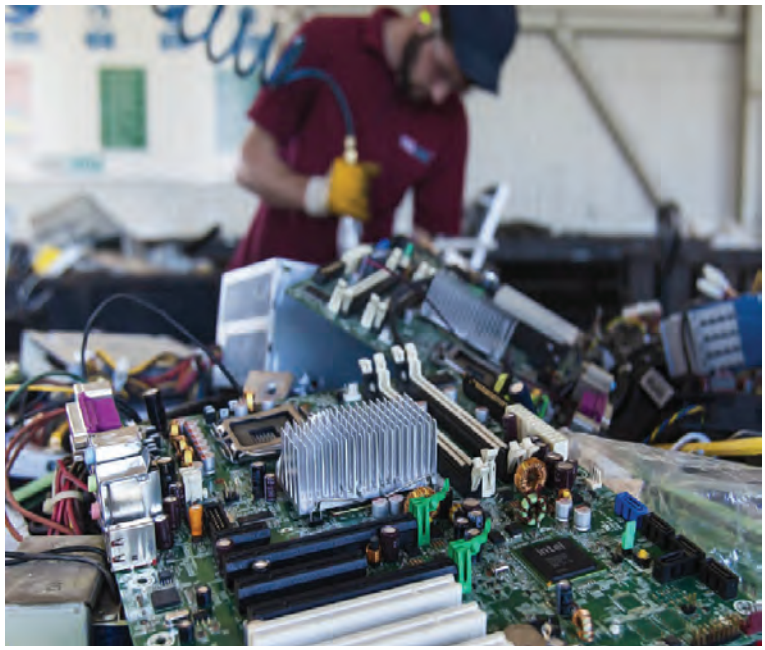
Additionally, recent events have shown how medical and public health related incidents impact public and environmental health by disrupting waste management services. The novel COVID-19 virus has not only lead to an increase in the volume of medical wastes being produced, with medical waste generation rates increasing by over four times in certain areas, but has also caused an increase in one-time use items as reuse is being avoided for fear of transmitting viruses. This increase in use of masks, gloves, and sanitizer bottles is noticeable in cities such as Hong Kong where a significant portion of these items is winding up in the ocean and along beach lines (Saadat et al., 2020). Moreover, several studies (Ouhsine et al., 2020; Klemeš, et al, 2020) have highlighted the recent surge in the environmental footprint of plastics, given the reliance on single-use PPEs which are thought to be advantageous

due to their disposable nature, as public health concerns surpassed environmental ones.

The pandemic has also greatly impaired recycling in countries such as the United States, Italy, and other European countries, where recycling systems were downscaled or completely shut down over concerns of further contributing to the spread of the virus (Zambrano-Monserrate et al., 2020). The large amount of medical wastes being produced increases the risk of infectious diseases spreading to individuals in direct contact with the wastes. The spike in healthcare wastes has disrupted waste management systems that were overwhelmed by the amount of medical wastes being produced. Available systems that were designed to operate under "normal" conditions lacked the capacity to treat such large quantities of hazardous wastes and promoted decision-makers to consider using facilities designed to treat MSW to relieve the incremented pressure (Klemeš, et al., 2020). This in turn led to concerns regarding the potential consequences that may arise from using such facilities and systems to treat potentially hazardous wastes. These risks are elevated in the Arab countries, as source segregation programs tend to be absent and medical wastes are often commingled with the municipal waste stream, which increases risks of formal and informal workers such as scavengers and waste collectors to come into contact with hazardous and contaminated wastes.

C. Electrical and electronic waste

Like most of the world, the Arab region is witnessing an increase in electronic waste as a result of the digitalization of modern society, with more people relying on electronic appliances and equipment (Alameer, 2014). E-wastes include electronic items that are not wanted or not working such as computers, televisions, and other everyday electronic products. In the case of the GCC, the volume of E-waste is growing at an annual rate of 3-5 percent (Alghazo et al., 2019). E-waste does not commonly have a distinct disposal stream and is swept along with the general municipal waste stream (Sweepnet 2014a, Alghazo, et al., 2018). As in the case of hazardous materials, this reality is in part attributed to the absence of a holistic set of standards and regulations and a lack of law enforcement (Saidan and Tarawneh, 2015; Alghazo et al., 2019). Information on this waste category



is also relatively deficient as limited amount of baseline data exists in a large number of Arab countries. A sizable portion of this waste stream is likely being recovered in certain contexts, like in Jordan, by the informal sector by disassembling electronic equipment in search of valuable parts and materials that could be sold to vendors and industrial facilities (Sweepnet, 2014a, Saidan and Tarawneh, 2015, Alghazo, et al., 2018). The activities of the informal sector have supplemented formal waste providers, given that the number of recycling facilities that are capable of up taking this waste stream is limited, with most using rudimentary methods such as manual labor to recapture the waste (Alghazo, et al., 2018).

E-waste carries a number of hazardous pollutants including heavy metals such as arsenic, mercury, selenium, and cadmium (Alsheyab, 2014). The leaching of such metals could contaminate soil and water sources, which is highly detrimental given that the Arab region suffers from intense water scarcity and food insecurity. Meanwhile, their combustion could lead to the release of dioxins into the air (Alsheyab, 2014). Communities near mismanaged E-waste recycling and disposal facilities have reported adverse health effects (Borthakur, 2014). Evidence has shown that exposure to some of the 1,000+ different chemicals that exist within the e-waste stream can lead to genotoxicity, congenital malformations, and behavioral

changes (WHO, 2015). Recovering such wastes could be financially beneficial given that they contain precious and industrial metals such as gold, palladium, copper, aluminum and platinum that have a high reuse potential (Sweepnet, 2014a; Alsheyab, 2014). In fact, according to a study conducted by Alghazo et al. (2019) the e-wastes produced in the GCC in 2018 alone are estimated to be worth more than a billion euros. Despite this, many Arab countries lack proper e-waste management policies and strategies, as well as recycling facilities. Consequently, most e-waste is disposed of with MSW in dumpsites and landfills (Sweepnet, 2014a; Alghazo, et al., 2018). Some studies show that only 5 percent of e-waste is recycled, whereby regional efforts have mostly been limited to random and small scale initiatives by private companies and NGOs (Zafar, 2018; Allen, 2017).

Morocco and Lebanon ship their e-waste to other countries for recycling (Sweepnet, 2014b) while in Jordan waste pickers or mobile scrap dealers collect e-waste from MSW containers and dumpsites to sell them to recyclers who recover the metals (Alameer, 2014; Saidan and Tarawneh, 2015). On the other hand, Tunisia has the best e-waste recycling and collection systems in the Arab region (Abou-Elseoud, 2008; Alameer, 2014). The GCC countries also face challenges in e-waste management due to a lack of relevant policies and strategies and proper recycling facilities. Most of the e-waste in the GCC countries are currently mixed with other types of waste before disposal in landfills (Alghazo et al., 2018). A summary of waste management practices in most Arab countries is presented in Table 1.

FIGURE 1 **POSSIBLE HEALTH HAZARDS, PATHWAYS AND POTENTIAL EFFECTS ASSOCIATED WITH THE MANAGEMENT OF SOLID WASTE**

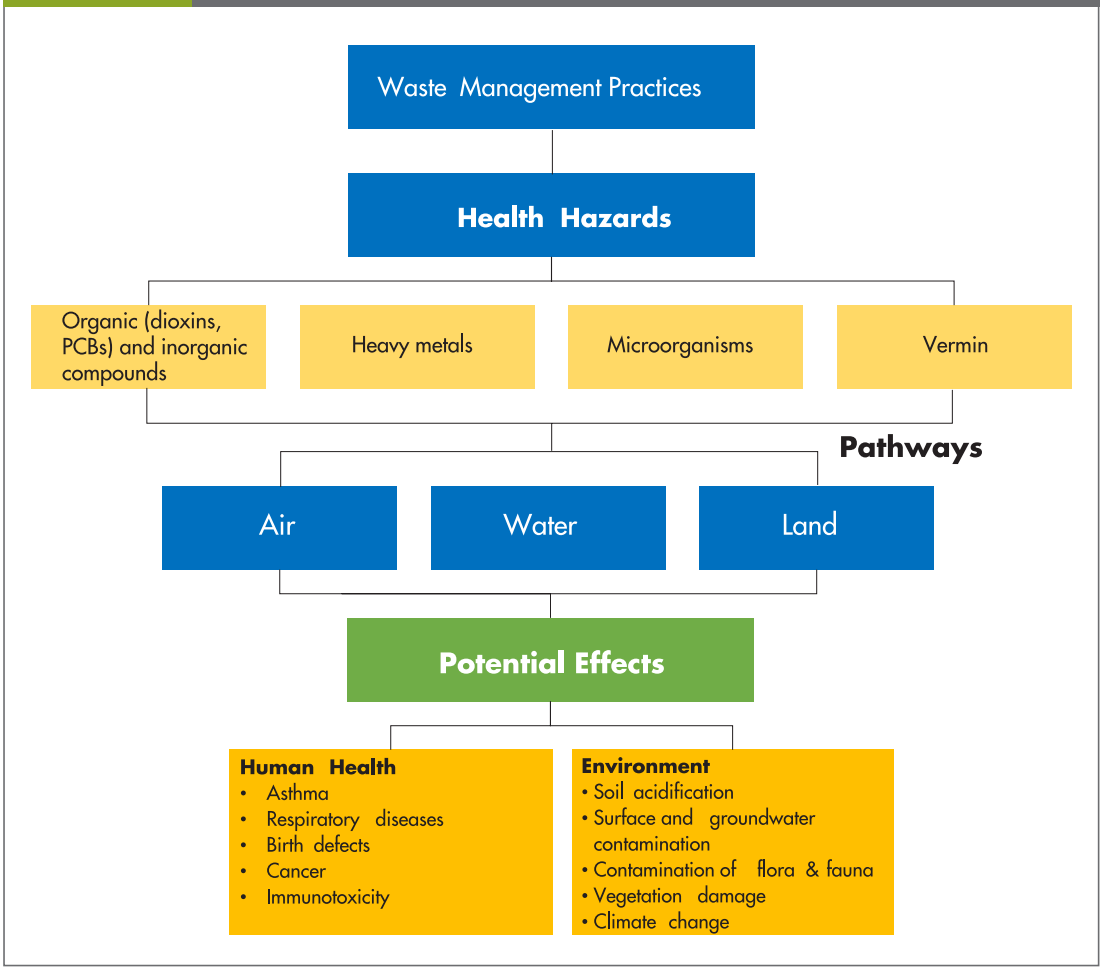


TABLE 1 **A SUMMARY OF WASTE MANAGEMENT PRACTICES IN ARAB COUNTRIES**

Country	Municipal solid waste	Hazardous waste			Construction and Demolition waste	References
		E-waste	Medical waste	Industrial waste		
Algeria	• About 60 percent of MSW is disposed in open dumps while the rest are landfilled • Collection is between 85 percent and 90 percent in urban areas and between 65 percent and 70 percent in rural areas	• Collected together with household waste and bulky refuse • Recycled by the informal sector	• Collected and disposed with MSW • Some are directly routed to landfills or burned in situ or in open burners • Lack of special storage areas	• Open burning, mixing with other waste types and inappropriate storage	• Disposed in dump sites and along roads and public areas	SWEEPNET, 2014
Bahrain	• Private contractors are responsible for waste collection and waste transportation • MSW is disposed of at the one and only landfill site operating in the country which is expected to reach capacity in a few years	• Lack of awareness and laws on e-waste	• Treatment/disposal methods include incineration, autoclaving, returning wastes back to suppliers, landfilling, and disposal in sanitary sewers	• Nonhazardous waste are disposed MSW landfills • Hazardous waste are disposed in a hazardous landfill site	• Dumped in MSW landfill • Used in sea reclamation	Mohamed et al., 2009; Alghazo et al., 2018
Egypt	• MSW collection ranges between 0-35 percent in rural areas and 40-95 percent in urban areas • About 9 percent of MSW is composted, 2.5 percent recycled, 5 percent landfilled and 83.5 percent openly dumped • 18 percent of agricultural wastes is used directly as fertilizer, 30 percent is used as animal food and the remainder is burnt directly on the fields or is used for heating in the small villages using low efficiency burners	• Lack of a national collection, treatment and disposal program for e-waste • The private sector is involved in e-waste recycling	• Collection, treatment and disposal of medical waste is poor • Untreated medical waste is either mixed with municipal solid waste or illegally recycled • Treatment methods includes incineration, shredding and autoclaving	• Mainly disposed in MSW dumpsites • One hazardous waste treatment unit provides collection, transportation, treatment and final disposal	• Collected and disposed in dumps • Only a small quantity is recycled	SWEEPNET, 2014; Elfeki & Tkadlec, 2015

TABLE 1CONT **A SUMMARY OF WASTE MANAGEMENT PRACTICES IN ARAB COUNTRIES**

Country	Municipal solid waste	Hazardous waste			Construction and Demolition waste	References
		E-waste	Medical waste	Industrial waste		
Iraq	• Most are dumped in uncontrolled landfills	• Disposal in landfills	• Some hospitals perform segregation • The most common method of disposal is incineration onsite or outside the facility in a central incinerator	• Disposal in landfills	• Disposed in landfills	Knowles, 2009; UNEP, 2008
Jordan	• About 7 percent of MSW is recycled, 48 percent landfilled and 45 percent openly dumped • There are 21 landfills in Jordan with one being a sanitary landfill and the other 20 are designated dumping sites • There is an informal waste recycling sector consisting of waste-pickers and scavengers	• Disposed of in MSW containers and collected by waste pickers or mobile scrap dealers for recovery of plastics and metal parts	• Collected in special storage facilities until incinerated or autoclaved onsite, or transported to be incinerated in another location • Inefficient and improper segregation of medical and municipal waste	• One hazardous waste treatment center for central storage, treatment, and disposal	• Private sector is involved in the handling and transport of C&D waste to designated disposal sites	SWEEPNET, 2014a
KSA	• No waste separation • Disposed in landfills and dumpsites • recycling of paper and cardboard	• Mixed with MSW and disposed in landfills • Some recycling exists in the private sector and non profit organizations	• Collected, treated and disposed of by licensed private sector companies which rely on microwave, autoclave and thermal incineration treatment technologies	• Private companies are responsible for collection • The wastes are transported to treatment facilities which are then buried in Class 1 landfills • Illegal dumping and lack of segregation from MSW remains a challenge	• Dumping of C&D waste in uncontrolled sites or along roadsides • Some are disposed in landfills	Alghazo et al., 2018; Ouda et al., 2016; Alkurdi, 2018
Kuwait	• All MSW is disposed of in landfills	• Lack of management programs • Private companies perform collection and recycling at a corporate and individual level	• Waste is segregated using color coded bags • Nonhazardous are separated from hazardous waste • All hospitals have storage areas • All waste is disposed of through incineration	• One plant/ landfill receives all industrial waste consisting of hazardous and nonhazardous waste • The hazardous waste landfill is engineered to prevent migration of wastes or leachate	• A small fraction recycled into basic building materials	Alhumoud & Alhumoud, 2007; Alhumoud & Al-Kandari, 2008

Country	Municipal solid waste	Hazardous waste			Construction and Demolition waste	References
		E-waste	Medical waste	Industrial waste		
Lebanon	• Around 8 percent of MSW is recycled, 15 percent composted, 48 percent landfilled and 29 percent openly dumped • Almost all of the MSW generated in Lebanon is collected by public or private companies	• Some are collected by NGOs and shipped for treatment and/or disposal	• About 60 percent is treated by autoclaving • Around 1,250 tons per year are incinerated at the hospitals • The rest is mixed with MSW without treatment • Most of treated medical waste is being disposed at landfills or dumpsites	• Most industrial waste is considered nonhazardous • Lack of proper segregation • Most waste is discharged into adjacent water bodies, stored on site, disposed of in privately owned landfills, incinerated in the open, or dumped	• Disposed with MSW	SWEEPNET, 2014a; El-Fadel et al., 2001
Libya	• Poor collection and transportation leading to accumulation of MSW in urban areas • Some burn their waste for volume reduction • Open dumping is the most common disposal method	• Disposed in open dumps	• Few hospitals are equipped with incinerators • Mainly, disposal with general domestic waste in an open dump which is then buried or occasionally incinerated • Lack of regulations on disposal methods	• Dumped into the sea and landfills	• Dumping in open areas	Omran et al., 2018; Sawalem & Herbell, 2009; Hamad et al., 2014
Morocco	• About 1 percent of MSW is composted, 8 percent recycled, 37 percent landfilled and 52 percent openly dumped • Collection rate is 85 percent in urban areas • The total number of landfills is 220	• The informal sector collects 90 percent of e-waste which is exported to foreign smelters while the rest is recycled by the private sector	• Healthcare facilities are responsible for the management of their produced waste • Most hospitals and medical centers tend to dispose of their waste in an uncontrolled manner • Treatment methods include shredders – sterilizers acquired by hospitals and private companies, autoclaving and incineration	• The majority is disposed of in uncontrolled dumps, municipal landfills, on nearby land, in abandoned quarries or along rivers, without any treatment or control	• Illegal dumping due to the lack of disposal facilities	SWEEPNET, 2014a; Negm & Shareef, 2019
Oman	• Disposed in landfills and dumpsites • Lack of adequate recycling • Presence of unregulated 350 dumpsites/ landfills managed by municipalities • 10 percent of MSW is recycled	• Dumped in landfills or dumpsites	• Several healthcare treatment facilities rely on incineration and autoclaving	• Dumped in landfills or dumpsites	• Dumped in landfills or dumpsites	Alghazo et al., 2018

TABLE 1CONT **A SUMMARY OF WASTE MANAGEMENT PRACTICES IN ARAB COUNTRIES**

Country	Municipal solid waste	Hazardous waste			Construction and Demolition waste	References
		E-waste	Medical waste	Industrial waste		
Palestine	• About 33 percent of MSW is landfilled, 67 percent openly dumped and less than 1 percent recycled • Agricultural waste is burnt on farms with minimal processing or composting	• Lack of separation and mixing with MSW	• Mixed with MSW • Some hospitals perform autoclaving or by uncontrolled burning in incinerators that does not reach the temperatures required nor has air treatment units	• More than 94 percent is mixed with MSW either at the collection stage or at the disposal stage	• Openly dumped	SWEEPNET, 2014a
Qatar	• MSW is not separated at the source and is placed in containers near houses • The municipality collects MSW to a transfer station where the waste is stored for few days before being transferred to the landfill • Some recoverable materials are separated at the landfill which are then sold to private recycling centers achieving 8 percent recycling • Some organics are composted	• Collection of e-waste and shipment to Singapore for recycling	• Private companies are responsible for collection and treatment by incineration	• The waste is sent to an authorized waste treatment authority to be treated, stabilized, recycled, or incinerated. • 50 percent is landfilled while 36 percent of waste is recycled	• Landfilled in the desert	Al-Maaded et al., 2012; Clarke et al., 2017
Sudan	• Poor collection services • Residents dump their waste in public areas, streets and rivers or burn the waste	• Lack of segregation • Open dumping and burning	• Lack of proper segregation • Disposed of in dumps used for MSW • Only a small portion of waste in some hospitals is collected separately and treated in a central incinerator	• Lack of segregation • Open dumping and burning	• Mixed with MSW and dumped in landfills	Saad, 2013; Siddig & Tohami, 2018

D. Impact of waste management practices in the Arab countries on public health

Several studies (Giusti, 2009; Ahmed et al., 2020) examined the epidemiological association between health, hygiene and proper waste disposal. Yet, many studies are hindered by the lack of exposure data, specificity, and adjustment for confounders such as age, gender, socio-economic status, smoking, and occupational history (Rushton, 2003). Indeed, a WHO report released in 2015 indicates that the means and scale at which solid waste pollutants impact the health of the population remains only partially understood. Evidence remains suggestive but not conclusive in several instances, with studies generally being unable to accurately quantify exposure levels or eliminate potential confounders. This is partially attributed to the fact that exposure to pollutants

Country	Municipal solid waste	Hazardous waste			Construction and Demolition waste	References
		E-waste	Medical waste	Industrial waste		
Syria	• Before the conflict 80 percent was disposed of at open dump sites located on the outskirts of towns • During the conflict collection has been greatly affected leading to accumulation of MSW on streets • During the conflict uncontrolled dumping and burning is occurring	• A sizable market for second-hand devices and spare parts is present	• Mixed and disposed with MSW	• Disposed in domestic waste dumps • Lack of segregation into hazardous and nonhazardous waste	• The war has generated vast quantities of rubble and debris from damaged buildings which can be contaminated with munitions	Te Pas et al., 2015; Madi & Srour, 2019
Tunisia	• About 5 percent of MSW is composted, 4 percent recycled, 70 percent landfilled and 21 percent openly dumped • MSW collection is 80 percent in urban areas and 10 percent in rural areas	• Collection and recycling	• No sorting at source and inappropriate storage of hazardous waste • Several incinerators do not comply with environmental standards	• Collection and treatment by specialized companies	• Dumped in public areas	SWEEPNET, 201 4a; Alameer, 2014
UAE	• The main disposal methods are open dumping and landfilling • Some are composted or recycled	• Disposed with household waste	• Incineration is most commonly used with some hospitals using autoclaving and chemical disinfection • Some of the incinerators are old, poorly maintained with no proper equipment to control air pollution	• Undergoes pretreatment to become nonhazardous waste and is then transferred to specially designed landfills	• Absence of segregation, reduction and recycling • Disposed of in landfills	Alghazo et al., 2018; Al-Hajj & Iskandarani, 2012; Al-Qaydi, 2006
Yemen	• About 6.7 percent of MSW is recycled, 26 percent landfilled and 68 percent openly dumped • MSW coverage is 65 percent in urban areas and 5 percent in rural areas	• Lack of treatment facilities • Mixed with MSW	• Disposed with MSW	• No hazardous waste landfills or plants are in place • Disposed with MSW	• Dumped illegally in open spaces near to construction sites	SWEEPNET, 2014a

originating from mishandled wastes is heavily influenced by spatial factors which can dictate the concentrations that populations of interest are exposed to, with environmental contamination levels generally decreasing with distance from centers of contaminations. This has led to studies focusing on waste workers and the residential population residing closest to improperly operated SWM facilities who are typically the most impacted. Nonetheless, studies have associated exposure to waste-related pollutants to respiratory, neurological, and gastrointestinal diseases, an increased risk of certain cancers, behavioral changes, and congenital malformations. Possible health hazards, pathways and potential effects associated with the management of solid waste are depicted in Figure 1.

Evidently improper collection and inadequate disposal of waste can lead to serious air, soil and

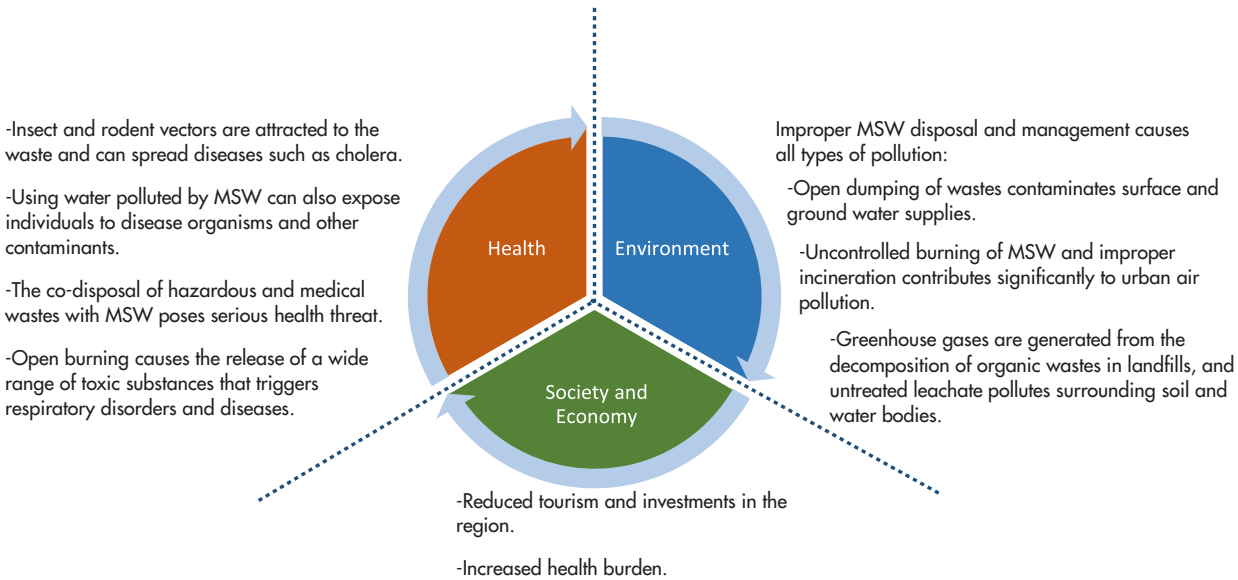
water contamination, which in turn can have major impacts on the health and wellbeing of the population (Zwijnenburg et al., 2015; WHO, 2016). This is particularly a major problem for developing countries where collection, disposal and management of solid waste is often uncontrolled and unregulated (Epstein, 2015). Exposure to solid waste could be through inhalation, ingestion and bodily contact, and is highly influenced by the presence of effective policies for SWM (Ziraba et al., 2016). However, inhalation is the most common and important route of exposure to solid waste due to the high uptake rate (Epstein, 2015; Laitinen and Rantio, 2016). People who are exposed to solid waste can be categorized as follows: (1) waste generators, which includes the general population, (2) waste collectors and transport and disposal workers, such as municipal workers, (3) waste-pickers and (4) those who live or work near solid waste disposal sites (Ziraba et al., 2016).

With practices such as open dumping and burning of waste being commonly relied upon for the disposal of accumulated refuse, pollutants are constantly being dispersed into the environment by means of leaching into soil and water resources and into the air through incineration. The open burning of waste negatively influences air quality and leads to the release of atmospheric pollutants and the suspension of particulate matter in the air. Greenhouse gas emissions, volatile organic compounds, polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), and some heavy metals are released when wastes are uncontrollably incinerated (Baalbaki et al., 2016, Azar and Azar, 2016). These substances are associated with health conditions such as respiratory and cardiovascular illnesses, cancer, and neuropathy (Azar and Azar, 2016). Meanwhile, the improper disposal of wastes, by means of landfilling or dumping, can cause heavy metals, such as mercury, lead, nickel, and cadmium, to leach into soil and water bodies (Vongdala et al., 2018), which can cause people to come directly into contact with these metals should the contaminated water be used for bathing or drinking, or indirectly should these metals infiltrate surface and underground water sources or be used for irrigation purposes. These metals can also enter the food chain, as certain metals have the potential to buildup in plants and animals. Their ingestion can cause neurological diseases, organ failure, and several types of cancers (Baalbaki et al., 2016). Lastly, improperly disposed wastes can also negatively affect human health since wastes tend to attract rodents and insects, which can act as vectors for many diseases (Arif and Doumani, 2014). Figure 2 summarizes the main environmental, health and economic impacts of improper solid waste management.

Waste handlers and collectors in many Arab countries are among the most exposed population and are at constant risk of exposure to this occupational hazard given that sorting at source is minimal (El-Sherbiny et al., 2011; Ziraba et al., 2016; Ziraba et al., 2016). This is further exacerbated by the unregulated nature of the waste sector in the region that fails to train workers on the proper handling of waste and use of personal protective equipment (Ziraba et al., 2015). Exposure to solid waste, be it municipal, medical, industrial, electrical, hazardous waste or a combination of all can lead to exposure to harmful substances such as contaminated dust, chemicals, toxins, microorganisms and pathogens which often lead to a variety of health conditions and infections (Abou-El Wafa et al., 2014; Epstein, 2015). In Egypt and Palestine, studies have found high prevalence of respiratory disorders, such as shortness of breath, sore throat, cough and high temperature among municipal solid waste collectors and attributed this to the lack of proper engineering and legislative measures (Abou-El Wafa, 2014; Abd El-Wahab et al., 2014). Similarly, respiratory problems, along with eye infections and gastrointestinal tract infections were among the major health problems identified in landfill workers in Saudi Arabia (Abdou, 2007).

Living or working near dumpsites is particularly relevant in the Arab context, mainly in low and middle-income countries where the waste sector is characterized by a high percentage of uncollected waste (El-Sherbiny et al., 2011). This phenomenon is usually observed in urban areas and villages and often leads to open dumping or burning, causing the release of a wide range of toxic substances into the environment (Mavropoulos, 2015; Laitinen and Rantio, 2016). Open dumping can lead to the production of foul odor and harmful gases (such as CO_2 and NO_x), the percolation of toxic

FIGURE 2 MAJOR ENVIRONMENTAL, HEALTH AND ECONOMIC IMPACTS OF IMPROPER SOLID WASTE MANAGEMENT



pollutants into the soil, contamination of nearby water sources, unhygienic pest infestation and transmission of microbial organisms to different environmental elements such as water, air or soil. Open burning can release toxic substances into the ambient air causing air pollution and contributing to the increase in levels of greenhouse gases (Massoud and Merhebi, 2016). Burning of waste becomes more harmful when the waste is unsorted and mixed, as is the case in some low- and middle-income Arab countries. The burning of plastic products can lead to the release of dioxin, a highly toxic harmful and persistent substance that has been linked to a variety of health conditions, including developmental and reproductive problems (WHO, 2010). The burning of medical waste can also result in the release of hazardous substances into the air such as particulate matter (WHO, 2018).

Existing scientific evidence found varying health outcomes associated with the aforementioned exposures including infections, skin, eye and ear problems, blood disorders, cancer and congenital disorders (Mavropoulos, 2015; Ziraba et al., 2016). Moreover, an increase in adverse health effects has been reported by people living near controlled and uncontrolled dumpsites, including headaches, sleepiness, respiratory symptoms, psychological conditions, and gastro-intestinal problems (Vrijheid, 2000; Abdou, 2007). A study conducted in 2017 in Lebanon, which aimed to assess the association between exposure to open dumpsites and waste burning and the prevalence of acute health symptoms, found a higher prevalence of gastrointestinal, respiratory, dermatological and constitutional symptoms among an exposed population, as compared to a non-exposed population (Morsi et al., 2017). Studies conducted in Lebanon also found a significant increase in cancer risk among populations living near waste burning sites (Baalbaki et al., 2016). A recent study found an increase in monthly hospital admissions due to diarrhea during the waste crises, as compared to pre and post-crisis time intervals. The same study also found a rotavirus diarrhea outbreak during the crisis among both children and adults and hypothesized that the unhygienic accumulation of waste on the streets has increased the reservoir of the rotavirus that caused the outbreak (Ahmed et al., 2020). Similarly, a study conducted in 2019 investigated a cluster of unexplained elevated cancer incidences in a rural village in Palestine and found a strong spatial association between nearby open burning of e-waste components and the cluster of elevated risk of childhood lymphoma (Davis and Garb, 2019).

Furthermore, conflicts and wars, which are constant in some countries in the region, exert additional tension on environmental services and often lead to the breakdown of waste management

LEBANESE WASTE CRISIS

In Lebanon, municipal solid waste management has been a chronic problem, predominantly in areas with high population density, high production of refuse, and low availability of land adequate for landfills. The waste crisis erupted in July of 2015 after authorities closed the primary landfill for the capital Beirut and the surrounding coastal governorates without providing an alternative. The Lebanese government had no contingency plan to deal with waste management, and as a result solid waste was stockpiled and trash quickly began to overflow from the streets and riverbanks of Beirut and Mount Lebanon in what can now be considered Lebanon's worst trash crisis in history. With limited resources and limited alternatives for sanitary disposal of waste, there has been an increase in uncontrolled dumping and open burning of waste all over the country. Despite the crisis temporarily ending and NGOs, municipalities, and the private sector becoming more involved in the sector, the overall inefficacies and deficiencies that plagued the Lebanese solid waste management structure prior to the crisis persisted. According to a recent report by the Ministry of Environment, the performance of Lebanon's current solid waste management system has considerably deteriorated when compared to the state it was in prior to the 2015 crisis, as 35 percent of Lebanon's contemporary wastes are being landfilled while 50 percent are being openly dumped – a significant increase to prior years when 32 percent of wastes were being openly dumped and 51 percent were being landfilled. The increase in the amount of wastes being openly dumped has caused the number of open dumpsites to increase from 670 in 2010 to 904 at present. Up until today, Lebanon's solid waste management structure has been in a perpetual state of emergency despite significant capita being invested into the field. Despite the unsustainability of Lebanon's solid waste management structure becoming more publicly apparent during the crisis, practices such as open dumping and burning have always been common in the country, especially in rural areas. This all highlights the inequity in service delivery and strengthens the need for a holistic solid waste management scheme directed towards addressing the sector on a nationwide basis.

Findings issued by the American University of Beirut determined that the level of carcinogens in the air increased by no less than 2,300 percent when wastes were being openly burnt during the crisis period. High levels of dioxins – a carcinogenic air pollutant capable of infiltrating the food chain – and polycyclic aromatic

hydrocarbons (PAHs) – another carcinogenic family of air pollutants that has the capacity of causing kidney and liver damage and can lead to respiratory problems – were also detected. The levels of dioxins in the air were reportedly 416 times more carcinogenic than in previous years, while dibenzanthracene, a carcinogenic PAH, was detected for the first time ever in Lebanon's ambient air. These findings, however, may only be the tip of the iceberg, given that the haphazard dumping and burning of wastes has been associated with an increased risk of pancreas and skin cancer among males, birth defects, the spread of communicable diseases, respiratory, neurological, and dermatological disorders, and an increased risk of cancer in the stomach, colon, and larynx, due to the potential release of certain toxins such as heavy metals which can enter the body via ingestion, inhalation, or absorption. The potential of such outcomes occurring is exacerbated in the context of Lebanon since medical wastes are mixed with the general waste stream and wastes, in several instances, are dumped in close proximity to water bodies which increases the risk of the spread of waterborne diseases. The public health toll that this event has had will be difficult to accurately quantify, and its ramifications may take decades to fully appear, as illnesses such as cancer can take a significant amount of time to fully mature. The lessons learnt from the garbage crisis ought to be used to develop a sustainable system for solid waste management in Lebanon, especially that the two, relatively, new landfills are approaching the end of their lifecycles, to mitigate the impacts that the waste sector is having on public health and avert similar events in the future.

Source: MOE/UNDP/ECODIT, 2011; Baalbaki et al., 2016, Massoud et al., 2019.

TABLE 2 SUMMARY OF THE HEALTH IMPACTS OF WASTE MANAGEMENT PRACTICES IN SOME ARAB COUNTRIES

Country	Health impacts on solid waste workers	Health impacts on general population	Health cost of improper solid waste management	References
Algeria	• Sharp objects such as glassware and contaminated needles represent a potential hazard leading to increased risk of injury and disease transmission in a hospital of Batna city among health care workers			Sefouhi et al., 2013
Egypt	• Almost half of the enrolled municipal solid waste workers (MSWWs) were infected with different type of parasites • Impact of mixed solid waste management on health of MSWWs included high prevalence of gastrointestinal, respiratory, skin and musculoskeletal morbidities • Respiratory complaints were prevalent among MSW collectors		• Uncollected MSW and substandard disposal practices are estimated to result in adverse health impacts equivalent to 1.5 percent of GDP	World Bank, 2015; Eassa et al., 2016; Ekram et al., 2014; Abou-ElWafa et al., 2014; Abd El-Wahab et al., 2014
Iraq			• Health costs of poor municipal, industrial and medical waste management are estimated at 0.14 percent of GDP	Al Lami et al., 2013
KSA	• Major health problems identified among landfill workers are respiratory infections and/or allergy, eye infections, gastrointestinal tract infections, and musculoskeletal injuries	• Heavy metal soil contamination, specifically Chromium, from a municipal solid waste dumpsite poses unsafe cancer risk levels for both children and adults		Abdou, 2007; Ali, 2019
Lebanon	• The prevalence of acute health symptoms was greater among the people who work near garbage dumpsites and waste burning than the non-exposed workers, including gastrointestinal, respiratory, dermatological and constitutional symptoms	• Open burning of waste increased rates of premature births and low birth weight after the Lebanese waste crisis • Increase in pollutant concentrations during the crisis translated into an increase in short-term cancer risk from about 1 to 20 people per million on the days when waste was being burned • Increase in admission rates due to diarrhea during the waste crisis as compared to pre and post-crisis months • Rotavirus diarrheal outbreak was observed during the crisis	• Health and Quality of Life damage cost is estimated at USD8 million per year, or 0.05 percent of GDP	Morsi et al., 2017; Mouganie et al., 2020; World Bank, 2003; Baalbaki et al., 2016; Ahmed et al., 2020

TABLE 2 CONT. SUMMARY OF THE HEALTH IMPACTS OF WASTE MANAGEMENT PRACTICES IN SOME ARAB COUNTRIES

Country	Health impacts on solid waste workers	Health impacts on general population	Health cost of improper solid waste management	References
Libya	• Prevalence rates of hepatitis B and C virus were significantly higher in medical waste handlers than non-medical waste handlers examined			Franka et al., 2009
Palestine	• A sample of scavengers reported having back pains, breathing issues, skin diseases, sore throat, and cough with high temperature, and complained of intestinal diseases • Waste collectors suffered from different types of diseases and symptoms, such as sore throat, cough, and high temperature, diarrhea or bloody stool, shortness of breath, and skin disease	• Strong spatial association of e-waste burning activity with a distinct unexplained cluster of elevated risk of childhood lymphoma		Al-Khatib et al., 2020; Melhim, 2004; Davis et al., 2018
Syria		• Increase in skin and respiratory problems and communicable diseases from the collapse of the waste sector during the Syrian war		OCHA et al., 2014
Sudan	• Waste-pickers at Juba open solid waste dumpsite are at a high risk of health problems from exposure to contaminated leachate and fumes from burning of hazardous waste	• Poor municipal solid waste management in Juba is causing contamination of the Nile River and posing high risk to the human health, particularly typhoid and diarrhea		Lo-Karija et al., 2013; UNEP, 2013
Yemen	• Improper management of clinical/medical waste have transmitted the cholera pathogen to the water sources, leading to an outbreak			Al-Gheethi et al., 2018

systems (Zwijnenburg et al., 2015). Syria, one of the Arab countries that has been facing ongoing conflict and instability since the start of its civil war in 2011, has endured serious damage to its waste sector. A multi-sectoral needs assessment conducted in Syria found an increase in skin and respiratory problems and communicable diseases such as visceral leishmaniasis from the collapse of the waste sector (Zwijnenburg et al., 2015). Similarly, an investigation of potential factors contributing to the cholera epidemic in 2017 in Yemen found that improper management of clinical and medical waste caused by the destruction of waste facilities during the war caused for the transmission of the pathogen into Yemen's water sources (Al-Gheethi et al., 2018).

The toll of the mismanagement of solid waste on public health is not accurately quantified in Arab countries due to the absence of proper monitoring and evaluation schemes and gaps in the available information concerning waste management.

A summary of the literature that is available on health impacts of waste management practices in some Arab countries is presented in Table 2. Further research is needed in the MENA region to accurately account for the socio-economic and public health costs that society is paying annually due to improper waste management.

E. Legislative and Institutional Framework for SWM in the Arab Countries

Weak legislation has been directly associated to the stagnant state of SWM in the Arab region. The legislation in most Arab countries lacks the proper provisions that allow for applied models to be properly assessed, as comprehensive monitoring and evaluation frameworks are typically absent, and data is often scarce. This is exacerbated by the fact that strategies, policies, and decrees adopted often lack quantifiable and measurable targets that can benchmark the efficacy of implemented measures (Sweepnet. 2014a; Elnaas, 2015). Moreover, the published laws and regulations, in several contexts, do not incentivize sustainable practices by partners and stakeholders as "reward and punishment" systems tend to be absent. Incomplete or deficient legislation can cause the roles and responsibilities of governmental authorities to be ill defined and to overlap. This causes the division of labor to be distorted and undermines the role of environmental institutions, which hampers accountability and allows for the infringement of jurisdictions (Sweepnet, 2014b, Aljaradin and Persson, 2014). Several studies (Al-Maaded et al., 2012; Elnaas, 2015) reported that the root cause of the problem is a lack of implementation, as issued laws are seldom enforced. The absence of cost recovery mechanisms has also been identified as a prominent contributor hindering the sector's sustainability as it reduces the availability of alternative treatment and disposal options, because no more than 30 percent of the costs involved in service delivery are typically recovered (Elnaas, 2015). This revenue may not even be transferred to the municipalities who often provide the service but would be

ZABALEEN

The Zabaleen is a community that has been active in Egypt since the 1930's and has sustained itself through the provision of informal solid waste services to residents. They are described as being highly efficient and organized, forming an interconnected social network of workers and small businesses that are capable of valorizing even the organic portion of collected wastes, as roughly 85 percent of collected wastes are recycled, reused, or expended as feedstock. This helps reduce the amount of wastes being landfilled or openly dumped and decreases the resource intensity of production operations as local economies become increasingly circular. These outcomes, in turn, yield positive social and environmental dividends as the burden of disease that the recovered wastes would have had on the population and environment is diminished and the environmental footprint of economic activities is abated. The activities of the Zabaleen have become so integrated into the waste value chain that approximately 40 percent of the waste generated in Greater Cairo is handled by them.

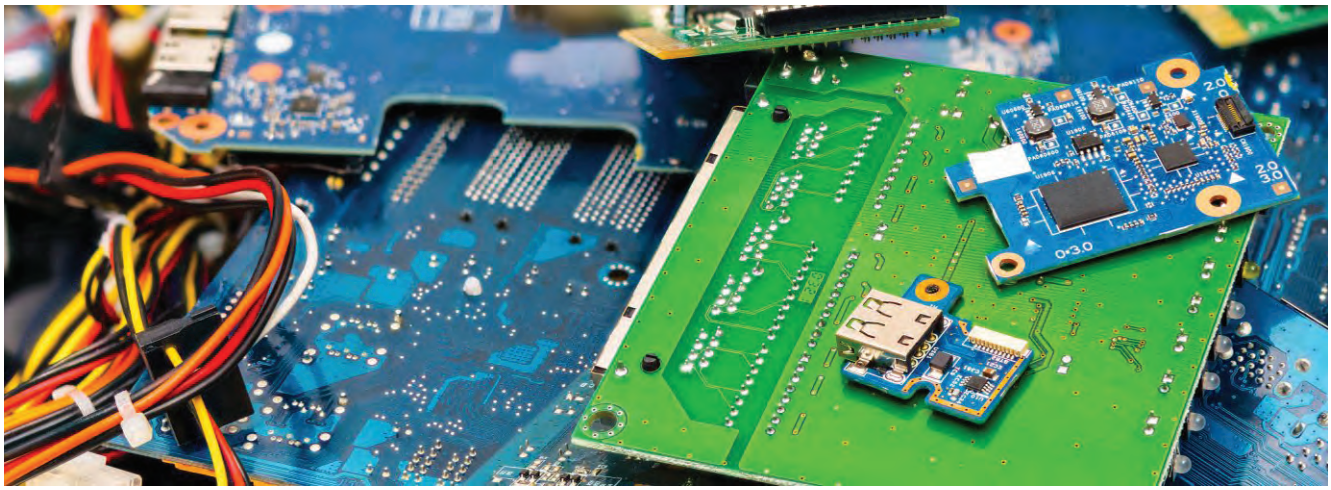
The waste value chain that the Zabaleen abide by is procedurally similar to that which is traditionally adopted by informal actors: it is primarily encapsulated in the upstream sector of waste management and their role ends when the materials they have collected and processed are sold to recipients, typically in the form of raw, repaired, or repurposed material. The revenue generated from the recovery of material is determined by the price rates set by customers – including private commercial companies – the quality of the material recovered, and the available supply of the product relative to its demand. Their stream of income is diversified as their operations target an array of materials that include paper, plastics, glass, and textiles, and offer waste collection services for a set fee. The Zabaleen, however, have been at odds with governmental authorities who are attempting to relocate the settlements of the community and modernize the waste management sector through the introduction of formal private companies who are willing to invest in the construction of technologically intensive and financially demanding solutions. Consequently, since 2002, the Zabaleen community have been facing what may be an existential crisis as informal workers are being deprived access to their source of income, wastes, competing with contracted private firms. Efforts to integrate formal and informal efforts have not be fruitful thus far. The "top-down" approach that has been adopted by governmental authorities is threatening the jobs and source of income for a community roughly comprising 100,000 members. Additionally, the newly formed contracts that have been established with the private firms may result in the percentage of wastes being recovered to be dialed down, since these companies are obliged to recycle only 20 percent of the generated refuse, in contrast to the Zabaleen who recover roughly 85 percent. A more horizontal, rather than vertical, approach is needed to ensure that this underprivileged and disadvantaged social group does not lose its livelihood and to prevent any potential future conflicts. Additionally, the government should improve the working conditions of people engaged in the sector, as informal workers often work in highly unsanitary conditions and could be exposed to hazardous materials, which may have negative repercussions on the safety and health of the general population.

Source: Fahmi and Sutton, 2010; Kuppinger et al., 2014; Eisenschenk, 2016; Jaligot et al., 2016.

moved to a centralized fund controlled by national authorities. This in turn diminishes the human and financial capital available to local administrations as waste services can drain up to 90 percent of a municipality's financial resources.

III. ALTERNATIVES FOR SUSTAINABLE AND INTEGRATED SOLID WASTE MANAGEMENT

Despite the negative state of waste management in the Arab world, there is a positive outlook on the sector as several countries are attempting to transition towards more sustainable models. However, the pace at which steps are undertaken is relatively slow and the direction of these initiatives is outdated in the sense they are not in line with contemporary notions of sustainability. The concept of circularity has yet to become pervasive in most Arab regions as "end of pipe" solutions continue to prevail. Generally, the policy frameworks set forth in the Arab region center around controlling the wastes after they had been generated, rather than preventing their materialization,



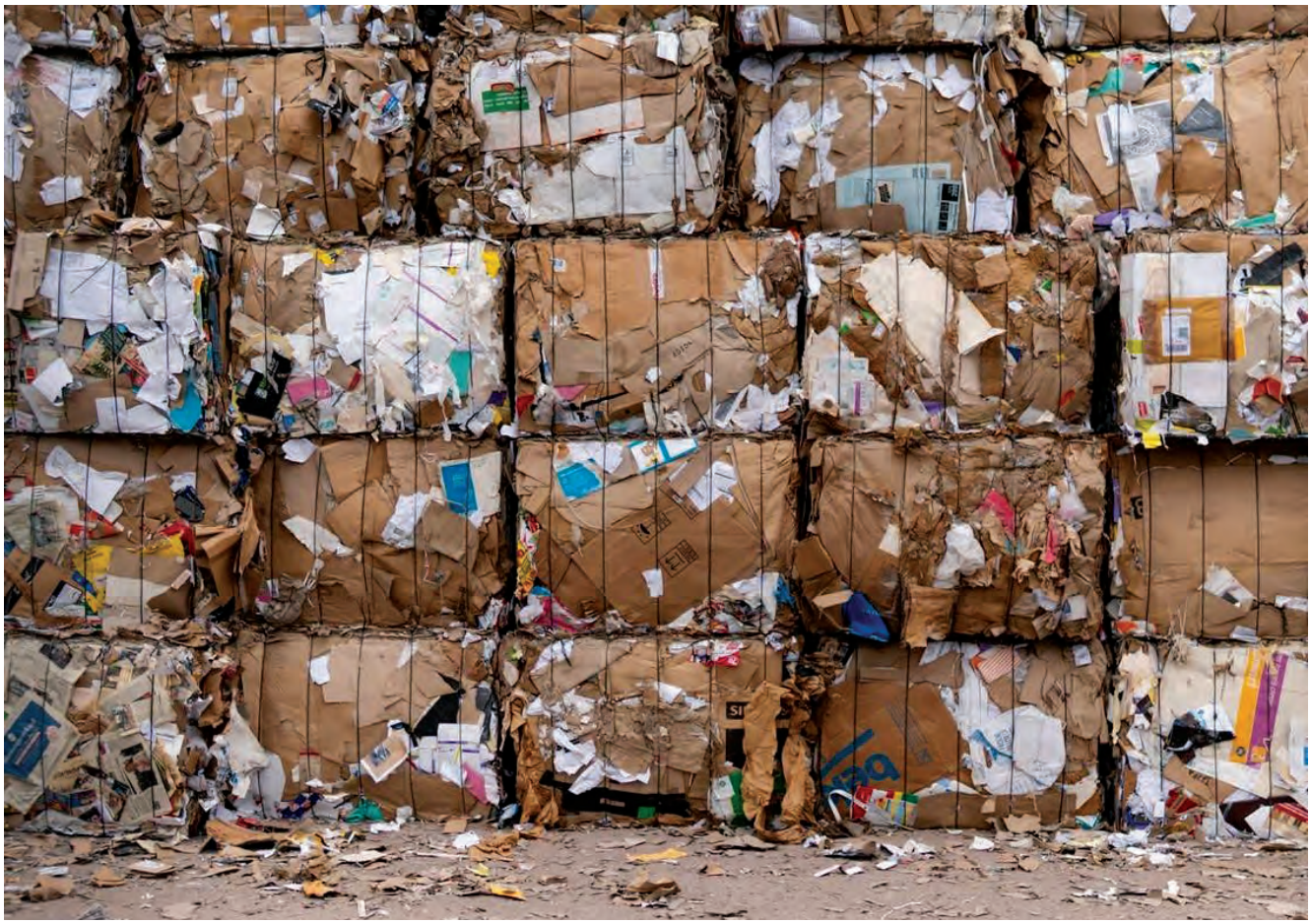
with an emphasis on improving downstream operations such as treatment and disposal. This violates the principles of the hierarchy of waste management, which emphasizes the need to prevent waste generation and recirculate generated waste material back into the economy as raw material. Adopting a more circular and 3R-centric approach (Reduce-Reuse-Recycle) to waste management is critical to combat rapid resource depletion as some nations have greatly increased their uptake of non-renewable natural resources such as Kuwait, which has doubled its level of resource consumption during the 10-year timeframe between 2002 and 2012) (Al-Jarallah and Aleisa, 2014).

A. Waste minimization and prevention

Waste minimization through prevention is the founding principle of the waste hierarchy and is the most desirable and prioritized objective in integrated waste management strategies. Waste minimization programs prioritize and invest in initiatives to reduce and reuse the waste, as opposed to prioritizing methods for their treatment or disposal (Pires and Martinho, 2019). This method reduces the resource intensity of product supply chains by avoiding the unnecessary use of materials, energy, and water and often requires simple adjustments to processes that produce waste (Pires and Martinho, 2019). The establishment of an effective waste minimization program in the Arab region requires working with various stakeholders involved in the waste value chain including households, manufacturers and governments.

B. Resource recovery and recycling

Waste represents a largely untapped source of raw material in the Arab region, as resource recovery rates remain generally low despite most of the disposed stream being composed of recoverable material (Al-Maaded et al, 2012; Ouda et al., 2018). Resource recovery in most countries appears to be minimal as efforts remain shy of where they should be, even among the GCC countries, with resource recovery mostly being conducted by the informal sector, personal initiatives, and small-scale pilot projects that highlight the need for scalable solutions (Loukil and Rouached, 2012; Al-Jarallah and Aleisa, 2014, Sweeptnet, 2014a). Waste recycling faces a variety of challenges in the region, leading to its infrequent implementation in many of the Arab countries. The challenges vary from the lack of public awareness on waste recycling and separation practices to the absence of formal recycling initiatives, lack of appropriate funding, and the cross-contamination of recyclable material, which diminishes their value and recyclability due to mixing with other types of waste (Mrayyan and Hamdi, 2006; Aldayyat, et al., 2019). Consequently, the recycling sector has yet to emerge from its infancy, with recycling rates at lower than 10 percent in the MENA region (Loukil and Rouached, 2012). Recycling can be promoted by encouraging separation at the source through proper legislation and financial incentives, and raising environmental awareness among the public. Various economic instruments can be used to encourage recycling such as placing a tax relief on recycled material or reducing taxes on businesses that perform recycling.



In addition, despite the high organic content of the generated MSW, composting practices are minimal in the Arab region. The adoption of composting, similar to recycling and reusing, requires source separation (Elnaas, 2015).

C. Circular economy

Circular economy models are characterized as sustainable prevention-oriented strategies that seek to replace traditionally applied linear models, which view waste management as a straight streak of processes that has a start and an end. Regenerative models seek to divert materials away from the disposal waste stream to relieve waste management structures of the pressures incremented by ever increasing waste generation rates and to decrease the negative repercussions associated with resource consumption and extraction. This can be achieved by means of prolonging the lifespan of materials, reducing the resource intensity of production cycles, improving the efficiency of supply chains, and recirculating used materials back into the economic stream. Circular economy models can contribute to the environmental, social, and economic wellbeing of a nation by reducing the health and environmental burden of wastes, providing job opportunities for local populations, conserving natural resources, and reducing the need for imported goods. The need to shift to a more cyclical approach is becoming more pressing as the costs to attenuate the environmental stressors generated by disposed wastes is becoming increasingly burdensome. Governmental authorities ought to introduce the enabling conditions and policies that can facilitate enacting circular models, and these include but are not limited to:

- *Introduction of incentives and disincentives and cost recovery mechanisms*

Disincentives may include pay-as-you-throw (PAYT) mechanisms such as extended user or

producer responsibility policies that shift the costs associated with disposing or treating products to the end users or manufacturers in order to alter consumer and producer behaviors. Meanwhile, incentives may include corporate tax cuts, which can relieve businesses and attract investors, and the introduction of certificates that can improve a company's public image. Higher tipping fees at landfill facilities, especially in the GCC where tipping fees tend to be relatively low, could also be introduced, alongside weight or volume-based collection fees that would also serve to decrease waste volume.

- *Alteration of consumer behavior*

Behavioral campaigns need to be conducted to promote a higher level of acceptance among the general public to reused or repaired material, as such products typically carry negative connotations. The campaigns would also serve to alter the attitudinal behaviors of residents by incentivizing 3R-centric practices among residents. In addition, countries in the region could incentivize manufacturers, distributors, and consumers into adopting more environmental conscience practices by introducing financial disincentives on environmentally abusive behaviors (Bejjani et al., 2019). Applying the "polluter pays principle" would internalize the environmental costs associated with the wastes that consumers and producers are generating and would provide a more accurate value to the products being marketed.

IV. CONCLUSION AND RECOMMENDATIONS

The management of solid waste in the Arab region is a challenging task with significant implications on human health and well-being, environmental preservation, sustainability and the economy. As evident by the existing research, across the board Arabs are experiencing health problems that are linked to poor solid waste management practices. The existing legislative and institutional frameworks are not sufficient to protect the health and wellbeing of the population. There is a need for the establishment of data generation and monitoring systems that highlight existing problem areas and allow for better prioritization and allocation of resources. Research assessing exposure to waste and health outcomes is limited in the region, but much needed to advocate the public, local officials and all those concerned, to act. Improving contemporary SWM systems is provisional on abiding by the order of priority set by the waste hierarchy and implementing the principles that govern integrated solid waste management. The following set of recommendations are essential to facilitate the transition towards a preventative and circular system that is founded on the core principles of environmental sustainability:

- Decentralized context driven plans that account for the prevailing social, geographical, cultural, and economic conditions of target areas ought to be drafted.
- The COVID-19 pandemic has highlighted the need to add a buffering layer capable of absorbing some of the shock caused by unforeseen events or emergencies.
- Old and obsolete waste facilities ought to be retired in favor of new ones to reduce the health footprint of the sector and increase the efficiency of operations. The new facilities should also be placed in remote areas to reduce on any associated health risks. Furthermore, open dumpsites ought to be remediated to halt the dispersion of pollutants.
- Cost recovery mechanisms need to be established, especially in low-income countries where solid waste services tend to drive local governments who do not have the capacity to properly collect taxes into bankruptcy.
- Following the development of all-inclusive legislative frameworks, proactive monitoring and evaluation mechanisms ought to be installed to ensure the implementation of issued legislation.
- New public-private partnerships ought to be established based on transparent and competitive bidding processes, with the contracts containing operational incentives and disincentives.
- Capacity building and training activities should be realized for concerned stakeholders to help reduce technical inefficiencies and to improve the overall implementation of sustainable waste management strategies.
- Public awareness campaigns that promote the participation of residents in designed schemes are desperately needed and would lay the foundation for the adoption of a participatory form of governance that is built upon civic engagement.

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MARINE ENVIRONMENT AND HUMAN HEALTH

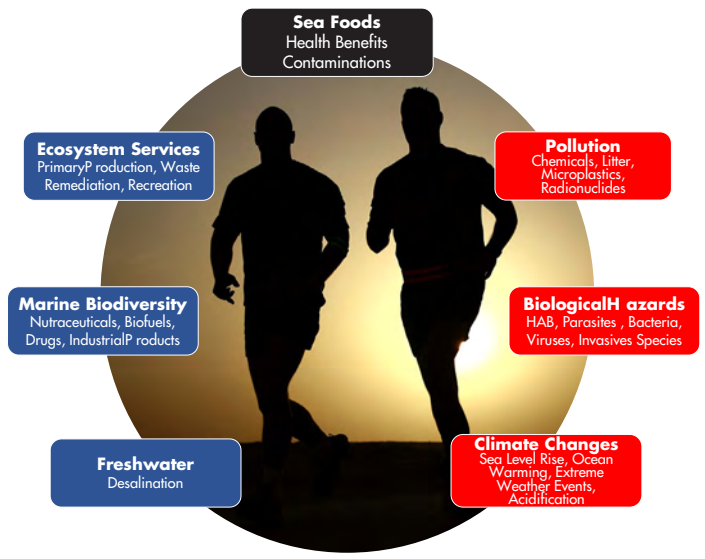
Amr El-Sammak, Amira Hamdan

I. INTRODUCTION

There has been little attention for the effect of the poor state of the marine environment on human health in the Arab region. A rise in urban development and industrialization has led to more pollution, deterioration in quality of life and a general increase in negative health impacts. Among other factors, land-based pollution, harmful algal bloom (HAB), microplastics, and contaminated seafood have impacted the health of the Arab population. Most of the recorded petroleum hydrocarbon and metal concentrations in the marine environments of Arab countries fall within the acceptable levels. However, hotspots of metal and hydrocarbon contaminations were identified in areas affected by oil pollution from refineries and intensive dredging or recreation activities. To date, no studies have adequately investigated the direct health impact of HABs in the Arab region. The lower diversity in the ecosystem adjacent to a desalination plant may prompt HAB occurrence, however, a low level of HAB toxins in distilled drinking water would not be enough to cause a risk to human health.

The level of sewage treatment in the Arab countries varies and the capacity is not sufficient to deal with the existing loads. The accumulation of microplastics in the food chain, especially in fish and shellfish species, could have consequences for the health of human consumers in the Arab region. The level of seafood contaminations with metals along the coast of the Arab States is within the maximum permissible limit for human consumption. Human risk assessment due to the intake of toxic metals through seafood consumption indicates no risk, although heavy seafood consumers have a higher level of mercury in their hair than usual. Overall, additional research is recommended on the impact of microplastics and seafood contamination on human health and the marine environment.

FIGURE 1 RISKS, BENEFITS AND OPPORTUNITIES OF OCEANS AND HUMAN HEALTH



Source: modified from Fleming et al., 2014

II. BACKGROUND

The marine and coastal environment impact human health and the wellbeing of individuals and/or communities both positively and negatively (Figure 1). They provide significant sources of environmental and ecological services, which is why the quality of marine environment is essential for maintaining life and human health. On the other hand, human utilization of marine and coastal environment has negatively and extensively impacted these eco-services. The human activities in coastal zones such as aquacultures, urban development, fisheries, coastal industries and recreation generate a significant amount of chemical pollution (e.g. metals, persistent organic pollutants, nanoparticles, radionuclides and nutrients) and contribute to the deterioration of the natural environment.

Historically, most observable human health and well-being issues associated with the marine and coastal areas are the losses and harm among the marine occupations such as fishing (NIOSH, 2003) . However, the interrelationship between human health issues and the ocean, marine, and coastal environment has become more obvious, partly due to an increase in the number of people living in coastal areas.

The Sustainable Development Goals (SDGs) give importance to both human health and marine environment, since SDG 3 (good health and well-being) is about ensuring healthy lives and promote wellbeing, while SDG 14 (life below water) aims to “conserve and sustainably

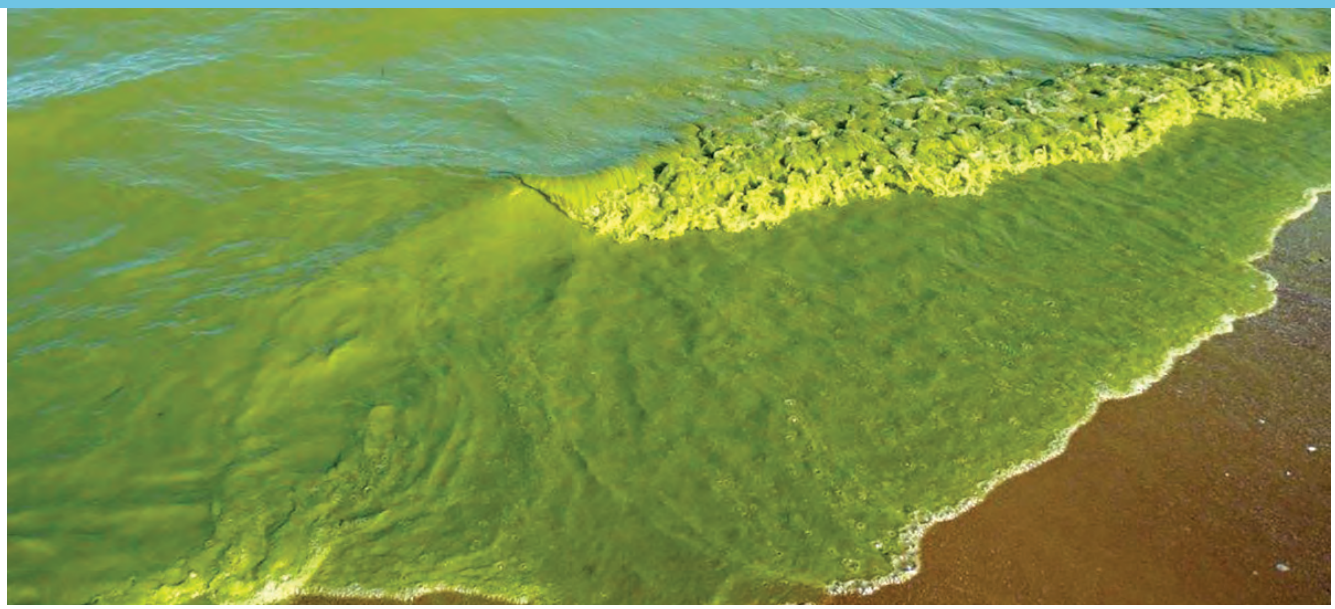
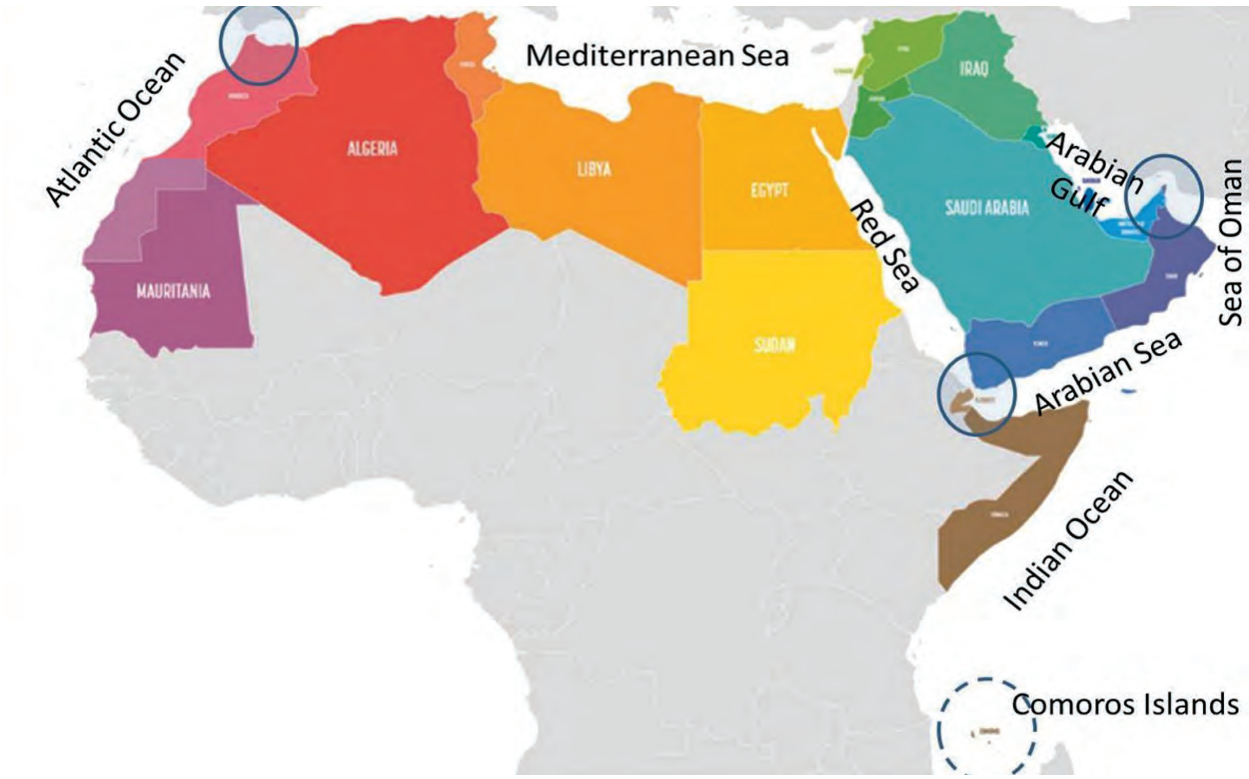


TABLE 1 **REGIONAL SEAS PROGRAMMES FOR THE ARAB REGIONS.**

Marine Area	Coastal Countries	Organization/Programme responsible for management	Challenges & stressors
Mediterranean Sea	Morocco Algeria Tunisia Libya Egypt Palestine Lebanon Syria	Mediterranean Regional Seas Programme (Mediterranean Action Plan)	Petrochemical and chemical industries, tourist activities and urbanization.
Red Sea and Gulf of Aden	Egypt Sudan Jordan Saudi Arabia Somalia Yemen Djibouti	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)	Dredging and filling operations, disposal of domestic and industrial effluent, unmanageable use of resources, tourism industry, desalination activities
Arabian Gulf and Sea of Oman and Arabian Sea	Iraq Kuwait UAE Bahrain Qatar Oman Saudi Arabia	Regional Organization for the Protection of the Marine Environment (ROPME)	Fossil fuel related activities; offshore installations, tanker loading terminals, heavy traffic and exceptionally high oil tanker and desalination processes
Southwest Indian Ocean	Comoros Somalia	Eastern Africa Regional Seas Programme	Fisheries and related activities
Eastern Central Atlantic Ocean	Morocco Mauritania	Western Africa Regional Seas Programme (WACAF)	Fisheries and related activities

Source: AFED 2008

FIGURE 2 **COASTLINE OF THE ARAB COUNTRIES SHOWING THE THREE STRAITS CONNECTING REGIONAL SEAS AND THE OCEANS.**



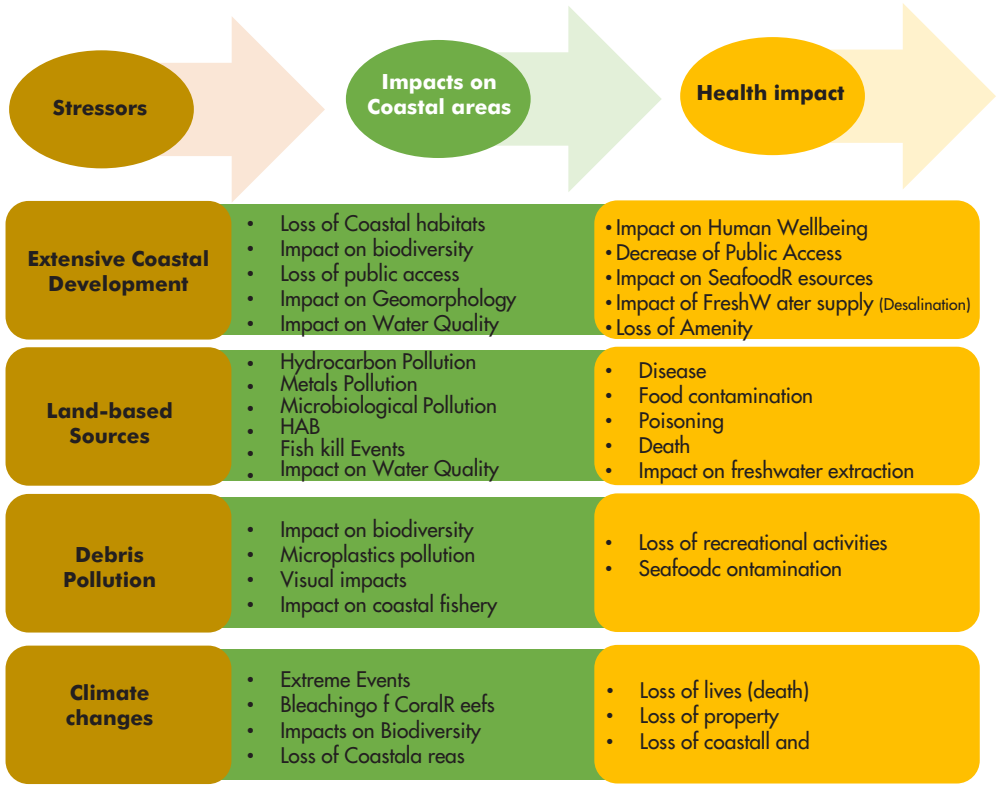
use the oceans, seas and marine resources for sustainable development" (https://sdgs.un.org/goals). SDG 14 specifically names the following relevant target in 14.1: "By 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution". The proposed indicator for Target 14.1 is: "Index of coastal eutrophication and floating plastic debris". In fact, sustainable use of oceans has many links with environmental determinants of health, such as oceans as a sustainable food resource and the need for adequate sanitary management before it reaches rivers and oceans (Prüss-Ustün et al., 2016).

The Arab region's fragile marine and coastal environment stretches over 30,000 kilometers, of which 18,000 are populated (AFED 2009). The region includes five main regional marine bodies of water (Figure 2). Each of these seas or oceans is guided by a regional conservation organization or programme. Three straits connect these regional seas with main oceans, where Bab-el-Mandeb connects the Red Sea to the Indian Ocean through the Gulf of Aden/Arabian Sea, the Strait of Gibraltar connecting the Mediterranean Sea with the Atlantic Ocean and the Strait of Hormuz connecting the Arabian Gulf with the Indian Ocean through the Sea of Oman.

The Arab region has extensive coastal areas where large percentages of the population live in a number of highly populated economic centers. Due to population growth, urban development and industrialization have been common in coastal centers, leading to more pollution and at times to negative health impacts and deterioration in the quality of life.

The impact of the marine environment on human health in the Arab region has received little consideration. Common stressors on marine environment in the region are extensive coastal development, land-based sources of pollution, coastal and marine debris and climate change. Figure 3 summaries the stressors and their related

FIGURE 3 STRESSORS, IMPACTS ON THE COASTAL AREAS AND ON HUMAN HEALTH IN THE ARAB REGION



impacts on marine environment and human health in the Arab region.

This chapter will handle only some issues related to these stressors, namely land-based sources and microbiological pollution, harmful algal blooms, coastal debris/microplastics and seafood contamination. Climate change will be discussed as a cross-cutting issue throughout this report.

III. LAND-BASED SOURCES OF POLLUTION IN THE ARAB REGION

The Arab States have witnessed major economic, social and industrial development following the discovery and exploitation of their vast oil reserves (Al-Abdulghani et al., 2013). Increases in both the population and tourism in the coastal areas of many Arab countries have been well observed, however, the dynamic balance between social and economic factors on one hand and conservation of the marine environment on the other, is dramatically threatened by the large and constant inflows of anthropogenic inputs through a variety of land-based and sea-based sources of pollution. Land-based sources include urban and industrial activities and direct discharge of untreated or partially treated sewage into the immediate coastal zone (Coll et al., 2010). The sea-based sources of pollution include offshore oil exploration and extraction, shipping, dredging, recreational boating and fishing.

Table 2 summarizes the land-based sources of pollution, and notes examples of hot spot areas in the ROPME Sea Area (RSA), the Mediterranean Sea (MS) and the Red Sea and Gulf of Aden (RDGA).

A. Anthropogenic Organic Chemicals

Petroleum hydrocarbons, such as total petroleum hydrocarbon (TPH) and polycyclic aromatic hydrocarbon (PAH), are the most widespread organic pollutants in the marine environment of the Arab region, especially in areas used for oil

TABLE 2 SUMMARY OF POLLUTION SOURCES, HEALTH IMPACTS AND HOT SPOT AREAS

Sources/ Effluents	Types of Pollution	Main Environmental and Health Impacts	Hot Spot Areas (Examples) (Collected from many sources)		
			RSA	MS	RDGA
Sewage/domestic Outfall	Heavy Metals Microbial Pollution Hydrocarbons Organic Matter Nutrient Salts Pesticide	Water deterioration, Sea Food contamination, Eutrophication and HABs, Loss of Fisheries, Impact on recreational bathing areas, Burden Disease	Sewage outfall distributed along the coastal area (Entire RSA), Kuwait Bay (Kuwait), Suliabikhat Bay (Kuwait), Tubli Bay (Bahrain), Doha city (Qatar) Jubail (KSA), Ras Al-Tanura and Dammam (KSA) Dubai Creak, Abu Dhabi Coastal Area, Mina Al Fahal (Oman)	Oran (Algeria) Alger (Algeria) El Mex Bay (Egypt) Alexandra (Egypt), Damietta (Egypt), Gaza Strip (OTP), Tripoli harbor (Lebanon), Great Beirut Area (Lebanon), Tripoli (Libya), Nadar (Morocco), Lake of Bizerte (Tunisia),	Jeddah, Dibba, Yanbu Al Bahr, Gizan (KSA), Suez, , Hurghada , and Sharm Al Sheikh (Egypt), Aqaba (Jordan), Port of Sudan (Sudan)
Industrial Outfall	Heavy Metals Petroleum Hydrocarbon Organic Matter	Deterioration of Seawater, Marine Habitat degradation and Loss, Seafood contamination, fisheries loss	Ras Az zour (Kuwait) Shuaiba Industrial Area, and Mina Abdulla (Kuwait) Kafji (KSA) Jubail (KSA) Mesaieed Industrial Area (Qatar) BAPCO/ALBA (Sitra-Bahrain) Al Ruways (UAE) Jabal Ali (UAE) Rask Al-Khaimah (UAE) Mina Fahal Area (Oman), Shinas and Sohar area (Oman).	Alexandria (Egypt), Zanzur (Libya), Oran (Algeria), Algiers, Bay of Algiers (Algeria), Safi, Tetouan and Kenitra (Morocco), Gabes (Tunisia)	King Fahd Port, Rabigh Industrial Port (KSA), Adabiya Port, Suez, Ain Sukhna Oil Terminal, Port of Aqaba (Jordan), El Khair Oil Terminal- south of Port of Sudan (Sudan).
Desalination Plants	Brine water Thermal Pollution Organic Matter Heavy Metals	Deterioration of Seawater, Marine Habitat degradation and Loss, Seafood contamination, fisheries loss	Desalination plants distributed along coastal area of the Arab countries, mostly along RSA, and Red Sea and few along MS.		

exploration activities (Arabian Gulf, Gulf of Suez and the Mediterranean Sea) as well as industrial areas. The Arabian Gulf is likely ranked among the most heavily impacted regions, receiving the highest inputs of petroleum hydrocarbon on the planet (Sheppard et al., 2010). Despite the large number of hydrocarbons found in petroleum products and the widespread nature of petroleum use and contamination, only a relatively small number of compounds are well characterized for their toxicity. The health effects of some fractions can be well characterized based on their components or representative compounds (e.g., light aromatic fraction - BTEX-benzene, toluene, ethylbenzene, and xylenes). However, heavier TPH fractions have far fewer well-characterized compounds. Systemic and carcinogenic effects are known to be associated with petroleum hydrocarbons. Table 3 represents the levels of TPH and PAH in the sediments of different

TABLE 3 LEVELS OF TPH AND PAH IN THE COASTAL SEDIMENTS AT SOME AREAS

Area	Country/Location	TPH (mg Kg^{-1})	PAH (μg Kg^{-1})	Reference
RSA	Arabian Gulf/KSA	85.86 25.18	24.61 5.80	Asok et al., 2019
	Qatar/Halul Island Qatar/Doha Qatar/Ras Laffan Qatar		4.5 ng/g 0.49 ng/g 0.46 ng/g 7.8 - 0.3 ng/g	Rushdi et al., 2017
	Kuwait (Average)	251 – 2	1670 – 2 μg Kg^{-1}	De Mora et al., 2010
	Kuwait (North)	270	295.2	El-Sammak et al., 2004
	Kuwait (Average)	744 – 4.2	1286 – 12.9	SOMAR 2017
	Bahrain	776	6.6	Tolosa et al., 2005
	UAE	73 -100	6.3 – 9.4	Tolosa et al., 2005
RSGA	Yemen	4.07 - 18.88		Al Saad et al., 2006
	Egypt/ Gulf of Suez		18.99–97.19 ng/g (Avg. 45.51)	Salam et al., 2014
	Egypt/Gulf of Aqaba		6.86–100.05 ng/g (Avg = 40.998)	
	Egypt/Red Sea proper		0.74–456.91 ng/g (Avg = 93.49)	
MS	Tunisia/Gulf of Tunis		9 – 0.8 (μg/g)	Mzoughi et al., 2010
	Egypt/Abu Qir		BDL to 2660 μg/kg dw	Khairy, et al., 2008
	Egypt/Many location		13.5 to 22,600 ng/g	Barakat et al, 2011
SQG	S (DGV)	280	10,000	Simpson et al 2005
	Sediment Quality Guideline (GV-High)	550	50,000	

SQG = SEDIMENT QUALITY GUIDELINES, DGV = DEFAULT GUIDELINE VALUE, GV-HIGH = GUIDELINE HIGH

areas. Most of the recorded TPH and PAH fall within the concentration of the sediment quality guidelines (ANZECC & ARMCANZ, 2000, Simpson et al., 2005)

B. Metal Pollution

Although sources of metals in the marine environment are numerous and diverse, little evidence of the adverse biological effects exists other than risk to human health posed by metals in seafood. Many trace metals, even in low concentrations, can have harmful effects on marine biota. Elevated metals in seawater are unlikely (other than in the immediate vicinity of point sources), due to their rapid removal by adsorption to suspended materials, in most cases (Fleming et al., 2008). Heavy metals that pose more threat to human health are mercury (Hg), Cadmium (Cd), Lead (Pb) and Arsenic (As) (Jarup, 2003). Table 4 reports the level of different metals in the sediments of some selected hotspot areas in the ROPME Sea Area (RSA), Red Sea and Gulf of Aden (RSGA) and Mediterranean Sea (MS). Most of the recorded metals fall within the concentration of the acceptable level of sediment quality guidelines/background levels (Table 4).

IV. HARMFUL ALGAL BLOOMS AND HEALTH IMPACT

Blooms of phytoplankton, such as dinoflagellates, diatoms and cyanobacteria cause HABs. HABs can deplete oxygen and block the sunlight that other organisms need to live, and they release toxins that are dangerous to animals and humans (Box 1).

Consumption of seafood contaminated with algal toxins can result in five seafood-poisoning syndromes: paralytic shellfish poisoning

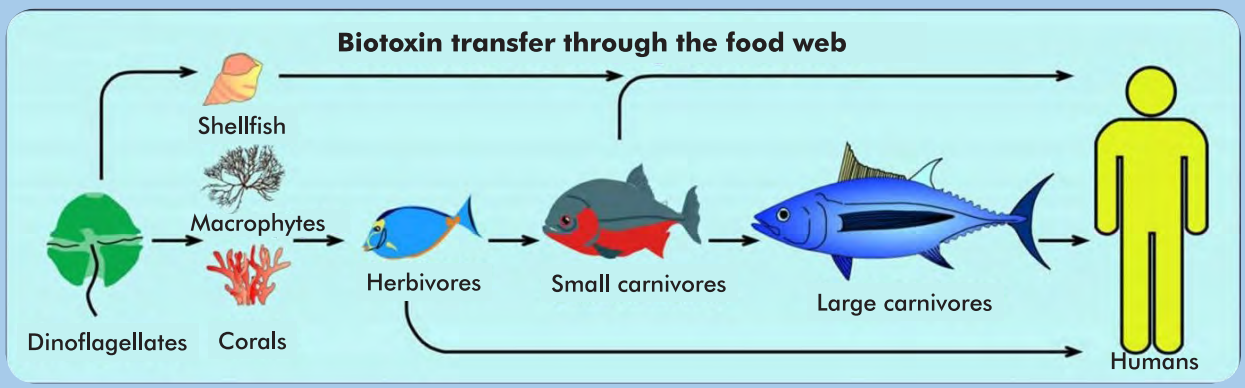
TABLE 4
METALS CONCENTRATION IN THE SEDIMENTS AT SOME SELECTED COASTAL AND OFFSHORE LOCATIONS

Area	Country	Maximum, Minimum (Average) Metals ($\mu g\ g^{-1}$)										Reference
		Az	Cd	Cr	Cu	Hg	Ni	Pb	V	Zn	Fe	
RSA	Arabian Gulf (Background Level)		20 -1.2		30 -15		80 -70	30 -15		60 - 30	20,000 10,000	Al Abdali et al., 1996
	KSA/Ras Tanajib		31.59			0.15		46.33				Sadiq, 2002
	Oman/ Mina Al Fahal	5.01	0.16	119	2.03	<0.0001	43.4	1.59	18.6	6.48	5540	Mora et al., 2004
	Kuwait/Kuwait Bay	9.7 0	2.43 0	1119 47.9	122.24 9.63	---	49.06 1.04	32.58 0	81.6 27.3	--	--	Ali and Chidambaram, 2020
	Kuwait/Suli-abikhat Bay	7 1	4 2	190 65	100 10	--	130 25	32 2	--	290 10	--	Al-Sarawi et al., 2015
MS	Egypt/Abu Qir Bay	8.67 1.60	4.89 0.31	--	22.85 10.24	--	--	16.79 1.9	70.64 5.57	104.08 25.23	--	Abdel Ghani et al., 2013
	Egypt/Eastern Harbour	16.21 4.01	1.83 0.3	--	129.2 3.8	--	--	112.09 1.3	23.1 2.85	206.89 2.9	--	Abel Ghani, 2015
	Egypt/Mediterra-nean Coast	--	(0.22)	(82.74)	(8.46)	--	(25.93)	(13.17)	--	(22.19)	--	Soliman et al., 2015
RSGA	KSA/Red Sea Coast - Jizan	(0.34)	(0.48)	(5.64)	(16.39)	--	(14.32)	(3.86)	--	(22.19)	--	Soliman et al., 2015
	Yeman/Gulf of Aden	--	--	233.93 17	111 8.09	--	48.07 16.17	138.06 14.8	--	263.49 21.85	---	
	Egypt/Gulf of Suez	--	3.32 ND 0.96	99.00 3.47 (26.42)	7.87 4.11 (1.05)	0.242 0.024 (0.65)	232.57 20.86 (46.47)	89.49 ND (31.11)	--	169.32 1.47 (47.59)	7872 1651 (414)	Ibrahim et al., 2019
SQG/Back-ground Level	OSPAR	25	0.31	81	27	0.07	36	38		122		OSPAR, 2008
	ERL (Effect Range (Low	8.2	1.2	81	34	0.15	20.9	46.7		150		Long and Mac Donald, 1998
	ERM (Effect Range (Medium	70	9.6	370	270	0.71	51.6	218		410		
	(NA-SQG (DGV	20	1.5	80	65	0.15	21	50		200		ANZECC & ARMCANZ, 2000
	NA-SQG (GV-(High	70	10	370	270	1.0	52	220		410		

SQG = SEDIMENT QUALITY GUIDELINE, DGV = DEFAULT GUIDELINE VALUE, GV-HIGH = GUIDELINE HIGH

BOX 1

BIOTOXIN TRANSFER PATHWAYS



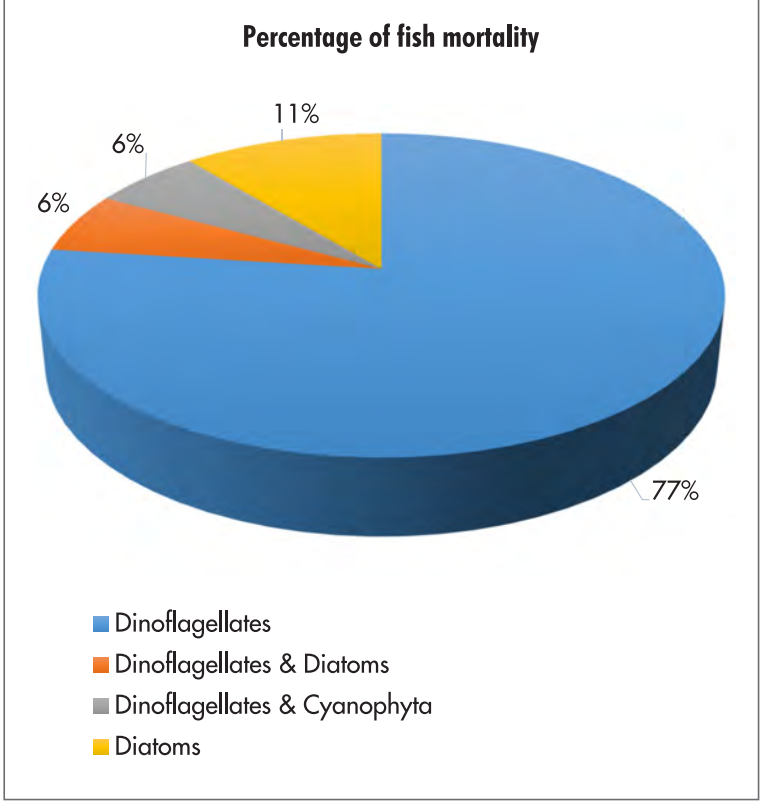
A biotoxin-producing organism, such as the dinoflagellates *Dinophysis acuta or Alexandrium catenella*, is bioaccumulated by shellfish, which are apparently not affected by saxitoxin or lipophilic biotoxins. Consumption of the contaminated shellfish is a traditional way of diarrhetic or paralytic poisoning (DSP, PSP). Alternatively, some toxicogenic species attach to surfaces (macrophytes, corals) by an endogenous mucus (e.g. *Gambierdiscus, Ostreopsis, Prorocentrum lima*). Fragments of corals or macrophytes covered by the microalgae enter the food web through ingestion by herbivorous fish. This is the transmission mechanism of ciguatera fish poisoning (CFP). Certain fishes can also experience some sort of poisoning.

Source: Berdalet et al., 2015

(PSP), neurotoxic shellfish poisoning (NSP), amnesic shellfish poisoning (ASP), diarrhetic shellfish poisoning (DSP) and ciguatera fish poisoning (CFP). Some toxins elaborated by marine phytoplankton can even be acutely lethal. Ciguatoxin associated with ciguatera fish poisoning is toxic to humans in a total body dose of 70 ng. Because these toxins are tasteless, odorless, and heat and acid stable, normal screening and food preparation procedures will not prevent intoxication if the fish or shellfish is contaminated (De Moura et al., 2012). In addition to these diseases, aerosols of biotoxins produced by HABs cause respiratory issues, eye and nose irritation. Swimmers exposed to HABs are susceptible to a range of health issues including skin irritations and beach closures. Figure 4 summarizes possible impacts of HABs, including risks to health, the environment and the economy.

HABs are frequently occurring in the ROPME Sea Area (RSA). The physical geography of the RSA, heavy traffic and dumping of ballast water make it prone to HAB invasions (Sale et al., 2011). HABs in the Arabian Gulf occur mainly in fall and winter (Zhao et al., 2016). In the RSA, 337 phytoplankton species have been identified. 58

FIGURE 5 PHYTOPLANKTON CAUSING FISH DEATH IN THE RSA



BOX 2

KUWAIT BAY FISH KILL EVENT

In August and September 2001, Kuwait Bay experienced a massive fish kill involving over >2500 metric tons of wild mullet (Liza klunzingeri), due to the bacterium Streptococcus agalactiae. This event was preceded by a small fish kill (100–1000 dead fish per day) of gilthead sea bream (Sparus auratus) in aquaculture net pens associated with a bloom of the dinoflagellate Ceratium furca. Unusually warm temperatures (up to 35 °C) and calm conditions prevailed during this period. As the wild fish kill progressed, various harmful algae were observed, including Gymnodinium catenatum, Gyrodinium impudicum, and Pyrodinium bahamense var. compressum. Cell numbers of G. catenatum and G. impudicum exceeded 106 l−1 in some locations. All fish tested below the limits of detection for paralytic shellfish poisoning (PSP) and brevetoxins. Clams (Circe callipyga) were positive for PSP but at levels below regulatory limits.

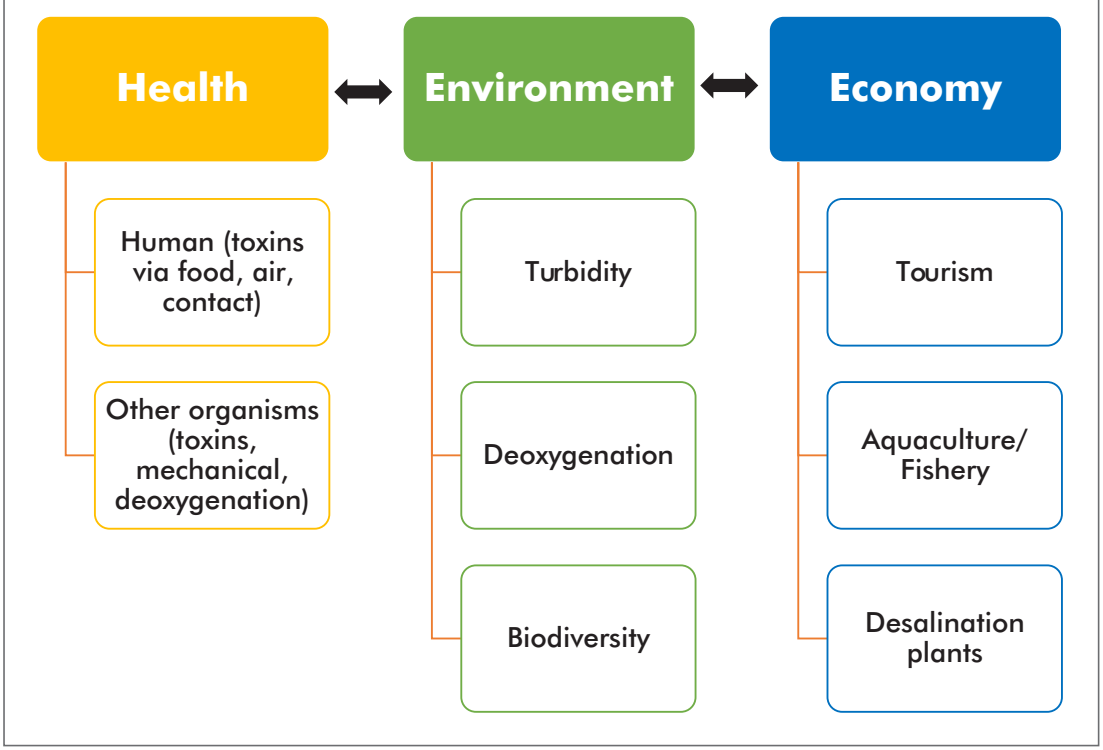
Sources: Glibert et al., 2002; Glibert, 2007

identified taxa are considered potentially harmful species, out of which 20 species are potentially toxic to human, 15 species can potentially cause death amongst fish and 23 are potentially bloom-forming species (ROPME 2013).

Increases in nutrient concentrations in the Gulf have often been concentrated in the Kuwait Bay and the area around the outfall of the Shatt-Al-Arab River, and they have been cited as the cause of a number of eutrophication incidents (Box 2).

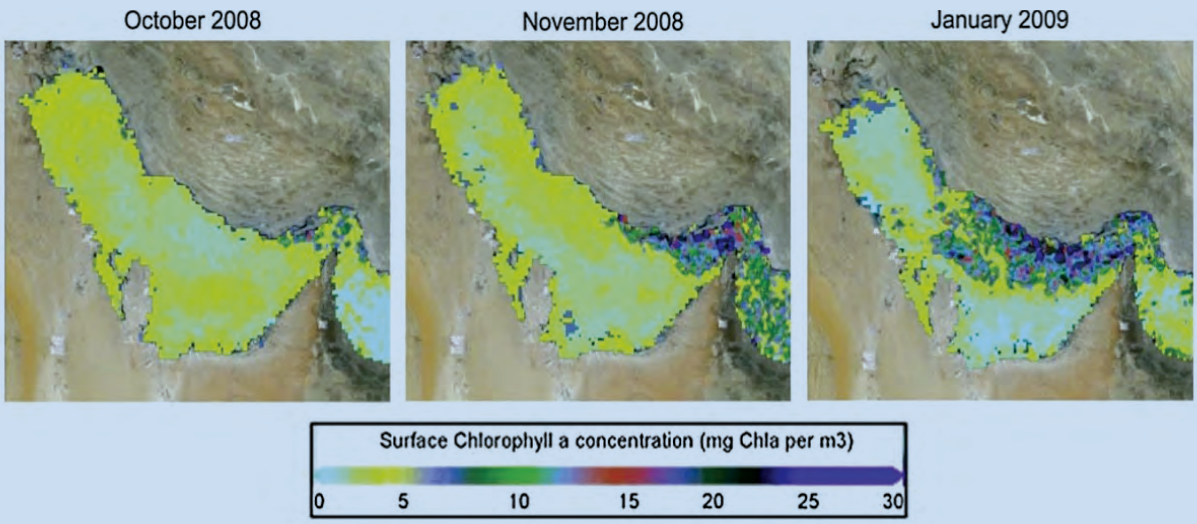
The role of sewage effluent in stimulating or initiating HAB events in Kuwait marine waters is a key question for understanding the complex interactions between drivers and response in the phytoplankton community (Riegl et al., 2012). Since 2003, ROPME has been implementing real-time remote sensing monitoring of algal bloom in the entire RSA. The observed bloom is described as "large" if it covers an area of 10 Km2 or "massive" if it covers a surface area larger than 10 Km2. The massive blooms that affected

FIGURE 4 RELATION BETWEEN ENVIRONMENT, HEALTH AND ECONOMY



BOX 3

THE CATASTROPHIC 2008–2009 RED TIDE



The Arabian Gulf Area has experienced massive marine mortality, resulting in serious economic loss. The eight-month bloom between 2008 and 2009 of dinoflagellate "Cochlodinium polykrikoides", killed thousands of tons of fish, hampered traditional fisheries, impacted tourism, forced the closure of desalination plants, and damaged coral reefs. The chronology of the 2008-2009 bloom suggest that it may have originated in the Gulf of Oman and was subsequently transported into the Arabian Gulf though the Strait of Hormuz. The massive fish kills were reported in Abu Dhabi, Dubai, Ajman, Fujairah, and Oman.

The bloom impacts included:

- The closures of at least five seawater desalination plants in the UAE due to clogging of intake filters due to the concern that red tide toxins might end up in the finished, drinking water.
- Impacts on coastal recreation and tourism, due the unpleasant odor associated with the bloom and because of fears regarding the potential risk to swimmers.
- Thousands of tons of fish and marine mammals were killed; in Dibba Al-Hassan, over 650 tons of dead fish washed ashore and in Khor Fakkan more than 700 tons were reported.
- Restricted traditional fishing activities in the UAE within eight miles of the eastern coast and three miles of the western coast.
- Significant damage to coral reefs in the Dibba Marine Protected Zone

Sources: Al-Muftah, 2015; Richlen et al., 2010; Sale et al., 2011

the Arabian Gulf from August 2008 to May 2009 caused widespread fish death, damage of coral reefs, interrupted desalination operations and limited fishing activities and the tourist industry (Nasr, 2014) (Box 3). The highest HAB events were recorded in 2001, 2000 and 2005. Dinoflagelates account more than 77 percent of the total fish kill events in the RSA (Attaran-Fariman, 2018) (Figure 5). Table 5 represents the chronological HAB events in the RSA.

HABs in the Mediterranean Sea are more commonly localized phenomenon related to areas of constrained dynamics such as bays, lagoons, ports, beaches and estuaries (Gar'es, et al., 2012, Ferrante at al., 2013). Along the Mediterranean coast of North Africa, the special distributions of chlorophylls and carotenoids are attributed to a human-altered pattern of physical structure and nutrient concentration, as well as to the Modified Atlantic Water (MAW). The nutrient-rich coastal environments of the Mediterranean Sea, and in particular semi-enclosed areas with low turbulence levels, constitute a unique environment in which several phytoplankton species with harmful effects may become dominant.

Among different types of harmful blooms recorded in the Mediterranean Sea and based on

TABLE 5 CHRONOLOGY OF FISH DEATH INCIDENTS IN THE RSA

Year of Incident	Member State	Organisms	Cause
August, 1976	Oman	Fish	Red tide
October, 1976	Oman	Fish	Red tide of Gonyaulax sp. & Noctiluca sp
February, 1978	Oman	Fish	Red tide of Gonyaulax sp. & Noctiluca sp.
January, 1987	Bahrain, KSA	Mammals, Birds, Starfish	Red and green algal bloom (KSA); Gymnodinium sp. (Bahrain)
February-April, 1988	Oman (middle RSA)	Fish	Red tide of Noctiluca sp. effect and bacterial infection
September, 1988	Oman (middle RSA)	Fish and shellfish	Red tide caused by diatoms and a few species of dinoflagellets (DO depletion)
February-April, 1989	Oman (middle RSA)	Fish	Red tide of Noctiluca sp.
April, 1993	Oman (middle RSA)	Fish	Red tide of Noctiluca sp.
September, 1993	Oman (middle RSA)	Fish	Red tide of Gonyaulax sp.
October, 1993	Oman (middle RSA)	Fish	Red tide of Dinophysis spp., Ceratium spp.
August, 1994	Oman (middle RSA), inside Port	Fish	Red tide of Gonyaulax sp.
April, 1999	Bahrain	Fish	Red Tide (Gymnodinium)
September-October1999	Kuwait	Fish	Red Tide (Karenia selliformis)
May, 2000	UAE	Fish	(Gymnodinium)
September, 2000	Oman (Middle RSA)	Fish	(mainly diatom blooms
November-December 2001	Oman (Al Sharqiya & Al Wasta, Outer RSA)	Fish (40 tons) turtles (250 Nos.), dolphins, birds	(Karenia selliformis, Prorocentrum micans, P. minimum)
October, 2005	Oman (Massirah, Outer RSA)	Fish	Lutjanidae, Sciaenidae, Prorocentrum micans, Trichodesmium erythraeum, Noctiluca scintallans

their toxicity, two types of phytoplankton were identified (Garcés and Camp, 2012):

- Toxic or potentially toxic algae (e.g., Alexandrium, Dinophysis, and Pseudonitzschia), which can cause toxic symptoms in the marine fauna and humans, e.g., fish and shellfish death, or poisoning in humans consuming the fish and shellfish populations

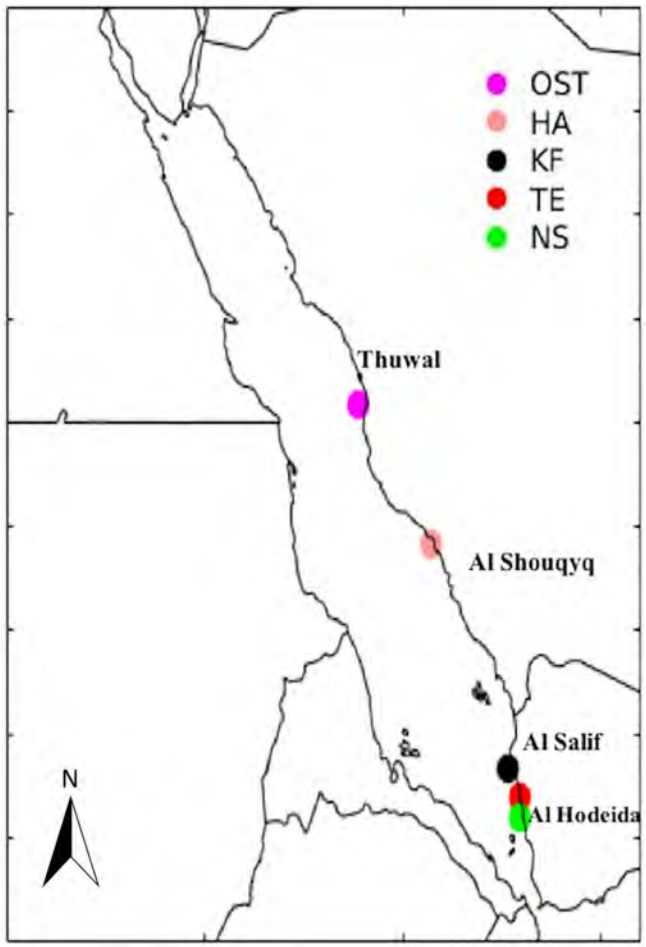
- High-biomass blooms (e.g., Noctiluca), which cause problems mainly because of the high biomass itself (cell abundances higher than 105-106 cells l-1 and the production of organic matter). High biomass blooms may cause significant ecological problems and harmful effects in the biota of the region (anoxia, community and food-web changes) as well as great economic problems connected to the deterioration of the coastal recreational waters (e.g., discoloration, odor etc.)

- Some marine planktonic microalgae (e.g., Alexandrium) belong to both categories

The Eastern Harbor in Alexandria, Egypt is one of these semi-enclosed bodies of water that suffers from repeated HAB incidents. There is evidence for the distinct increased recurrent frequency of the red tide blooms in Alexandria coastal waters, as well as an increase in their intensity, magnitude, and the number of harmful and harmless causative species (ICES,

Year of Incident	Member State	Organisms	Cause
August, 2006	Oman (Muscat, Middle RSA)	Fish	Gymnodinoid possibly Karenia selliformis
October, 2008	Oman	Demersal fish	Cochlodinium polykrikoides
November, 2008	Oman (Seeb to Muscat, and Sohar)	Anchovey and demersal fish	Cochlodinium polykrikoides
November, 2008	Oman (Quriyat)	Sparus auratus	Cochlodinium polykrikoides
November, 2008	Oman (Sur fishing harbour, Al-Sharkyah)	Demersal fish	Cochlodinium polykrikoides
January, 2009	Oman (Sur fishing harbour; Masirah fishing harbour; Al-Ashkarah, along Al-Sharkyah coast	Sardines	Cochlodinium polykrikoides
January, 2009	Oman (Shoymiah in Dhofar coast)	Demersal fish	Cochlodinium polykrikoides
February, 2009	Oman (Masirah)	Sardines	Cochlodinium polykrikoides
March, 2009	Umm Al-Quwain shoreline (shoreline 27 km2; water 145 km2) and Ras Al-Khaimah, UAE	Fish (mostly demersal fish)	Cochlodinium polykrikoides
March, 2009	Oman (Hasek along Dhofar coast-10T; Al-Shqarah along Al-Sharkyah coast)	Demersal fish	Cochlodinium polykrikoides
April, 2009	Oman (Dukum along Al Wasta coast; Sohar along Batinah coast)	Demersal fish	Cochlodinium polykrikoides
April, 2009	Oman (Sohar and Saham along Batinah coast)	Shellfish	Cochlodinium polykrikoides
February 2013	Oman (Sea of Oman)	Fish	Noctiluca scintallans
February 2013	Oman (Arabian Sea)	Fish	Trichodesminum sp.

FIGURE 6 **THE REPORTED HARMFUL ALGAL BLOOMS (HABS) IN THE RED SEA.**



Ost: Ostreopsis sp.; HA: H. akashiwo; KF: K. foliaceum; TE: T. erythraeum; NS: N. scintillans/miliaris.

2012). Phytoplankton investigations began with the observations of recurrent red tides in the Egyptian Harbors of Alexandria since 1966. The red tide was caused by Alexandrium minutum. Micromonas pusilla, which formed a heavy green tide accompanied by a bloom of Peridinium quinquecoine, caused the most important bloom. Although there was no death amongst fish or invertebrates, these blooms may cause economic loss to the local tourisms. The spread of potentially harmful phytoplankton in the Morocco coastal lagoon was limited to the availability of nutrients, where excessive level of nutrients appeared as inhabiting for the spread of HAB (Doudi et al., 2012).

HAB incidents occur throughout the year in different regions of the Red Sea (Gokul, et al., 2019). The reported species include, but are not limited to, dinoflagellates (Kryptoperidinium foliaceum, Noctiluca scintillans/miliaris, Ostreopsis sp., Cochlodinium polykrikoides), cyanobacteria (Trichodesmium erythraeum) and raphidophytes (Heterosigma akashiwo). These species have been occasionally associated with severe fish mortality over the last two decades. Figure 6 and Table 6 represent the recorded HAB incidents along the Red Sea (Gokul et al., 2019).

A. Health Impact of HABs in the Arab Region

None of the studies related to HAB have investigated their direct human health impact. Most studies either deal with HAB incidents or the impacts to the marine environment, including fish death. Table 7 summarizes the syndromes as well as their producer species, symptoms and treatment in the Arab region.

Lower diversity in the ecosystem adjacent to a desalination plant triggers HAB occurrence (i.e. higher cell numbers and higher biomass) due to the high salinity and high temperature of effluent (Gomaa et al., 2018). Higher temperature and salinity from the plant effluent decreases diversity and increases biomass, promoting a water bloom possibility. Reverse osmosis (RO) desalination plants are considered more vulnerable to HAB incidents since RO techniques can remove toxins from seawater (Boerlage and Nada, 2015). However, health risk from low level HAB toxins in the distilled drinking water produced by multi-stage flash distillation, multiple effect distillation or seawater reverse osmosis methods would not be enough to cause risk to human health (Gomaa et al., 2108).

In addition to the direct human impacts that may be caused by HABs, associated economic impacts affect human wellbeing, including:

- The Cochlodinium polykrikoides HAB off Fujairah in 2008 caused the shutdown of the hybrid plant at a cost of USD100,000 per day (Abu Dhabi Water Resources Master Plan, 2009)

TABLE 6 HAB INCIDENTS ALONG THE RED SEA

Country	Location	Date of Occurrence	Causative Organisms
Yeman	Al Salif	May 2013	K. foliaceum (binucleate dinoflagellate)
Yemen	Al Hodeidah	March 2009	N. scintillans/miliaris (heterotrophic dinoflagellate)
KSA	Al Shouqyq	May 2010	H. akashiwo and Ostreopsis sp
KSA	Thuwat	February 2012	H. akashiwo (raphidophytes) and Ostreopsis sp (dinoflagellate)
Yemen	Southern Red Sea	December 2012	T. erythraeum (toxic cyanobacteria)

Source: Data from Gokul et al., 2019.

- The Ghaleelah plant in Ras Al-Kheimah was shut down in March 2009 resulting in water shortages and electricity shutdowns for several days (Al Shehhi et al., 2014)

- The toxic dinoflagellates K. selliformis and P. rhathymumthat between September and October 1999 caused significant mortality of wild and aquacultured fish in the Kuwait Bay with an estimated economic loss of USD7 million (Al-Yamani et al., 2012)

V. MICROBIAL POLLUTION

The marine ecosystem provides a natural habitat for a range of microbial pathogens such as bacteria, viruses and parasites and poses threats to humans by contaminating seafood, drinking water and swimming areas. Seafood contamination from areas affected by microbial pollution, and swimming in these areas, can result in hepatitis, gastrointestinal disorders, and infections. There are several sources of bacterial contamination in coastal waters such as leaking septic tanks, poorly maintained sewage treatment plants, discharges from boats, and runoff from the land during heavy rainstorms.

Based on microbial pollution of coastal areas, the Arab countries can be divided into three categories based on their wastewater disposal practices (Shomar, 2013):

1. In Bahrain, Saudi Arabia, Oman, Qatar, Kuwait and the United Arab Emirates a high percentage of wastewater is treated and reused to irrigate agricultural lands or landscape areas, while the remainder is

TABLE 7 THE SYNDROMES ASSOCIATED WITH HABS AND THEIR PRODUCER SPECIES, SYMPTOMS AND TREATMENT

	Paralytic shellfish poisoning (PSP)	Neurotoxic shellfish poisoning (NSP)	Amnesic shellfish poisoning (ASP)	Diarrhetic shellfish poisoning (DSP)	Ciguatera fish poisoning (CFP)
Causative organismô	DINOPHYCEAE Alexandrium catenella A. leei A. minutum A. pseudogonyaulax A. tamarense A. tamiyavanichii Gymnodinium catenatum Pyrodinium bahamense	DINOPHYCEAE Karenia mikimotoi K. papilionacea K. selliformis K. Steidinger Chattonella marina Heterosigma akashiwo CYANOPHYCEAE Trichodesmium erythraeum	BACILLARIOPHYCEAE Amphora coffeaeformis Pseudonitzschia pungens Pseudonitzschia delicatissima	DINOPHYCEAE Dinophysis acuminata D. acuta D. caudata Saville-Kent D. miles Cleve D. norvegica D. tripos Phalacroma mitra P. rapa] P. rotundatum Prorocentru lima	DINOPHYCEAE Ostreopsis ovata O. cf siamensis Prorocentrum concavum
Symptoms in mild case	Within 30 min: tingling sensation or numbness around lips, gradually spreading to face and neck; prickly sensation in fingertips and toes; headache, dizziness, nausea, vomiting, diarrhea.	After 3–6 h: chills, headache, diarrhea; muscle weakness, muscle and joint pain; nausea and vomiting, paraesthesia; altered perception of hot and cold, difficulty in breathing, double vision, trouble in talking and swallowing.	After 3–5 h: nausea, vomiting, diarrhea, abdominal cramps.	After 30 min to a few hours (seldom more than 12 h): diarrhea, nausea, vomiting, abdominal pain.	Symptoms develop within 12–24 h of eating fish. Gastrointestinal symp- toms: diarrhea, abdominal pain, nausea, vomiting.
Symptoms in extreme case	Muscular paralysis; pronounced respiratory difficulty; choking sensation; death through respiratory paralysis may occur within 2–24 h after ingestion.		Decreased reaction to deep pain; dizziness, hallucinations, confusion; short-term memory loss; seizures	Chronic exposure may promote tumor formation in the digestive sys- tem.	Neurological symptoms: numbness and tingling of hands and feet; cold objects feel hot to touch; difficulty in balance; low heart rate and blood pressure; rashes. In extreme cases, death through respiratory failure.
Treatment	Paralytic shellfish poisoning (PSP)		At this point, the treatment of ASP is symptomatic.	Recovery after 3 days, irrespective of medical treatment	No antitoxin or specific treatment is available. Neurological symptoms may last for months or years. Calcium and mannitol may help relieve symptoms.

* Data of the Causative Organism from Al-Yamani et al., 2012

Source: modified after Ferrante et al., 2013.

TABLE 8 **TOTAL COUNTS (CFU/100 ML) OF COLIFORM, E. COLI, FECAL COLIFORM AND FEACAL STREPTOCOCCI IN DIFFERENT ARAB COUNTRIES**

Country	Total coliform (CFU/100 ml)	E. coli (CFU/100 ml)	Fecal coliform (CFU/100 ml)	Fecal Streptococci (CFU/100 ml)	Reference
KSA	10000	ND	7200	ND	ROMPE, 2013
Bahrain	653	ND	ND	ND	Bin Thani, 2018
Kuwait	--	68 – 974,962	144-128,801	83-42,688	Lyons et al., 2015
UAE	2590	ND	845	35	Rajan, 2018
Oman	2370	ND	ND	ND	ROMPE, 2013
Iraq	4856	854	ND	ND	Al-Haidarey et al., 2010
Lebanon	10500	ND	2100	100	Kadi, 2018
Libya	ND	ND	1100	ND	Kamizoulis, 2014
Morocco	ND	2000	ND	100	Kamizoulis, 2014
Morocco	127.05	--	39.6	15.2	Lamine et al., 2019
Egypt	36627	12502	ND	7698	Kamizoulis, 2014
Tunisia	500	0	100	100	Kamizoulis, 2014

discharged into the sea or open areas after advanced treatment.

2. Egypt, Morocco, Jordan, Iraq, and Syria follow moderate regulations for the disposal and reuse of treated wastewater, which does not meet national or international standards.

3. In Palestine, Yemen, and Lebanon a large fraction of wastewater effluents is disposed in the sea and open areas.

Microbiological measurements are indicators of sewage pollution in the marine environment. Sewage treatment plants exist in all Arab countries, but the level of treatment varies and the capacity is not sufficient to deal with the existing loads. In the Gaza Strip (OPT), around 60 percent of sewage effluents are treated and the remaining 40 percent are discharged to the sea without treatment due to the limited capacity of wastewater treatment plants. In Lebanon, sewage is discharged into the marine

BOX 4

MISHREF PUMPING STATION FAILURE

An unprecedented increase in anthropogenic activities resulted in insufficient capacity to treat the domestic wastewater generated by a rapidly increasing population in Kuwait. A significant portion of the untreated domestic wastewater was regularly released into the coastal areas. However, with the commissioning of the Sulaibia wastewater treatment plant in 2004 there was adequate capacity to treat all of the domestic wastewater. The sewage is normally pumped through Mishref station to a major station at Ardiya before going to Sulaibiya treatment plant, where dangerous chemicals are removed from the water before it is pumped into the sea. On 24 August 2009, the Mishref Sewage Pumping Station stopped operation due to a cascading series of equipment failures leading to 13 pumps breaking down. This major pumping station failure resulted in large quantities (about 180,000–200,000 m3 day−1) of untreated domestic sewage being released to the coastal area for several months, leading to a ban on swimming and fishing in the area and causing a bad odor in many parts of the city. The total financial losses were estimated at KWD21 million. The coastal areas receiving untreated wastewater were heavily contaminated with sewage. Sterol ratios based assessment resulted in categorization of some of the sites as "grossly contaminated", while most of the sites were "highly contaminated"

Sources: Saeed et al., 2012 & 2015

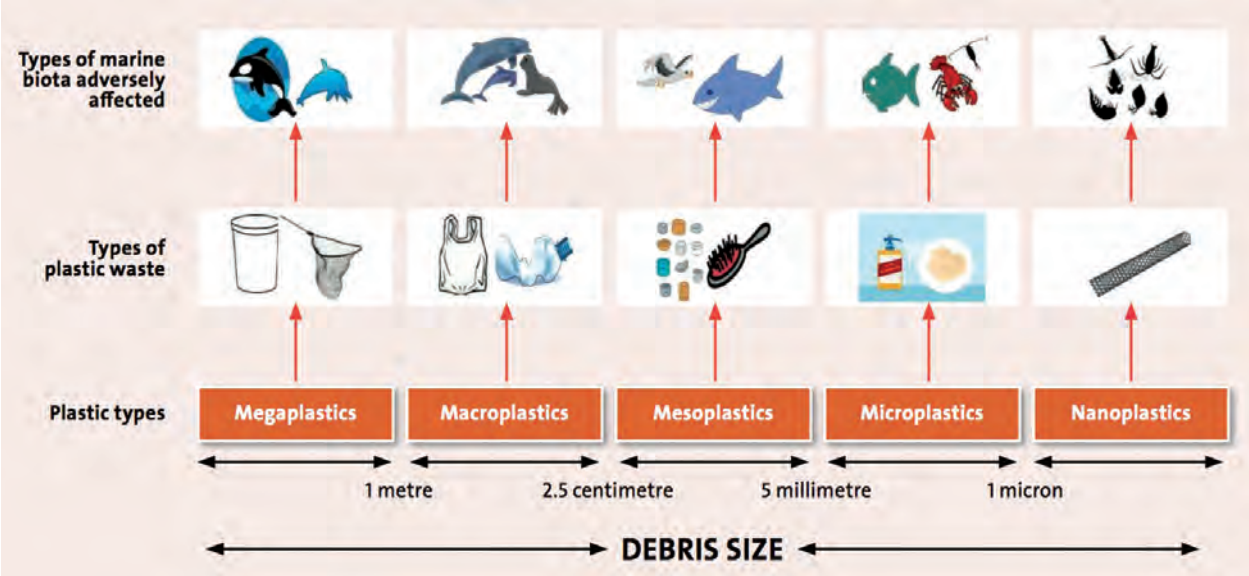
environment without primary treatment, hence, several beaches, especially in Beirut and Tripoli, were reported to be unsafe for swimming. In fact, the coastal area of Lebanon is exposed to a number of chronic anthropogenic stress factors from untreated sewage and industrial effluents, which can lead to high levels of organic pollutants and human pathogens in many locations. Table 8 represents some results of bacteriological surveys in some of the Arab States.

VI. MARINE MICROPLASTICS

Microplastics are pieces of plastic smaller than 5 millimeters that are easily ingested by marine life due to their small size. They can block or injure an animal's digestive tract and have toxic effects when hazardous components leach into the surrounding tissues. On the basis of origin, microplastics are categorized in two types: primary and secondary microplastic (Figure 7). Nanoplastics are plastic fragments with < 1 µm size, and all these microplastics and nanoplastics have potential implications for the bioamplification and bioaccumulation of various chemicals and pollutants due to their large surface to volume ratio. Table 9 summarizes the results of some studies regarding the microplastic (MP) contents in sediments, water and biota. It is important to mention that some study express the level of MPs in terms of volume, while others in terms of area (surface distribution).

The Mediterranean Sea is considered one of the most affected regions of the world with regard to macro- and microplastic pollution (Cozar et al., 2015; Hal et al., 2017; Kazour et al., 2019) with the highest amounts of municipal solid waste generated annually per person (208-760 kg/year) (CIESM 2014; Zambianchi et al., 2017). A total

FIGURE 7 DIAGRAMMATIC REPRESENTATION OF DIFFERENT TYPES OF PLASTICS AND THEIR EFFECT ON MARINE ORGANISMS



Source: Chatterjee and Sharma, 2019

TABLE 9 **MICROPLASTICS FOUND IN SEDIMENT, WATER AND BIOTA**

Country	Water	Sediment	Biota		Reference
			Concentration	Biota/Species	
Lebanon	6.7 MPs/m^3 (Volume)	4.68 MPs/g (Volume)	2.8 ± 1.9 (MPs/ Individual) 8.3 ± 4.6 (MPs/ Individual)	European Anchovy Spiny Oyster	Kazour et al., 2019
Tunisia	141.20 - 461.25 items kg^{-1} dry weight	1.6 – 4.6 MPs/g (volume)	703.95 -1482.82 items kg^{-1} wet weight	Molluscs	Abidli, et al., 2018 & 2019; Chouchene, et al., 2019
UAE		1000 – 60000 Pellets/m^2 (Surface distribution)			Khordagui et al., 1994
Qatar		0.71 MPs / m^3 (Volume)			Castillo et al., 2016
UAE	1000–60,000 pellets per m^2				Khordagui et al., 1994
Oman	50 - 200 pellets per m^2				Khordagui et al., 1994
Kuwait			1.57 mm (Size of MP)	Acanthopagrus latus/Sparidae (Fish)	Al Salam et al., 2020
			0.96 mm (Size of MP)	Eleutheronemaa tetradactylum/ Polynemidae (Fish)	
			0.96 mm (Size of MP)	Lutjanus quinquelineatus/ Lutjanidae (Fish)	
KSA	58,563 ±19,272 items/Km^2				Martin et al., 2019
Qatari coastal waters	4.38 × 104 and 1.46 × 106 particles km^{-2}	36 and 228 particles m^{-2}			Abayomi et al., 2017
Intertidal area, the Arabian Gulf		36 and 228 particles m^{-2}			Abayomi, et al., 2017
the length of the Arabian Gulf		1.5×10^3 PE particle km^{-2} 4.6×10^4 PP particle km^{-2}			Kor and Mehdinia, 2020
Egypt	24,200 fragments m^{-3}	242 fragment kg^{-1}			Shabaka et al., 2019

European anchovy = Engraulis encrasicolus, Spiny oysters = Spondylus spinosus
PE = Polyethylene, PP = Polypropylene

of 6.6 million tons of plastic waste is mismanaged yearly around the Mediterranean, although there is a large variation in the proportion of national waste countries mismanage (Table 10) (WorldWide Fund for Nature, 2019).

In principle, the Mediterranean Basin seems very vulnerable to possible accumulation of floating debris, since its dynamic is characterized by an inward surface flow of water from the Atlantic hampering surface floating items from being flushed out. This circulation pattern impacts the Arab countries located on the southern Mediterranean Sea. Few studies on microplastic (MP) pollution have been conducted in the southern and eastern part of the Mediterranean Basin. In Lebanon, the occurrence of MPs in the biota was detected in 83.4 and 86.3 percent in anchovies and spiny oysters, respectively. Screening of MP contents in water and sediments

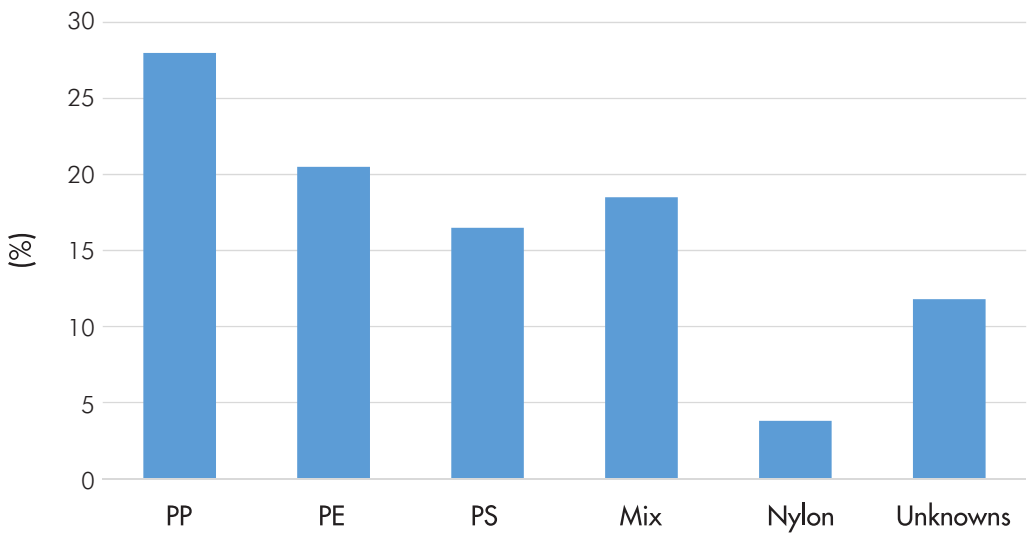
TABLE 10 PLASTIC GENERATION AND MISMANAGED WASTE IN SOME ARAB COUNTRIES

		Plastic Production	Plastic Waste Generation	Controlled Waste Treatment	Mismanaged Waste	Plastic Leakage Into Sea
Regional Total (MT)		37.81	23.97	17.45	6.57	0.57
contribution to regional total	Egypt	10.2%	12.6%	1.1%	43.1%	0.25 MT
	Morocco	1.9%	2.3%	1.2%	5.2%	0.01 MT
	Tunisia	0.8%	1.0%	0.9%	1.4%	0.01 MT

from the Eastern Harbor in Egypt revealed the presence of ten polymers in seawater and shoreline sediments (Shabaka, et al., 2019). Most of the extracted microplastics are secondary microplastics, as they appear to be remnants of larger plastic fragments. Most polymers detected in the Eastern Harbor are widely used in food packaging, plastic bottles and plastic bags.

Within the ROPME Sea Area the distribution and composition of litter accumulating in the marine environment is poorly understood, with only a limited number of available peer-reviewed reports (Lyons, et al., 2020). A study related to marine littering in the RSA dates back to 1989 when Shiber (1989) documented the presence of industrial plastic pellets along the shorelines of Kuwait. Very few MPs were found in the coastal and beach areas of Kuwait (Saeed et al., 2020). In biota, only three pieces of plastics were recovered from gastrointestinal tracks of hamour fish. It appeared that the microplastic levels in sediment, water and biota were much lower compared to published values from adjoining areas, although they were comparable to the absolute numbers of particles from Qatar and Oman. The dominant type of MPs was polypropylene (PP), polyethylene (PE) and polystyrene (PS), which are the commonly used polymers for the production of disposable and single use products (Figure 8). Relatively low counts of MPs were observed in all the matrixes including the beach

FIGURE 8 TYPES OF MICROPLASTICS IN KUWAIT (DATA FROM SAEED ET AL., 2020)



BOX 5

REGIONAL PROGRAMME OF ACTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT FROM LAND-BASED ACTIVITIES IN THE RED SEA AND GULF OF ADEN (RPA/LBA)

PERSGA has taken the initiative to put together the "Preparatory and Fund Raising Phase" for the RPA/LBA. This initiative came about through coordination and with financial support from UNEP/GPA Coordination Office and the UNEP Regional Seas Programme. Two integrated key documents were produced. The first document presented the "Road Map" for the Preparatory and Fund Raising Phase, while the second one detailed the "Project Portfolio". Management of marine litter in the PERSGA region is one of the proposed projects. This regional action plan for the sustainable management of marine litter has been prepared within the above-mentioned framework.

Source: PERSGA/UNEP, 2018

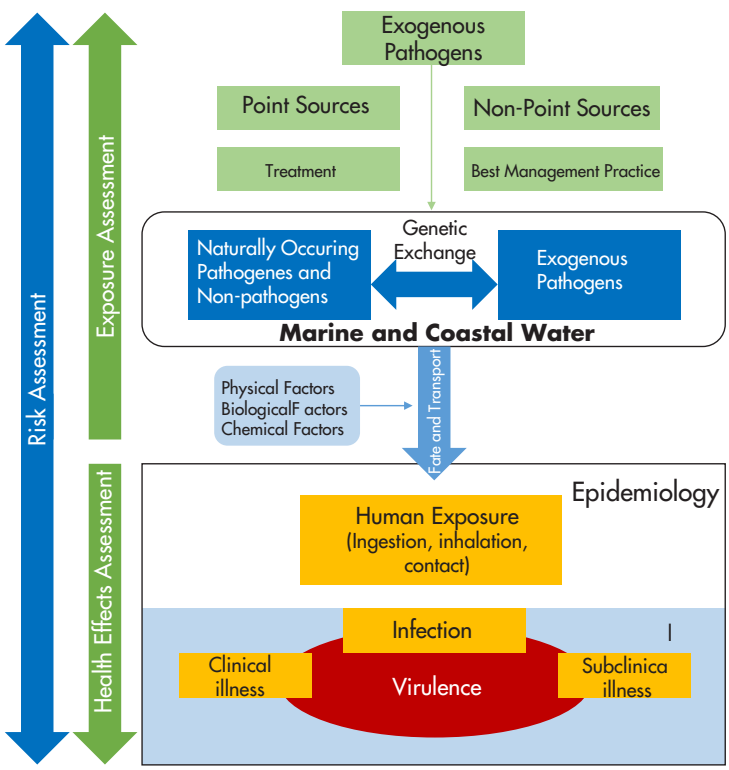
sediments and seawater. In general, the number of MPs found in the gastro-intestinal track of fish and mussels was very low.

It is also known that MPs can act as vectors for organic and inorganic pollutants in aquatic environments, posing a potential toxicological threat to wildlife and humans as they enter marine food webs (UNEP, 2016). However, the full extent of the risk posed by ingesting plastic contaminated seafood is yet to be determined (GESAMP, 2015). Studies in the ROPME Sea Area have also highlighted this risk, with work identifying MPs and their potential for marine food chain accumulation in fish and crustacean species (Lyons, et al., 2020). Three MP particles were detected within the guts of Acanthopagrus latus, Eleutheronemaa tetradactylum and Lutjanus quinquelineatus (Al Salem et al., 2020). Based on the nature and behavior of these particular – fish types that prefer to stay in muddy waters and sheltered lagoons – it is suspected that common primary sources of MP (i.e. waste fragmentation) have led to the passive/active intake (e.g. detritus ingestion) of these particles by species of fish in Kuwait.

The Red Sea holds one of the lowest concentrations of floating plastic worldwide and no evident congregation zones were identified so far, despite peculiar oceanographic features that render the basin an accumulation area for floating debris (PERSGA, 2018) . Marti et al., (2017) studied the floating plastic debris along the Arabian coast of the Red Sea. Plastic debris, dominated by millimeter-sized pieces, was constituted mostly of fragments of rigid objects (73 percent). Other studies have shown that the amount of plastic material in the Red Sea is less than in some other regional seas.

Baalkhuyur et al., (2018) studied the microplastic in the gastrointestinal tract of fish along the eastern coast of the Red Sea, representing different range of sizes and habitats (demersal, coral reef, seagrass,

FIGURE 9 RELATIONSHIP BETWEEN PATHOGENS, THE ENVIRONMENT AND HUMAN HEALTH



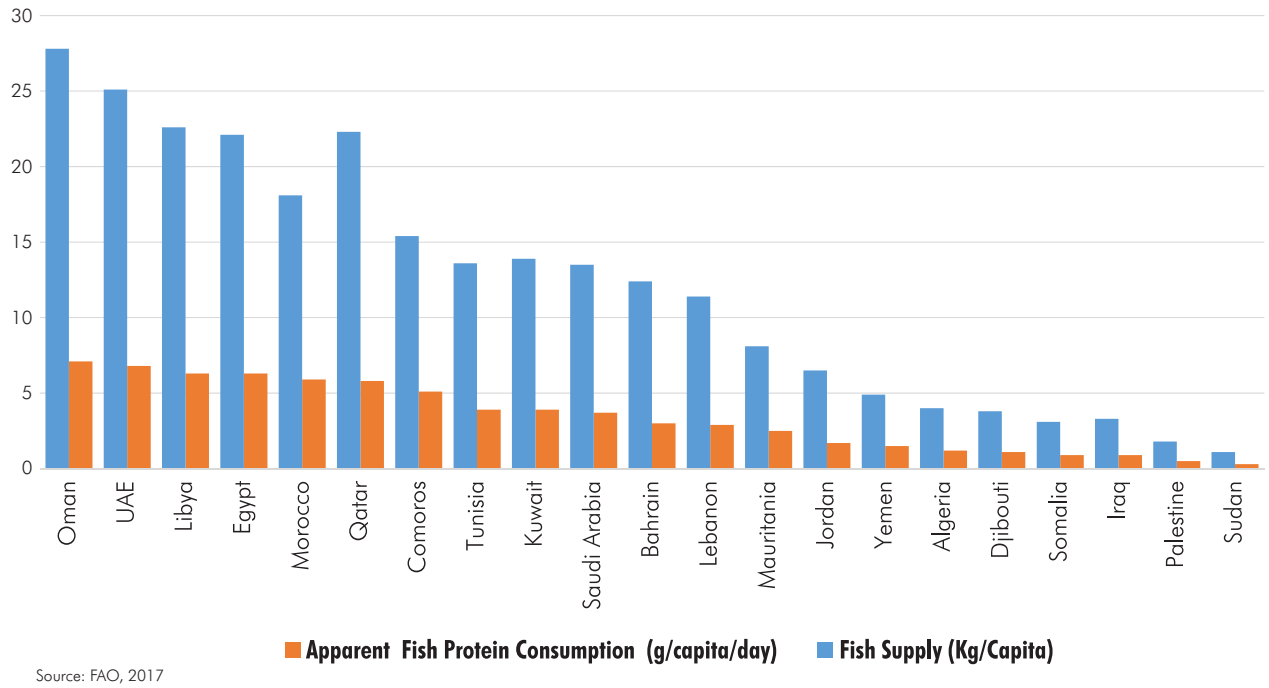
Source: modified after Stewart, 2008

TABLE 11 METAL CONCENTRATIONS IN THE MUSCLES OF SOME COMMON FISH IN DIFFERENT ARAB STATES

Location		Species	metal		
			Cu	Zn	Pb
RSGA/Egypt	Shalateen	Epinephelus sp	0.29 ± 0.05	2.42 ± 0.22	0.88 ± 0.12
		Caranx sp.	0.36 ± 0.02	2.88 ± 0.11	0.28 ± 0.05
		Sargocentron spiniferum	0.24 ± 0.04	2.43 ± 0.22	0.28 ± 0.07
RSGA/Egypt	Hurghada	Epinephelus sp	0.21 ± 0.07	3.00 ± 0.43	0.45 ± 0.09
		Caranx sp.	0.46 ± 0.01	4.94 ± 2.52	0.25 ± 0.10
		Scarus gibbus	0.37 ± 0.01	2.07 ± 0.09	0.24 ± 0.03
		Sardinella sp.	0.63 ± 0.10	6.49 ± 1.83	0.25 ± 0.08
RSGA/Egypt	Suez	Epinephelus sp.	0.23 ± 0.01	3.98 ± 0.61	0.43 ± 0.05
		Synodus sp.	0.17 ± 0.02	3.71 ± 0.10	0.28 ± 0.09
		Sardinella sp.	0.74 ± 0.28	8.23 ± 1.88	0.50 ± 0.43
RSGA	Red Sea	Epinephelus sp	0.66	3.37	0.53
RSGA/Egypt	Gulf of Aqaba	Epinephelus fasciatusb	0.97	9.13	4.80
RSGA/Egypt	Hurghada	Nemipterus japonicusa	0.28	2.13	0.33
KSA	Arabian Gulf	Epinephelus areolatus	1.62±0.48	27.20±6.24	4.87±1.15
		Plectropomus maculatus	5.12±1.28	166.50±25.5	0.62±0.15
KSA	Red Sea	Epinephelus areolatus	2.64±0.52	62.58±12.31	6.13±1.02
		Plectropomus maculatus	2.50±0.62	49.00±14.60	1.39±0.25
MS/Egypt	Alexandria	Siganus rivulatusb	1.59	7.95	0.73
MS/Tunisia	Sidi Mansour/ Safx	Diphodus annularis			
		Sepia officinalis			
		Sepia salpa			
	Kerkennah/Safx	Diphodus annularis			
		Sepia officinalis			
		Sepia salpa			
(MPL) (μg/g wet wt.) WHO 1989			30	100	2

metal						Reference
Cd	Fe	Mn	As	Ni	Hg	
0.12 ± 0.02	3.35 ± 0.79	0.15 ± 0.04				El-Moselhy, 2014
0.07 ± 0.01	7.12 ± 0.74	0.16 ± 0.02				
0.06 ± 0.02	5.48 ± 1.94	0.20 ± 0.08				
0.05 ± 0.01	2.96 ± 0.38	0.17 ± 0.04				
0.05 ± 0.02	9.53 ± 2.77	0.13 ± 0.03				
0.03 ± 0.004	3.04 ± 0.48	0.16 ± 0.02				
0.07 ± 0.01	11.53 ± 1.68	0.29 ± 0.05				
0.20 ± 0.06	2.54 ± 1.29	0.16 ± 0.01				
0.04 ± 0.01	1.61 ± 0.54	0.23 ± 0.03				
0.38 ± 0.29	10.92 ± 4.11	0.93 ± 0.19				
0.17						Emara et al., 1993
0.97	5.93	1.63				Abu Hilal and Ismail, 2008
0.02	6.31					El-Moselhy, 1996
		0.25±0.07	4.24±1.35	1.00±0.09		Kamal et al., 2015
0.75±0.14		0.87±0.11	21.70±5.61	4.24±0.87		
0.13±0.03		0.81±0.08	33.18±7.54	0.61±0.09		
0.06±0.01		1.00±0.11	36.75±7.38	1.25±0.32		
0.25	37.53	0.54				Khaled, 2014
					1.1 ± 0.41	Chaari and Chaffai, 2011
					0.08 ± 0.01	
					0.55 ± 0.23	
					0.6 ± 0.31	
					0.04 ± 0.02	
					0.43 ± 0.12	
1	100	1				Mokhtar, 2009

FIGURE 10 AVERAGE PER CAPITA SEAFOOD CONSUMPTION FOR THE ARAB STATES (PER CAPITA SUPPLY: ESTIMATE OF THE TOTAL SUPPLY AVAILABLE FOR THE POPULATION TOTAL



Source: FAO, 2017

and mesopelagic). Microplastic fragments were found in 14.6 percent of the fish examined, with an average prevalence of plastic fragments within each species of 14.4 percent. The highest number of ingested microplastics per individual was observed in Parascolopsis eriomma, a species feeding on benthic invertebrates in muddy and sandy offshore sediments.

Developing national and regional actions plans to tackle the threat of marine litter should be a priority for Arab states (Box 5). Several Arab countries such Egypt and UAE have launched single-use plastic bags reduction initiatives. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) has developed one such plan (PERSGA/UNEP, 2008) by establishing strategies, objectives and priority actions based on an assessment of coastal and marine litter in the PERSGA region (PERSGA/UNEP, 2018). Lyons et al., (2020) suggest a proposed framework that would act as a basis for developing a regional action plan suitable for the ROPME Sea Area. The framework covers objectives and associated actions under the themes of governance, research and monitoring, awareness and education and legal frameworks.

The potential ecological and human health risks of microplastics are relatively new areas of research, and there is currently a large degree of uncertainty surrounding this issue (GESAMP 2015). The accumulation of microplastics in the food chain, especially in fish and shellfish species of molluscs, crustaceans and echinoderms, could have consequences for the health of human consumers. The understanding of the fate and toxicity of microplastics in humans constitutes a major knowledge gap that deserves special attention.

VII. INTER-LINKAGE BETWEEN HUMAN HEALTH AND DIFFERENT SOURCES OF POLLUTION

There is a growing need for more awareness concerning the relationship between the healthy environment and human health. Global Environment 6, entitled Healthy Planet, Healthy People, emphasizes that a healthy planet is a necessary foundation for humans' physical, psychological, social, economic and emotional health and well-being, and is therefore critical for achieving all the SDGs (UN Environment, 2019). In fact, the human activities in the oceans have

TABLE 12 **CONCENTRATION (μG/G WET WEIGHT) OF HEAVY METALS FOUND IN MOLLUSCS, BIVALVES AND CRUSTACEANS**

Country	Area	Species	Metals				Reference	Exceed limits
			Pb	Cd	Hg	As		
UAE	Jebel Ali	Pinna muricata*	1.23	10.7	0.20	153	Mora et al., 2004	Cd, As
	Abu Dhabi	Pintada radiate*	2.29	2.73	0.09	30.6	Mora et al., 2004	As
Kuwait	Kuwait Bay	Amiantis umbonella	2.5 45.3±	34.7±1.7	0.9 ± 1.5		Tarique et al., 2012	
KSA	Tarut Bay	Meretrix meretrix	2.49±0.27	0.90±0.03			Alyahya et al., 2011	
Oman	Al Batinah	Liochoncha ornata	0.13	3.92	0.034		Al-Busaidi, et (al., 2013	Cd
Oman	Dhofar	Sacostrea cucculata	0.03 0.011±	3.31±1.14	0.017±0.008		Yesudhason, et al., 2013	Cd
Bahrain	BAPCO	Portunus pelagicus[3]	0.035±0.0175	0.0575±0.0315	0.035±0.0175		Musaiger & Al-Rumaidh, 2005	
Qatar	Ras al Nouf	Circentia callipyga*	1.45	1.17	0.315	156	Mora et al., 2004	Cd, As

* per dry weight; (1)– reference site; (2) - contaminated site; 3 – mg/ 100 g

serious social and economic implications, which directly and indirectly affect human health and well-being (UN Environment, 2019). Human pressures on the coastal and marine environment in the Arab region have continued to increase over the last decade, in concert with the growing human population and the expanded use of marine resources. Research relating marine and coastal environment with human health is addressing issues at different levels of examination (Figure 9).

A. Marine Pollution and Seafood Consumption

Seafood is the one of the highest sources of income in most of the Arab countries. Many studies have evaluated the concentration of pollution (metals and hydrocarbon) in oysters, clams, shell, carbs and commercial fishes. Since fish are at the top of the food chain, their contamination level (i.e. metal concentration) can be high due to their effect on the bioaccumulation affecting human health. Fish contamination depends on the sources of contaminations and the ability of fish to accumulate such compounds (Bolana et al., 2014). Toxic effects of metal consumption by humans depend upon the dose ingested, a function of the amount of seafood consumed, and the concentration of metals present (Davidson et al., 2011).

The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of Omega-3 fatty acid. The Arab states, especially the GCC (Gulf Cooperation Council) region (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE), have documented a substantial rise in per capita seafood consumption. The average per capita consumption in the Arab region in 2015 was 12.3 kg per year. In Oman and the United Arab Emirates, seafood consumption is one of the highest worldwide, estimated at 27.8 and 25.1 kg per year, respectively. Other countries in the region, such as in Libya, Qatar and Egypt, also have high seafood consumption at 22.6 and 22.5 and 22.1 kg per year, respectively (Figure 10).

TABLE 13 ESTIMATED WEEKLY INTAKE (EWI) FOR COMMERCIAL FISH IN SOME ARAB COUNTRIES

Country	Area	Species	Pb	Cd	Hg	As	Cu
UAE	Dubai	Lethrinus lentjan	2,19	93,245	27,425	844,690	
	Sharjah		2,74	71,305	37,298	460,192	
KSA	Wadi Hanifah	Several	119,472	13,984		176,85	
Oman	Saqar	Scomberomorus commerson	85,70	20,035	37,262		
		Cheimerius nufar	108,10	5,449	50,967		
		Seriola dumerili		6,715	55,921		
	Mina Al Fahal	Epinephelus coioides	22,93	5,733			
Bahrain	Fasht Al Dahm	Epinephelus coioides	1,51	0,054	36,098	777,000	
Qatar	Al Khwar	Epinephelus coioides	11,06	1,272	101,790	303,413	
Palestine OT	Gaza	M. cephalus	10,171				27,013
		M. furnieri	3,171	5,446			71,015
FAO/WHO	PTWI[70]		1,750	490	350	1,050	245,000
	PTWI[60]		1,500	420	300	900	210,000

EWI of Pb, Cd, Hg and As from fish muscles in μg/ per capita
PTWI70 = Permissible Tolerable Weekly Intake (μg/week/70 kg person)
PTWI60 = Permissible Tolerable Weekly Intake (μg/week/60 kg person)

In the Red Sea, most fish have a lower concentration of heavy metals in their muscles, higher concentrations in their liver and gills (El Moselhy et al., 2014). Many studies attributed high metals accumulation to the feeding habit of the fish, meaning that benthic fish are likely to have higher heavy metals concentrations than fish inhabiting the upper water column. It is well known that muscles are not an active site for metals biotransformation and accumulation, but in polluted aquatic habitat, the concentration of metals in fish muscles may exceed the permissible limits for human consumption and imply sever health threats.

Table 11 illustrates metal concentrations in the muscles of some common fish from different Arab states, while table 12 shows metals concentrations in molluscs, bivalves and crustaceans. With a few exceptions, the metal contents in the examined fish species along the coast of the Arab states fall within the maximum permissible limit (MPL) for human consumption. In fact, health risk analysis of heavy metals in the edible part of different commercial fish species in the RSA, RSGA and MS coast of the Arab countries are at a safe level for human consumption (El-Moselhy et al., 2014).

Most of the relevant studies conclude that heavy metals in fish tissues were within allowable concentrations and pose no threat to public health. However, some studies reported levels of metals that exceeded the permissible limits. Hotspots of heavy metal contamination were identified in localized areas influenced by oil pollution from refiners and intensive dredging or recreation activities. Therefore, regular monitoring of heavy metal levels in fish species seems necessary to prevent health risks and to ensure nutritional safety conditions.

Maximum Permissible Limit (MPL) of heavy metals in fish muscles (mg/g wet wt.)

Mn	Zn	Ni	Reference
			Kosanovic et al., 2007
			Mahboob et al., 2014
			Al-Busaidi et al., 2011
			Abdul-Wahab et al., 2013
			Mora et al., 2004
			Mora et al., 2004
82,257	38,332	2,506	Elnabris et al., 2013
173,236	84,175	3,456	
68,000	490,000	2,450	
58,000	420,000	2,100	

B. Exposure Assessment

Risk assessment of dietary fish and metal intake are customarily examined based on prolonged exposure and not based on one average meal. However, there is an increasing concern that one average meal of fish and seafood could severely affect our health. From the public health point of view, while some heavy metal concentrations in the analyzed seafood in many Arab states were well within the prescribed limits set by various authorities, others were not.

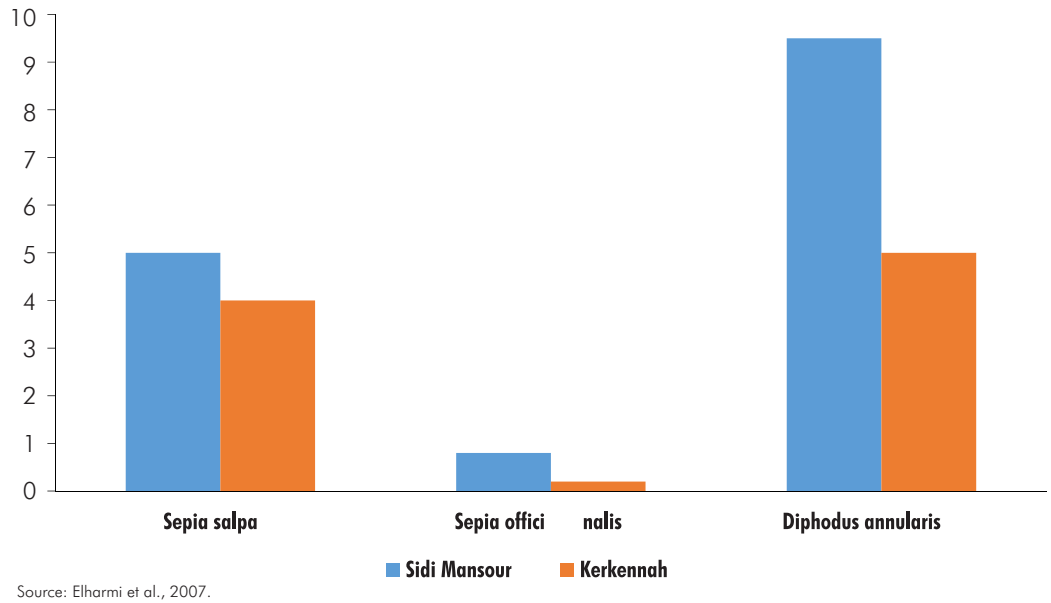
To assess the public health impact of metals in fish, it is essential to estimate the daily intake of metals by humans. This can be done by multiplying the average quantity of fish consumed per capita per day by the concentration of metal. That quantity is then calculated per week (Estimated Weekly Intake, EWI). All EWIs were obtained using the apparent consumption of fish and seafood for each country reported by FAO statistics. For the comparison of the EWI per capita with the PTWI (provisional tolerable weekly intake) for each metal, an average weight of 60/70 kg was used (JECFA, 2011). The EWIs for fish are presented in Table 13.

The target hazard quotient (THQ) is one of the parameters usually considered as a valid indicator of the extent of a population's exposure to an adverse health risk (Kamal, 2015). THQ with respect to heavy metals cadmium (Cd), lead (Pb) and arsenic (As) for fish from the Red Sea and Gulf of Aden are less than 1 for all exposure levels. This indicates that no risk is imposed due to the intake of these metals. Kamal et al. (2015) used lifetime cancer risk as another human health indicator. The cancer risk of arsenic in fish in the Red Sea and Gulf of Aden are higher than the threshold of 10-5 set by US-EPA for exposure frequency of all fish samples, except when consumed for one meal per day (Kamal et al., 2015).

Al-Saleh et al. (2011) reported the concentration of metals in maternal blood, cord blood and the placenta of healthy women admitted for delivery in a central hospital in Saudi Arabia. The authors questioned the participants on their consumption of seafood ("yes" or "no") and found significant influence of fish consumption on cadmium (Cd) and mercury (Hg) concentrations in the maternal blood as well as mercury in the placenta. Placental lead (Pb) levels were positively associated with maternal Hg levels. Elevated levels of metals are explained by the high consumption of fish, since levels were higher than in the non-fish eaters.

Mercury appears to be one of the most common persistent and toxic pollutants in the marine ecosystem. Due to its affinity for fatty animals' tissue, the methylalid form, especially monomethyl mercury, tends to bioaccumulate and bio-magnify more readily than other forms of mercury, leading to its biological amplification in the food chain. Mercury levels in toenails or hair provide the best biomarkers of chronic mercury exposure, given their slow growth (Mozaffarian & Rimm, 2006). An assessment of Hg in 100 hair samples from fishermen in Kuwait carried out in 2000 by Al-Majed and Preston found that 78 percent of them had Hg levels around twice that of the reference mean (Al-Majed & Preston, 2000b). These fishermen ate from between 1 to 3 meals of fish per day,

FIGURE 11 ESTIMATED DAILY INTAKE OF HG (μG/DAY) FOR RESIDENTS IN TUNISIA THROUGH DIFFERENT SPECIES



Source: Elharmi et al., 2007.

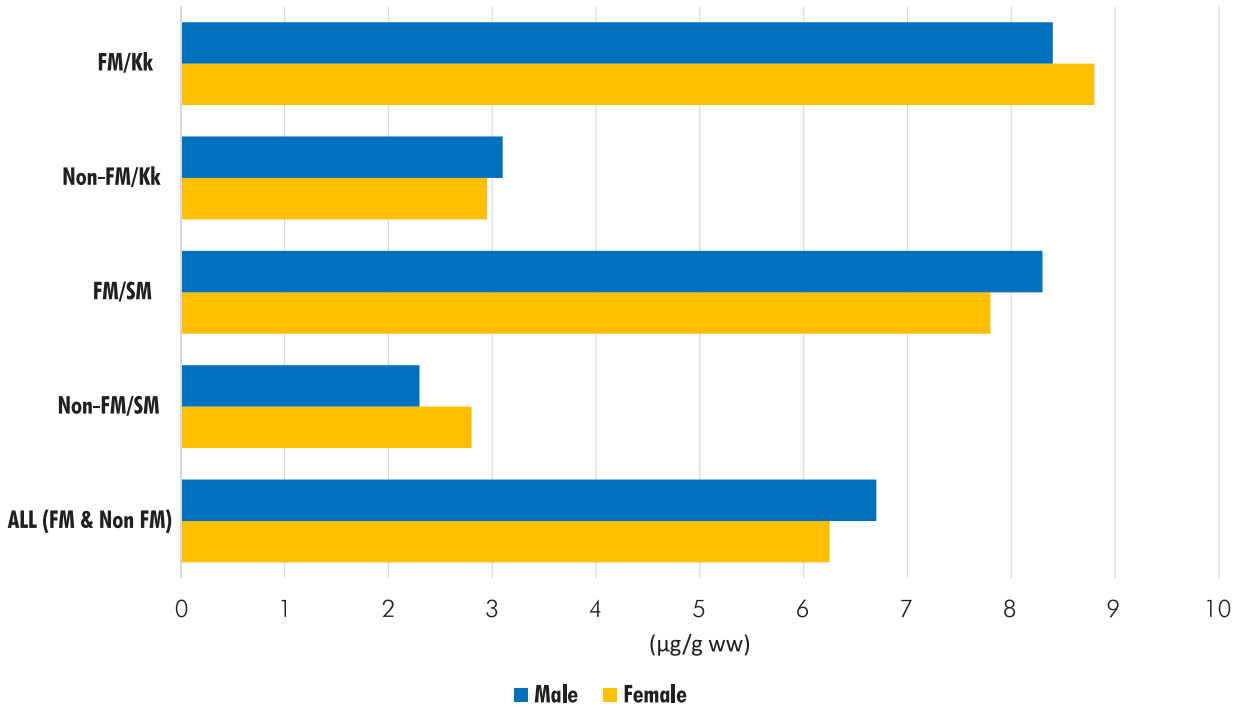
which is not the case for the general population but most likely is for the majority of fishermen throughout the Arab states.

Foodborne exposure to methyl-Hg was also found in the UAE (Davidson et al., 2012) by analyzing fruits, vegetables, fish and seafood consumption. It was found that of the total population enquired, 69 percent of the men and 31 percent of the women could be at risk of overexposure to methyl-Hg from eating seafood. However, they do not take into account the benefits of the consumption of seafood that may outweigh the risks (Davidson et al., 2012).

Total Hg concentration in the hair is a reliable marker of methylmercury exposure through fish consumption. In the Mediterranean coast of Morocco, assessment of Hg content in hair of 108 individuals indicated that nearly the entire population (96 percent) is fish consumers (Elhamri et al., 2007). 36 percent of the total studied population can be considered heavy consumers (3-5 times/week). The daily intake of Hg by residents (Figure 11) differs based on seafood and the level of their Hg contamination.

Heavy consumers such as fisherman have a high level of Hg in their hair compared to normal consumers

FIGURE 12 MERCURY CONCENTRATIONS (μG/G WET WEIGHT) IN HAIR OF RESIDENTS IN SAFX COASTS (FM = FRESHERMAN, KK = KERKENNAH SITE, SM = SIDI MANSOUR SITE)



Data from Mezghani-Chaari et al., 2011

(Mezghani-Chaari et al., 2011). However, there is no gender difference between either heavy or normal consumers of fish (Figure 12).

VIII. CONCLUSION AND RECOMMENDATIONS

Most research studying the marine environment and its impact on human health in the Arab region are dealing only with exposure assessment. Stressors on the marine environment include extensive coastal development, land-based sources of pollution, coastal and marine debris, and climate change. Land-based sources include the urban and industrial activities and the direct discharge of untreated or partially treated sewage into the immediate coastal zone. Oil pollution in the Arabian Gulf represents 4.7 percent of the total oil pollution in the world, however, only a relatively small number of compounds are well characterized for their toxicity. Arab countries produce about 13.2 billion cubic meters of wastewater a year and treat about 40 percent of it; they discharge the rest to open water channels, the sea or ground reservoirs, raising concerns for public health and the environment. On the other hand, most of the relevant studies conclude that heavy metals in seafood in the Arab States were within allowable concentrations and pose no threat to public health, with the exception of some contaminated hotspots.

Taking into consideration that the interaction between marine and coastal areas in the Arab region and human health are complex, research on the linkage between marine environment and human health must explore the direct impact on human health such as marine pollution, pathogens, toxin transfer to human and antimicrobial resistance, as well as the benefits of the marine environment to human health including its natural products such as antimicrobial drugs and antimicrobial-active marine bacteria. Specific targets of the Sustainable Development Goal covering life under water (SDG 14) are all relevant to human health and well-being. Achieving these targets requires improved governance and strengthened regional cooperation, ensuring sustainable management of shared marine resources.

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Impact of Climate Change on Human Health

Ahmed Gaber, Randah R. Hamadeh, Djihan Hassan, Hayam Elshirbiny

I. INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to long-term changes in weather conditions and patterns of extreme weather events with global wide-spread effects including impacts on environmental and human health. Environmental health impacts include the rise and fall in mean annual temperature, sea level rise and loss of biodiversity. Humans' vulnerability to the potential health impacts of climate change are divided into direct and indirect impacts. The direct impacts include cardiovascular diseases (CVD), respiratory diseases, heatstroke, injuries and fatalities. Indirect impacts include the spread of waterborne, foodborne and vector borne diseases, water and food insecurity, displacement and forced migration, and impacts on mental health and occupational health. Climate change also indirectly affects population health by impeding sustainable development and exacerbating poverty. Climate change and health are two of the greatest challenges facing the Sustainable Development Goals (SDGs) 2030 Agenda. SDG 3 aims to ensure healthy lives and promote well-being for all, and SDG 13 calls for taking urgent action to combat climate change and its impacts.

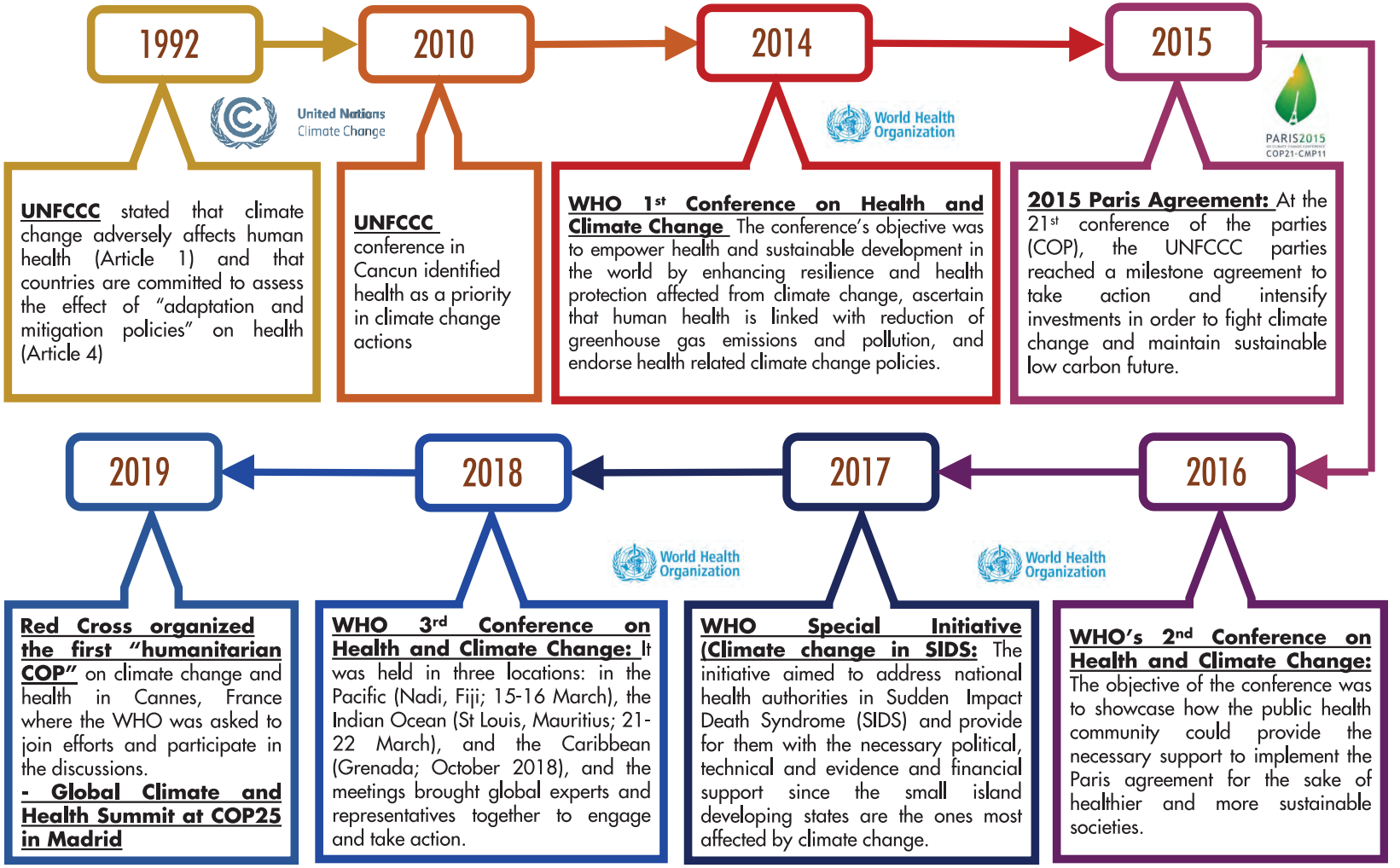
The 2015 Paris Agreement is a global climate treaty that will become a public health treaty as countries take action. The Agreement states that "the right to health" will be central to the actions that countries take. In addition to aiming to keep global warming below 2 degrees Celsius, the agreement commits countries to implement adaptation plans to protect human health from the worst impacts of climate change such as heat waves, floods and droughts, and the decline of water and food security. Moreover, the 24th Conference of the Parties (COP24) in 2018 issued a special report on health and climate change that highlighted the interconnection between the two and presented an overview of the tools and initiatives that can be used by the international public health community to support the implementation of the Paris Agreement. The document also presented recommendations for the United Nations Framework Convention on Climate Change (UNFCCC) to realise the benefits of addressing climate change and avoiding its worst health impacts. Figure 1 shows a timeline illustrating key global action milestones related to climate change and human health.

This chapter builds on the "Impacts of Climate Change: Vulnerability and Adaptation – Human Health" section in the 2009 AFED report (AFED, 2009) and seeks to update and present in more detail the impact of climate change on human health globally, and in the Arab world specifically. Moreover, it gives an update on the burden of climate-related diseases in Arab countries including vulnerable populations, and provides projections for countries.

II.REVIEW OF GLOBAL EFFECTS OF CLIMATE CHANGE ON HEALTH

Climate change is a complex phenomenon involving variable processes that can impact human health by threatening basic needs of clean air, safe drinking water, nutritious food supply and safe shelter (WHO, 2019a). A changing climate also influences human health by affecting morbidity and mortality (McMichael & Lindgren, 2011). According to the UNFCCC (2017), the impacts of climate change on health are already evident, and are expected to manifest themselves even more in the coming years. Climate and health are closely connected, and alleviating the effect of climate change will directly improve population health by reducing global health issues, such as climate-related mortality from CVD and respiratory diseases (WHO, 2019a). Both direct and indirect impacts of climate change on human health are mediated by other environmental, ecological, social and geographical factors, which

FIGURE 1 **TIMELINE FOR GLOBAL MILESTONES ON CLIMATE CHANGE AND HUMAN HEALTH**



have further health implications (McMichael & Lindgren, 2011). The effects may be short- or long-term, sometimes with life-long consequences for health and well-being. For example, non-communicable diseases (NCDs) such as mental illness after extreme weather events, climate-related displacement, immigration and loss of culture, could be permanent (WHO, 2018a).

The association between climate change and health is multifaceted, with many factors involved. This is reflected in the literature where, both direct and indirect mechanisms by which climate change can affect global health are classified and represented differently and with varying areas of focus. For example, air quality is sometimes considered a direct impact of climate change and at other times an indirect impact. Air quality and its impacts on human health is discussed in more detail in chapter 4 of this report. Table 1 shows examples of different references and how they classify direct and indirect impacts of climate change on global health.

A. Direct impacts of climate change on health

Three key climate change impacts cause direct health consequences; namely extreme weather events, increasing global average temperatures,

TABLE 1 EXAMPLES OF THE CLASSIFICATIONS OF DIRECT AND INDIRECT IMPACTS OF CLIMATE CHANGE ON HEALTH ACCORDING TO DIFFERENT SOURCES IN THE LITERATURE

Impacts of Climate Change on Human Health	McMichael & Lindgren, 2011	Papworth et al., 2015	Watts et al., 2015	WHO, 2018a	World Bank, 2017
Direct Impacts					
Extreme weather events	✓	✓	✓	✓	✓
Increasing temperatures	✓	✓	✓	✓	✓
Sea-level rise	✓	✓			✓
Air quality	✓				
Indirect Impacts					
Air quality			✓	✓	✓
Water security / quality	✓	✓	✓	✓	✓
Food security / quality	✓	✓			✓
Increased infectious diseases	✓	✓			
Social disruption and population displacement	✓				
Increased NCDs		✓			
Ecological change			✓	✓	
Land use change			✓	✓	
Environmental refugees (civil conflict)					✓
Mental health					✓

and sea-level rise. Each of these key impacts is defined as follows:

- **Extreme weather events** refer to a value of a weather- or climate variable going beyond a threshold near the upper or lower end of the range of observed values (IPCC, 2012). They include global scale extreme events (i.e. El Nino, La Nina, and Quasi-Biennial Oscillation (QBO)) and regional or local scale meteorological hazards (i.e. storms, wildfires, droughts, heat waves, and floods) which directly cause injuries and fatalities and, in some cases, can turn local communities into environmental refugees (IPCC, 2012; World Bank, 2017).

- **Exposure to increasing global average temperatures** is directly linked to increasing NCD morbidities such as CVD and respiratory diseases (McMichael & Lindgren, 2011). In addition, higher temperatures facilitate the formation and dispersal of various air pollutants such as ozone, which forms more easily from car exhausts at higher temperatures. High levels of ozone in the air (i.e. ozone pollution) can cause an increase in CVD and respiratory diseases and might even lead to mortality during intense heat waves (McMichael & Lindgren, 2011). Ozone pollution is also harmful to crops such as soybeans, wheat, oats, green beans, and peppers, and already causes millions of tons of crop losses each year which in turn impacts global food supplies and food security (Center for Climate Change and Health, 2016). Variability in temperature, rainfall and humidity due to climate change also affects the range, volume and seasonality of pollens and spores ('aeroallergens') in the air, which increases the occurrence of hay fever and asthma (McMichael & Lindgren, 2011).

- **Sea-level rise** leads to coastal inundation and flooding, which can cause forced migration and displacement of coastal communities, making them more vulnerable to various health issues such as mental illness and malnutrition as a result of loss of jobs, housing and infrastructure (Papworth et al., 2015).

B. Indirect impacts of climate change on health

Three key indirect climate change impacts cause indirect health consequences; namely food and water insecurity, the spread of climate-sensitive infectious diseases, and population displacement (WHO, 2018a).

- Climate change influences **food and water security and quality** in various ways. For example, extreme weather events, sea-level rise and rising temperatures will lead to reductions in crop yields, damaged crops, loss of farmland and livestock, increased crop and livestock damage by pests and pathogens and increased food prices. In addition, warmer oceans and seas will lead to reductions in yields from fisheries as the fish move to higher latitudes for cooler waters (McMichael & Lindgren, 2011). Moreover, decreasing precipitation and droughts will lead to diminished water flows in many regions, and coastal inundation resulting from sea-level rise will affect fresh water aquifers and cause salination (World Bank, 2017; McMichael & Lindgren, 2011). Compromised quality of food and water coupled by global reductions in their supplies will have major health consequences such as increased hunger and starvation, malnutrition, and increased cases of diarrhea and poisoning (Watts et al., 2015; WHO, 2018a).

- The survival, reproduction, or distribution of **infectious disease pathogens** (i.e. bacteria, viruses) and intermediate hosts or vectors (i.e. mosquitoes, ticks, sandflies) –

as well as the availability and means of their transmission environment – can be impacted by the alterations in climate variables such as temperature, precipitation, wind, sunshine and sea-level (Wu et al., 2015). These alterations in climate variables occur in a rapid way during extreme weather events, which can also change the dynamics of human infectious diseases. Both the pathogens and vectors of infectious diseases are very small and devoid of thermostatic mechanisms, making them extremely sensitive to the local climate and they can only survive and reproduce under a limited range of climatic conditions. Furthermore, the incubation period of a pathogen within a vector organism is very sensitive to temperature and usually displays an exponential relationship (WHO, 2003). Studies have shown that climate change might have effects on many types of infectious diseases such as vector-borne, water-borne, food-borne and air-borne diseases (WHO, 2003; Wu et al., 2015). The ensuing health consequences include shifts in the geographic and seasonal patterns of human infectious diseases, and changes in their outbreak frequency and severity (Wu et al., 2015). For example, rising temperatures might cause changes in breeding habitats for certain vectors (i.e. mosquitoes) which will cause an increase in vector-borne diseases as they might be able to survive in new locations (Papworth et al., 2015). Box 1 offers a more detailed explanation of the impact of climate change on various aspects of infectious diseases.

- **Social disruption and population displacement** (i.e. forced migration) often happens as a consequence of extreme weather events. For example, droughts and wildfires lead to the loss of farming jobs, land, infrastructure and housing, and in some cases, causes rising conflict over scarce resources (World Bank, 2017; Lindgren, 2011). Consequently, human health is affected due to reduced access to health services, increased vulnerability to infectious diseases and increased mental illnesses such as anxiety, depression, and post-traumatic stress (WHO, 2018a; World Bank, 2017).

It is worth noting that indirect impacts of climate change on global health also include ecological and land use change, as well as an increase in NCDs such as CVD, renal failure and other kidney diseases. The disease burden ranges from loss of well-being and productivity to disease and death (WHO, 2019a). Figure 2 illustrates the direct and indirect impacts of climate change on global health as discussed in various sources, as well as their health consequences. Climate change also indirectly impacts occupational health with various consequences as illustrated in more detail in Box 2.

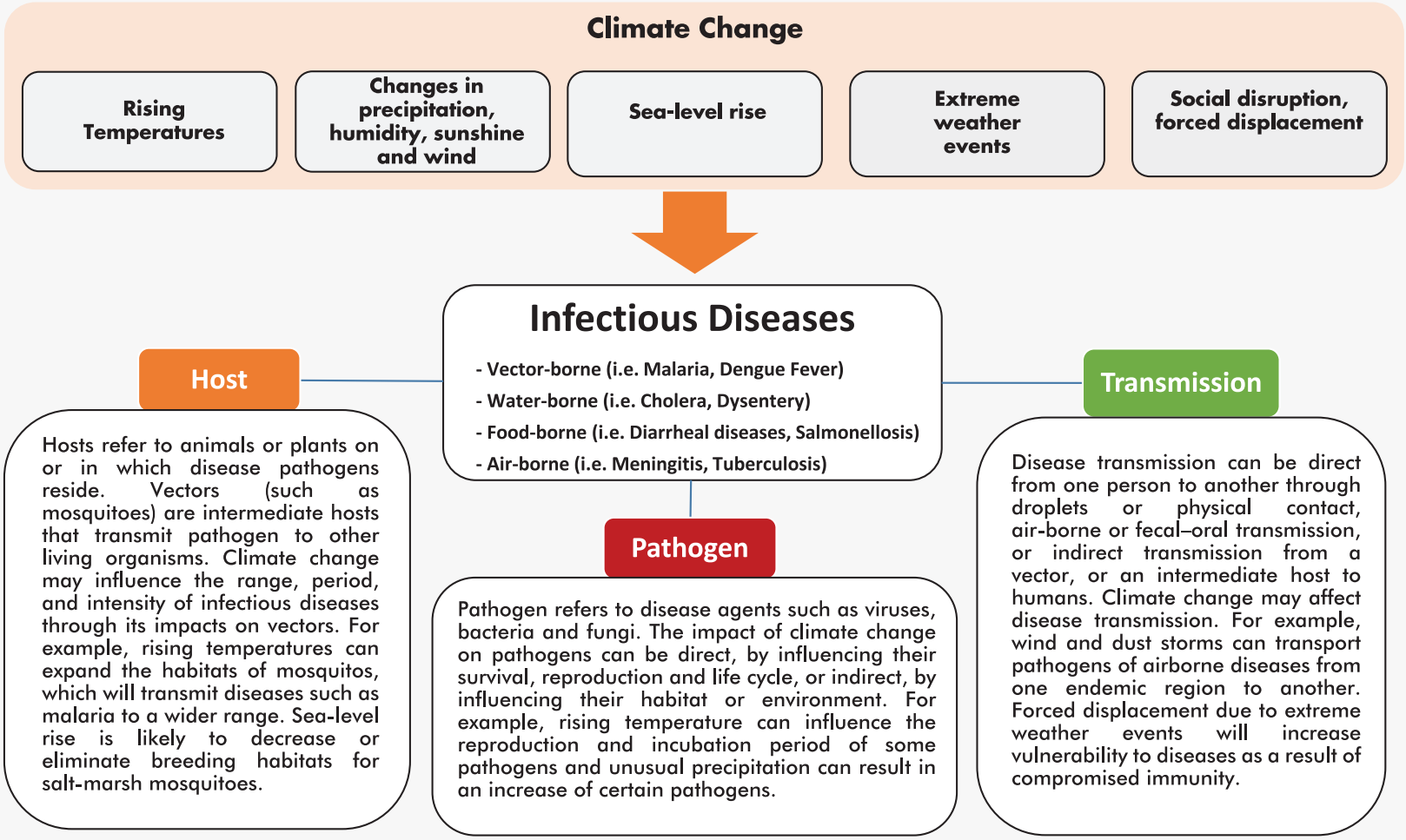
C. Other factors influencing the connection between climate change and global health

The impacts of climate change on health are strongly influenced and mediated by environmental, social, economic and resiliency factors. Environmental factors include geography, baseline weather, baseline air/water quality, soil/dust and vegetation. Social factors include poverty, inequality, conflict, displacement and individual and population factors such as age and gender (WHO, 2018a). Environmental and social factors play a significant role in influencing the health consequences of climate change. For example, during droughts, women and children in developing countries are often the worst affected as a result of their respective roles in the household (i.e. collecting water). However, male farmers have been found to be disproportionately more likely to commit suicide during droughts than females (WHO, 2018a). Furthermore, people's health vulnerability to climate change depends on their level of exposure, their personal characteristics (e.g. education, income, occupation and health status) and their access to health, social and communication services. Hence, elderly people, children, people with chronic cardiac and respiratory diseases, outdoor workers, migrants and homeless people are particularly susceptible to more severe health consequences of climate change (WHO, 2019a).

The health impacts of climate change also depend on geography. For example, rural communities are at risk of water scarcity, reduced agricultural production, food insecurity and disease transmission. Individuals living in rural and remote areas may be at increased risk of ill health because of limited access to health services and are generally more prone to social and economic disadvantage (WHO, 2019a). Resiliency factors

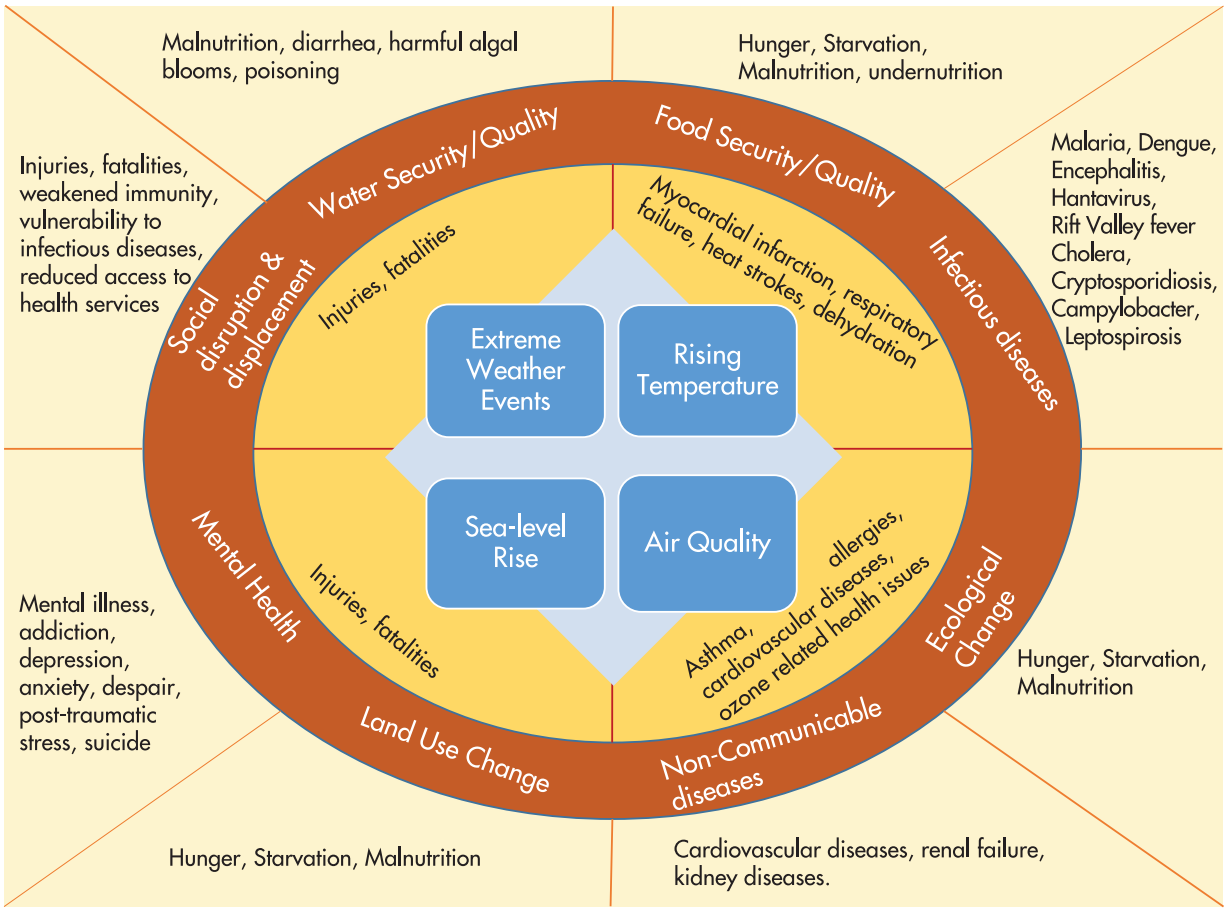
BOX 1

THE IMPACTS OF CLIMATE CHANGE ON VARIOUS ASPECTS OF INFECTIOUS DISEASES



Source: Adapted from: (Wu et al., 2015), (McMichael & Lindgren, 2011) and (WHO, 2003)

FIGURE 2 **DIRECT AND INDIRECT IMPACTS OF CLIMATE CHANGE ON HEALTH AND RELATED HEALTH CONSEQUENCES**



Source: Adapted from World Bank, 2017; WHO, 2018a; Papworth et al., 2015; & McMichael & Lindgren, 2011

include early-warning systems, socioeconomic status, health and nutrition, and primary healthcare – all of which have a massive influence on how climate change impacts public health (WHO, 2018a). Given the complex associations between climate change and global health, it is important to understand the various influencing factors at play in order to design effective mitigation and adaptation strategies with direct and clear effects on global health (UNFCCC, 2017; WHO, 2018a).

III. THE IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH IN THE ARAB REGION

The Middle East and North Africa (MENA) region is mainly comprised of Arab countries. The region is already experiencing extreme temperatures, particularly in the summer months. It is projected that the temperature will increase by 1-2°C between 2030-2050, impacting health (Elasha, 2010; UNDP, 2018). Thus, Arab countries face several health challenges in both morbidity and mortality due to climate change (Ahmadalipour & Moradkhani, 2018; Broom, 2019; Al-Mandhari, 2019). In addition, climate change has been reported to increase the occurrence of conflict (Bowles et al., 2015) thus intensifying the health burden (El-Zein et al., 2014).

A. Mortality

The few studies that have looked into the association between climate variability (rise in temperature, changes in humidity and precipitation) and overall mortality in the region

BOX 2

CLIMATE CHANGE AND OCCUPATIONAL HEALTH

Climate change has notable effects on health and productivity in the workplace, with implications for occupational health, safety and social protection. Workers in certain sectors and industries such as farmers, construction workers and those working in tourism and transportation are particularly vulnerable to the effects of climate change. Heat stress can lead to lower productivity, unbearable working conditions and an increase in the risk of cardiovascular, respiratory and renal diseases (UNFCCC, 2017). According to WHO, humidity in conjunction with temperature have an impact on workers in various sectors of the economy and such impacts on people's work can lead to mental health problems such as depression. Moreover, risk factors of suicide rates include unemployment and inability to provide food and shelter for themselves and their families (UNFCCC, 2017). One study showed that global labor productivity in rural populations exposed to temperature change was estimated to have decreased by 5.3 percent from 2000 to 2016. Higher temperatures pose profound threats to occupational health and labor productivity, particularly for people undertaking manual, outdoor labor in hot climates. Loss of labor capacity has important implications for the livelihoods of individuals, families, and communities, especially those relying on subsistence farming (Watts et al., 2015).

indicated that weather extremes have contributed to premature mortality (Lelieveld et al., 2016; Waha et al., 2017). It is expected that the mortality risk will be 8-20 times higher between 2006 and 2100 than it was during the period from 1951 to 2005 (Ahmadalipour & Moradkhani, 2018).

There were reported associations between elevated temperatures and mortality from some Arab countries due to climate change. The Arab region faced a heat wave in 2015 and 70 deaths were reported from Egypt, mainly among the elderly where elevated temperature and humidity were blamed (Herring et al., 2016). It was noted that an increase of 1°C above the maximum apparent temperature in Tunis, Tunisia would result in a 4.3 percent change (95 percent CI 2.7, 5.9) in all causes mortality (Leone et al., 2013). In the United Arab Emirates (UAE), two deaths (95 percent CI 0-2) were attributed to ambient temperature and 0.045/100.000 deaths were attributed to climate change in 2008 (MacDonald Gibson et al., 2013). The total daily mortality and mean daily temperature followed a V shape in a study from Greater Beirut in the period 1997-1999. The study concluded that heat-related mortality would increase in the coming decades (El-Zein et al., 2004; El-Zein & Tewtel-Salem, 2005). A more recent study by El Fadel and Ghanimeh in Greater Beirut expected premature deaths to rise by 3-15 percent by 2095 (El-Fadel and Ghanimeh, 2013). Further, El Zein & Tewtel- Salem (2005) indicated that heat-related mortality could be a public health concern in temperate to warm climates. An estimated excess mortality was projected for Bahrain, Oman, Qatar, UAE and Yemen by 2100. A 1°C increase in average temperature was expected to lead to a 3 percent increase in mortality from all causes (Husain & Chaudhary, 2008). Recent studies from Bahrain have concluded that extreme temperatures were not associated with overall mortality but positively correlated with humidity ($r=0.804$, $p<0.001$) (UNFCCC, 2018; UNFCCC, 2020a).

A recent study from Kuwait reported a statistically significant positive association between temperature extremes and mortality from non-accidental deaths between January 2010 and December 2016 (Alahmad et al., 2019). In the UAE, mortality from CVD that was attributable to climate change was reported to be 0.1 percent (95 percent CI 0, 2.0) in 2008 (MacDonald Gibson et al., 2013). Mortality rates from CVD, respiratory diseases and road traffic accidents were positively correlated with humidity ($r= 0.837$, $p<0.001$; $r=0.699$, $p <0.001$; $r=0.804$, $p<0.001$, respectively) for the period 1991-2015 in Bahrain. Mortality from asthma and other respiratory diseases were inversely correlated with temperature (UNFCCC, 2018).

Several countries in the region have experienced floods in the last decade (Algeria, Egypt, Iraq, Mauritania, Morocco, Oman, Palestine, Saudi Arabia, Somalia, Sudan and South Sudan) that resulted in fatalities (EM-DAT, 2020). The most recent occurred in 2020 in Egypt (EM-DAT, 2020) and Iraq (Floodlist News, 2020). There

BOX 3

CLIMATE CHANGE AND COVID-19

The COVID-19 pandemic has elicited an unprecedented global response, which involved a total population lockdown and a shutdown of some sectors in many countries. These extreme measures have had visible impacts on the global economy and the environment. The International Monetary Fund (IMF) projects that the global economy will shrink by 3 percent in 2020, with a recession expected in all major advanced economies (Bloomberg, 2020). However, the COVID-19 pandemic has shown some signs of positive impact on the environment. For example, nitrogen dioxide air pollution has decreased across Europe since the start of the pandemic and scientists expect carbon emissions to fall by 5 percent in 2020 (RFI, 2020; Euronews, 2020). In India, a significant reduction in smog and air pollution has resulted in a clear view of the Himalayas from some parts of the country for the first time in 30 years (Independent, 2020). On the other hand, the pandemic might also have negative environmental impacts such as an increase in the amount of medical and hazardous infectious wastes (UN, 2020).

Despite its positive environmental impacts, the COVID-19 pandemic has had very little impact on climate change and experts warn that without structural systemic changes, the reduced greenhouse gas emissions will only be temporary with no long-term effect on the concentrations of carbon dioxide that have been accumulating in the atmosphere over decades (RFI, 2020; UN, 2020). However, the pandemic has highlighted the effect and significance of global response to a global issue and it offers some lessons that can support such a response to climate change. According to Forbes (2020), there are three key lessons from COVID-19 that can be applied in climate change mitigation: (1) Scientific facts matter and have to be taken seriously; (2) Delayed response costs lives and hurts the economy; and (3) Globally coordinated policy measures are required. The World Economic Forum (2020) has also suggested key takeaway actions that can apply to climate change mitigation which include: building a good response system, taking action on a global scale, making people the top priority, trusting the experts, and making significant cultural shifts in habits of production and consumption (World Economic Forum, 2020).

Currently, there is no evidence of a direct connection between climate change and the emergence or transmission of COVID-19 (WHO, 2020). However, climate change may have an indirect effect on zoonotic diseases including COVID-19, Ebola, bird flu, swine flu, Middle East Respiratory Syndrome (MERS), Rift Valley Fever, Sudden Acute Respiratory Syndrome (SARS), West Nile virus, and the Zika virus (WHO, 2020; UNEP, 2020). Reductions in biodiversity, changes in land use, and changes in ecosystems and animal habitats exacerbated by climate change are getting humans in closer contact with wildlife, which increases the likelihood of interaction between these vectors and humans, hence, driving disease emergence and increasing transmission (WHO, 2020; UN, 2020; UNEP, 2020). Therefore, addressing the emergence of zoonotic diseases also requires addressing the impact of human activities on biodiversity and ecosystems and recognizing the close connection between animal, human and environmental health (UNEP, 2020). In addition, strengthening health systems and improving surveillance of infectious diseases in wildlife, livestock and humans should help reduce the risks of future outbreaks of other new diseases (WHO, 2020). Figure 3 shows the factors contributing to the emergence of zoonotic diseases according to UNEP (2016).

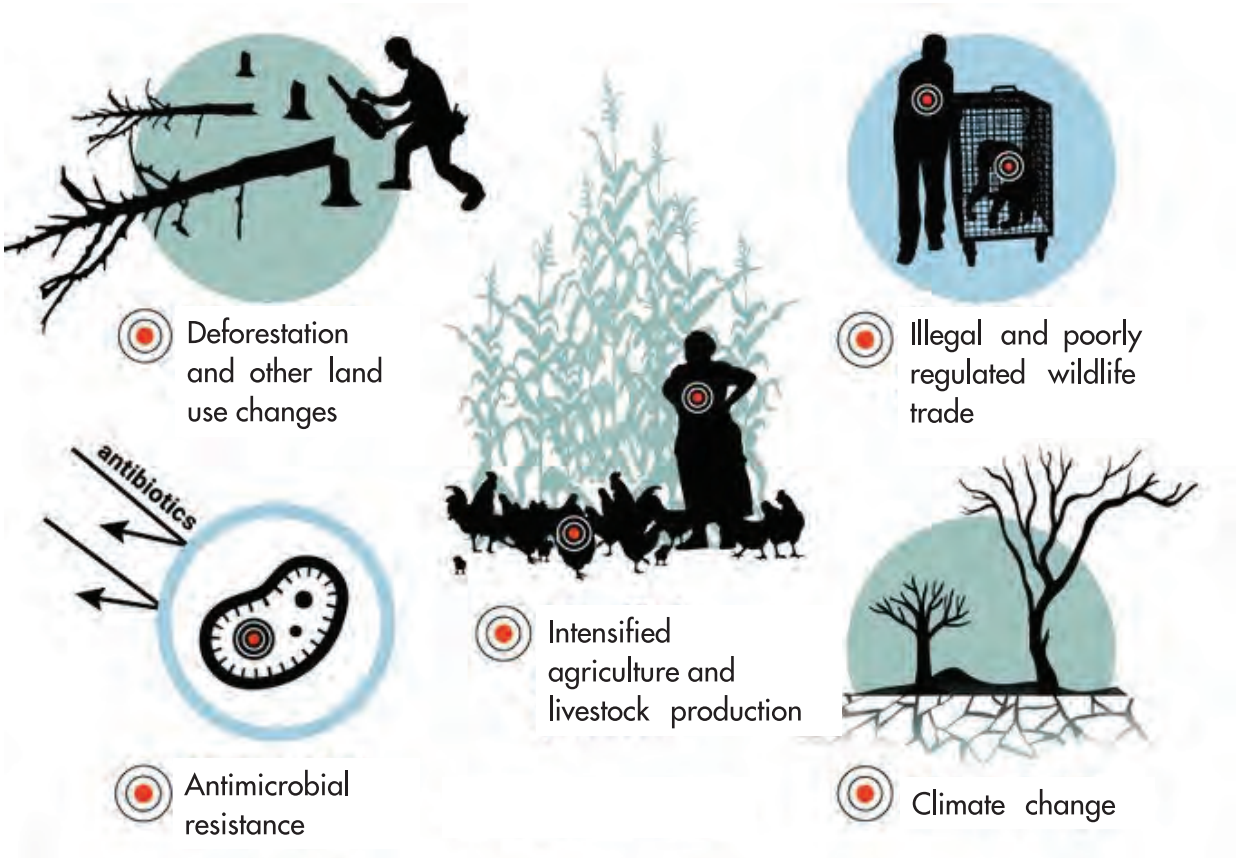
have been reports of several deaths due to heavy rains and flooding in Saudi Arabia (Lotfy & Alsaqabi, 2016). There were 77 deaths reported in 2009 and 10 in 2011 in Jeddah from rainfall and flooding (UNFCCC, 2020a). Other countries that had deaths from heavy rains in the last decade include Yemen (70 in 2008; 7 in 2010), Morocco (30 in 2010) and Algeria (29 in 2008) (UNFCCC; Verner, 2012). Further, in 2015, 7 people died from dengue fever that resulted from the displacement of 36,000 due cyclone in Yemen (UNFCCC, 2020a).

There were no significant associations between short term health effects of dust storms in Kuwait with the risk of same day mortality from CVD or respiratory diseases or overall mortality (Al-Taiar & Thalib, 2014). However, a recent study that examined mortality in Kuwait from 2000-2016 reported a positive association between deaths and dust storms and low visibility (Achilleos et al., 2019).

C. Morbidity

The Arab region is a hotspot for emerging and

FIGURE 3 INCREASING ZOONOSIS EMERGENCE



Source: UNEP, 2016

re-emerging communicable diseases and climate change is one of the contributors (Buliva et al., 2017). It contributes to the increase in waterborne, foodborne, and vector-borne diseases in the region (Lelieveld et al., 2016; USAID, 2018). Cholera and other waterborne diseases are associated with high temperatures in the region (WHO, 2009). Outbreaks of cholera have been reported in some Arab countries during the last decade (Iraq, 2012; Somalia, 2012, 2016, 2017; and Yemen, 2016, 2017) (Buliva et al., 2017).

Foodborne diseases (FBD) are a public health problem in the Arab region but their burden varies across the region. The Eastern Mediterranean Region (EMR) has the third highest amount of FBD cases per population. There are about 100 million people affected annually, one third of whom are children below 5 years old. FBDs are common regardless of the average level of income in the countries affected. GCC countries, the highest income countries in the region, have long summers with high temperatures, which increases risks of food poisoning (Faour-Klingbeil & Todd, 2019). Over 800 food poisoning cases were reported in 2018 in Dubai, a quarter of which were due to Salmonella (Al Ramahi, 2018). Salmonella also constituted about two thirds of the reported food outbreaks in Saudi Arabia in 2006, mostly between June and August, the hottest months of the year (Al-Goblan & Jahan, 2006). A study from Bahrain reported that foodborne climate-related diseases between 2001 and 2009 constituted 6.9 percent of all notifiable diseases - required by law to be reported to governmental health authorities - and were highest in the summer season, with a peak in July where the temperature is highest (Hamadeh et al., 2013). FBDs were also reported to be positively associated with humidity for the period 1995-2016 (UNFCCC, 2018).

Climate change is an important determinant of vector-borne diseases like leishmaniasis, malaria

TABLE 2 **PROJECTED INCREASES IN MORBIDITY AND MORTALITY DUE CLIMATE CHANGE BY ARAB COUNTRY**

Country (Source/s)	Morbidity	Mortality
Egypt (UNFCCC, 2020a), (Lotfy, 2014)	Parasitic diseases like schistosomiasis, fascioliasis, leishmaniasis, malaria, lymphatic filariasis, dengue fever, and mental illnesses	
Jordan (UNFCCC, 2020a)	Waterborne and foodborne diseases like cholera, dysentery, hepatitis E, giardiasis, bilharzias, poliomyelitis, and COPD. Emergence of West Nile virus fever, Dengue fever or Rift Valley fever and re-emergence of leishmaniasis, malaria, schistosomiasis and typhus	
Lebanon (UNFCCC, 2020a)	Waterborne diseases, vector-borne diseases, rodent-borne diseases, and malnutrition	Overall mortality
Morocco (UNFCCC, 2020a)	Malaria, schistosomiasis, typhoid and cholera	
Oman (UNFCCC, 2020a)	Malaria	CVD, respiratory diseases, infectious diseases and heat stress
Sudan (UNFCCC, 2020a)	Malaria	
Syria (UNFCCC, 2020a)	Leishmaniasis, diarrhea, typhoid fever, and waterborne diseases and re-emergence of malaria	
Tunisia (USAID, 2018) (UNFCCC, 2020a)	Typhoid, hepatitis, cholera and other waterborne diseases, vector borne diseases such as dengue fever, respiratory diseases, heart attacks, strokes Re-emergence of schistosomiasis and malaria.	Strokes, heart attacks, fatalities from droughts and flooding
Yemen (UNFCCC, 2020a)	Vector borne diseases, waterborne diseases, respiratory, CVD and malnutrition	Heat stress-related diseases, vector-borne diseases

and dengue in the region. Malaria is endemic in four Arab countries (Djibouti, Somalia, Sudan and Yemen) (Atta et al., 2016). Outbreaks and increases in malaria cases in Saudi Arabia have been attributed to heavy rain (UNFCCC, 2020a). The number of malaria cases in a recent study from the Sudan were reported to be significantly associated with maximum temperature, relative humidity and amount of rainfall (Hussien, 2019). Studies from Tunisia have reported that climate variability is a determinant of zoonotic cutaneous leishmaniasis (Bellali et al., 2018; Ben-Ahmed et al., 2009; Toumi et al., 2012). Humidity, more than rainfall, was found to be significantly related to the incidence rate of leishmaniasis (Ben-Ahmed et al., 2009).

Seven Arab countries – Djibouti, Egypt, Oman, Saudi Arabia, Somalia, Sudan, and Yemen – reported dengue fever outbreaks in the last decade (Buliva et al., 2017). A recent study from Jeddah, Saudi Arabia based on data from 2010-2014 showed that even temperatures between 25 °C to 33 °C and a decrease in relative humidity were significantly associated with dengue infection among febrile patients (Hashem et al. 2018). An earlier study from Jeddah reported that the risk of dengue fever increased in November, December and January: the months that have rainfall, an increase in humidity and a decrease in temperature change (Khormi et al., 2011). Further, Morocco and Algeria have experienced tuberculosis and scabies outbreaks that have been associated with climate change (Chibani, 2019).

In the UAE, 0.2 percent of CVD visits were attributed to the increase in annual average ambient temperature (MacDonald Gibson et al., 2013). High temperatures were reported to affect

BOX 4

CLIMATE CHANGE IS INSUFFICIENTLY ACKNOWLEDGED AS A HEALTH RISK IN ARAB COUNTRIES

Although extreme weather and climate action failure are ranked among the top five risks by likelihood and impact globally (World Economic Forum,2020), they were not identified as such by the MENA region respondents of the Global Risks Perception Survey (World Economic Forum, 2019). Despite the fact that research on the impact of climate change in the Arab region is scarce (Habib et al., 2010; Khader et al. 2015; AFED, 2009; Ahmadalipour & Moradkhani, 2018) existing research has indicated that human health has been adversely affected by climate change and more is yet to be evidenced. The Eastern Mediterranean Region (EMR) that includes 19 out of the 22 Arab countries, was reported to be the second region that is vulnerable to heat exposure after Europe (Watts et al., 2019). The Arab region faces direct health effects mainly linked to increases in temperature, heat waves, sand storms, droughts and flooding as well as indirect health effects that result in deaths and different morbidities (Verner, 2012; Tolba & Saab, 2009; Habib et al., 2010; Waha et al., 2017; El-Zein et al., 2014).

the development of ischemic heart disease in a Syrian study (Zawahri, 2004). The rates of annual hospital discharges from ischemic heart disease, circulatory diseases, CVD, respiratory diseases and mental illnesses were inversely correlated to temperature, and positively correlated to humidity in Bahrain between 2003 and 2016 (UNFCCC, 2018). Further, an inverse relationship between average temperature and consultation rates from respiratory diseases from health centers was observed in Bahrain. The rates were lowest in the summer months where the temperatures are very high and humidity the lowest (Hamadeh & Al-Roomi, 2014). Further, annual hospital discharge rates of respiratory diseases, asthma and COPD from 2003-2016 in Bahrain were inversely correlated with temperature (r=-0.709, p=0.005; r=-0.575, p=0.032; r=-0.698, p=0.006, respectively) and positively correlated with humidity (r=0.666, p=0.009; r=0.495; p=0.072; r=0.764, p=0.001, respectively) (UNFCCC, 2018). Similar findings were reported for asthma hospital admissions to both temperature and humidity in Kuwait (Qasem et al., 2008).

Despite the fact that many countries of the region experience dust and sand storms often, studies on their effect are rare. They have been reported to increase asthma (1.07; 95 percent CI 1.02-1.12) and respiratory admissions (1.06; 95 percent CI 1.04-1.08) in Kuwait (Thalib & Al-Taiar, 2012). Studies from Saudi Arabia also reported that sandstorms have respiratory consequences including asthma and COPD (Meo et al., 2013; Samarkandi et al., 2017).

Heat cramps and dehydration were associated with increase in temperature in studies from Kuwait (Al-Tawheed et al., 2003; Al Ahwal et al., 2000; Zawahri, 2004). A UAE study attributed heat cramps to humidity as well (Shanks & Papworth, 2001).

A highly significant positive correlation between rates of road traffic accidents and humidity was found in 2008-2016 in Bahrain (r=0.804, p<0.001), but a similar trend was not observed with precipitation (UNFCCC, 2018). The rates of sick leave from 2014 to 2016 for those younger than 65 years old were 40 to 160 per 1000, with the highest rates registered among 15 to 19 years old. There were no significant correlations between changes in climate parameters and the rate of sick leaves (UNFCCC, 2018).

Arab countries are diverse with respect to their nutrition profiles, with several having significant undernutrition or are in early nutrition transition (Al Jawaldeh & Maccoll, 2019). Arab countries with significant undernutrition have been experiencing droughts for many years, increasing the burden of food insecurity. In the last decade, Djibouti, Mauritania, Somalia, South Sudan, and the Sudan suffered from drought (EM-DAT, 2020).

D. Vulnerable populations

Children, elderly and outdoor workers are the most vulnerable to climate variability (Watts et al., 2019). High temperatures can result in several morbidities like heat exhaustion, heat stress and heat stroke amongst the elderly, the young, and those with comorbidities who are at higher risk (Waha et al., 2017). Maternal mortality could also increase because of heat stress in the region (UNDP, 2018).

TABLE 3 OPTIONS FOR ADAPTATION STRATEGIES TO REDUCE HEALTH IMPACTS OF CLIMATE CHANGE

Health Outcome	Legislative	Technical	Educational / Advisory	Cultural / Behavioural
Thermal stress	Building guidelines	Housing, public buildings, urban planning to reduce heat island effects, air conditioning	Early warning systems	Clothing, siesta
Extreme weather events	• Planning laws • Building guidelines • Forced migration • Economic incentives for building	• Urban planning • Storm shelters	Early warning systems	Use of storm shelters
Air quality	• Emission controls • Traffic restrictions	• Improved public transport • Catalytic converters • Smokestacks	Pollution warning	Carpooling
Vector-borne diseases	N/A	• Vector control • Vaccination, impregnated bed nets • Sustainable surveillance, prevention and control programs	Health education	Water storage practices
Water-borne diseases	• Watershed protection laws • Water quality regulation	• Genetic/molecular screening of pathogens • Improved water treatment (e.g., filters) • Improved sanitation (e.g., latrines)	Boil water alerts	• Washing hands and other hygiene behaviour • Use of pit latrines

Source: McCarthy et al., 2001

Construction workers in the Arab world are at higher risk of health consequences resulting from extreme hot temperatures as compared to the general population (Lelieveld et al., 2016) and Gulf countries in particular, where temperatures are quite high during the summer months, face more challenges (Al-Bouwarthanet et al., 2019; Bates, et al., 2010; Bates & Schneider, 2008). Construction workers in the UAE have a poorer hydration status than other expatriate unskilled and semi-skilled workers (Bates et al., 2010). A cross sectional study on expatriate labourers attending a health center – as part of the pre-employment screening and treatment of labourers in Bahrain at the time – reported that heat-related conditions ranked second (16.5 percent), after infectious diseases (62.9 percent) and that 70 percent of the labourers worked outdoors. Over one third of the patients had a two-day or longer sick leave due to these conditions (Al-Sayyad & Hamadeh, 2014).

Children are among the most impacted by climate change. Hot climate was attributed to 37.1 percent of migraines that developed among schoolchildren in the UAE (Bener et al., 2000). They are at a higher risk of admissions from asthma (RR=1.093; 95 percent CI 1.032-1.155) during sand storms, as reported by a study from Kuwait (Thalib & Al-Taiar, 2012). They are also very susceptible to diarrheal diseases and experience the most severe effects of dengue fever (Watts et al., 2019).

E. Projections by country

Temperature increases are expected to affect human health in the Arab region, among others due to changes in the geographical distribution of infectious diseases and the quality of air, water and food. It is projected that there will be an increase in malaria particularly in Sudan, Egypt and Morocco. Further, the increase in sandstorms can increase allergic and pulmonary diseases (Göll, 2017).

Only a few of the national communications submitted by Arab countries to the UNFCCC included health in their reports, and even fewer included health projections and projections of populations at risk of the diverse effects of climate change, as illustrated in Table 2.

Weather conditions in Egypt are expected to result in a rise in sea levels, destroying homes,

TABLE 4 **OPTIONS FOR ADAPTATION STRATEGIES TO REDUCE HEALTH IMPACTS OF CLIMATE CHANGE AND EXAMPLES OF IMPLEMENTED STRATEGIES**

Adaptation options	Examples of implemented strategies in OECD countries
Capacity Building: Developing human resources, institutions, and communities, equipping them with the capability to adapt to climate change	• Educating health professionals about the health impacts of climate change (France) • Developing heat risk adaptation guidelines (Canada) • Raising awareness of climate change impacts and social vulnerability (Ireland)
Management, Planning and Policy: Incorporating understanding of climate science, impacts, and vulnerability and risk into government and institutional planning, management, policies and regulations	• Strengthening of networks of expertise at national and international levels (Switzerland) • Establishing an internal multidisciplinary work group to investigate the occupational safety and health implications of climate change (US) • Developing a heat wave plan (UK)
Practice and Behaviour: Revisions or expansion of practices and on the ground behaviour that are directly related to building resilience	• Eradication of Aedes japonicus mosquito (Belgium) • Analysing and adapting the techniques used in building health and social facilities (France) • Stockpiling critical medical supplies and pharmaceuticals (US)
Information: Systems for communicating climate information to help build resilience towards climate impacts	• Identifying the capacity of the public health system and hospital system to plan and respond to vulnerabilities (Australia) • Assessing health impacts of climate change among Northern/Inuit populations (Canada) • Researching the potential effects of climate on outbreaks of environmentally-sensitive infectious diseases (US)
Warning or Observing Systems: Implementation of new or enhanced tools and technologies for communicating weather and climate risks, and for monitoring changes in the climate system	• Developing surveillance for heat response plan (Luxemburg) • Developing surveillance for food- and water-borne infectious disease (New Zealand) • Maintain and expanding real time UV monitoring (UK)

Source: Adapted from Austin et al., 2016

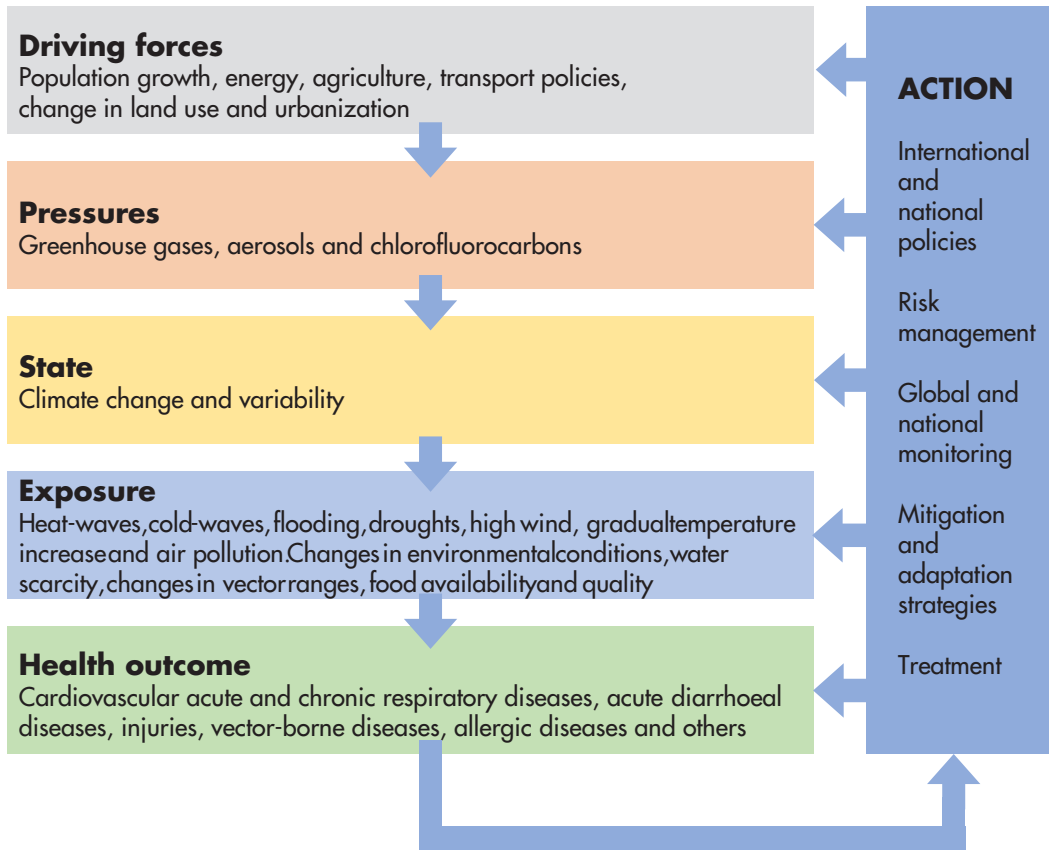
and increasing the risk of mental diseases (UNFCCC, 2020a). It is speculated that there would be an increase in parasitic diseases like schistosomiasis, fascioliasis leishmaniasis, malaria and lymphatic filariasis (Lotfy, 2014), and dengue fever could become a health issue as well (UNFCCC, 2020a).

Jordan has projected that a rise in temperature would lead to an increase in water and foodborne diseases, while flooding would increase the chance of vector-borne diseases. The likelihood of water-borne epidemics occuring such as cholera, dysentery, hepatitis E, giardiasis, bilharzias and poliomyelitis will increase. Some hemorrhagic fevers (West Nile virus fever, Dengue fever or Rift Valley fever) would emerge and others would re-emerge (Leishmaniasis, malaria, schistosomiasis or typhus). Further, the increase in humidity will probably lead to a rise in COPD cases (UNFCCC, 2020a).

The UNFCCC projects that an increase in temperatures will lead to an increase in mortality in Lebanon, rising from 2,483 deaths due to heat in 2010 to 5,254 in 2030. There would also be increases in waterborne, vector-borne and rodent-borne diseases and malnutrition as a result of extreme weather events. In Morocco, climate change is expected to increase incidences of infectious diseases like malaria, schistosomiasis, typhoid and cholera (UNFCCC, 2020a).

Climate change is expected to intensify Oman's health problems and increase the fatalities from CVD, respiratory and infectious diseases due to extreme weather events. By 2050, around 200,000 people will be at risk of malaria in Oman. Further, deaths amongst the elderly (65+years) due to heat stress are projected to reach 34 per 100,000 by 2080 compared to just above 3 deaths per 100,000 annually between 1961 and 1990 (UNFCCC, 2020a).

FIGURE 4 DRIVING FORCES-PRESSURES-STATE-EXPOSURE-EFFECT-ACTION FRAMEWORK FOR THE LINKAGES BETWEEN CLIMATE CHANGE AND HEALTH



Source: Kovats et al., 2003

Leishmaniasis, an endemic disease present in Syria, would probably increase due to climate change, while malaria would re-emerge. There would also be an increase in the incidence of diarrhea, typhoid fever, and waterborne diseases due to water shortage (UNFCCC, 2020a).

By 2050, the increase in temperature in Tunisia (0.7-2.6°C) is projected to result in an increase in mortality from heat, particularly amongst the elderly, leading to strokes and heart attacks. Fatalities from droughts and flooding are also expected (USAID, 2018). Vector borne diseases such as dengue are projected to increase (USAID, 2018). Although schistosomiasis and malaria have been eradicated, it is expected that the change in temperature and rainfall patterns might have an effect on the insect vectors of these diseases. Water scarcity would result in an increase in waterborne diseases, and heat waves would increase respiratory diseases. An increase in heart attacks, strokes and respiratory infections would also result from air quality degradation (UNFCCC, 2020a). The rise in sea levels and flooding may play a role in the development of outbreaks of typhoid, hepatitis, cholera and other waterborne disease (USAID, 2018). It is speculated that Tunisia will face food insecurity between 2020 and 2099 and that there will be an increase in malnutrition, particularly in children, due to droughts and floods (USAID, 2018).

Vector-borne and waterborne diseases, respiratory and CVD will be exacerbated due to climate change in Yemen. The impact of climate change, particularly due to an increase in temperature, is expected to put children, women (mainly the pregnant), elderly, outdoor workers, the poor and the internally displaced and at higher risk. The effects are mostly heat stress-related diseases and deaths, as well as vector borne diseases and malnutrition in those below 5 years (UNFCCC, 2020a).

TABLE 5 EXAMPLES OF MITIGATION STRATEGIES AND THEIR HEALTH CO-BENEFITS

Mitigation Strategies to reduce GHG emissions	Health Co-benefits
Clean energy sources such as solar, wind or hydro power/reduction in fossil fuel combustion	• Improve urban air quality • Decrease CVD and respiratory diseases
Reduced use of wood burning and other biomass for indoor cooking/the use of clean fuels and household cookstoves	• Improve indoor air quality • Reduce deaths from household air pollution (especially amongst women and children) • Lower risk of injury during fuel collection • Reduce burning accidents
Energy-efficient and climate-adapted housing and buildings (e.g. using minimal energy for heating, cooling, or lighting, effective use of natural daylight and ventilation, screening to prevent entry by insects, more robust building envelope)	• Reduce morbidity and mortality related to heat and cold exposure, as well as risks of airborne infectious disease transmission and acute and chronic respiratory diseases related to indoor air pollution risks, mould, and dampness. • Protect occupants not only from heat and cold, but storms and extreme weather, as well as diseases borne by pests and vectors.
Well planned urban public transport policies encouraging use of public transport, walking and cycling	• Increase physical activity and reduce obesity • Reduce traffic injury and deaths • Reduce air pollution-related mortality (from strokes, respiratory and heart disease) • Reduce noise pollution
Reduction in meat consumption/shifting to diets richer in fresh, in-season vegetables, fruits and legumes	• Reduce risks of obesity, heart disease and cancers associated with excessive consumption of red meat and some processed foods • Reduce diet-related non-communicable diseases
Reforestation projects	• Restore dietary diversity in some regions, as well as medicinal substances and other health-related materials
Improved wastewater treatment (including sanitation)	• Improve air quality • Reduce infectious disease risk

Source: Adapted from McMichael & Lindgren, 2011; WHO, 2015d; WHO, 2018a

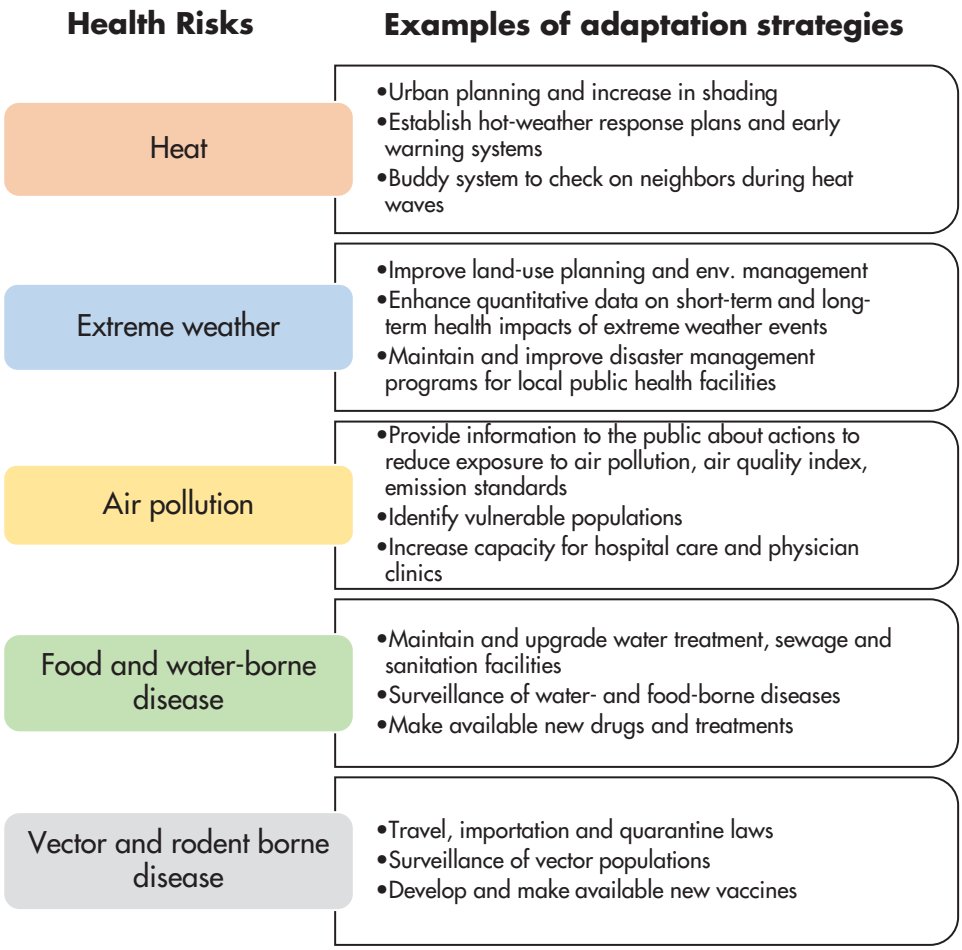
IV. CURRENT STRATEGIES AND BENEFITS TO HUMAN HEALTH BY ADDRESSING CLIMATE CHANGE

Due to the negative impact of climate change on health, both adaptation and mitigation measures must be exercised. Adaptation measures involve both spontaneous measures such as adjusting to living at higher temperatures, and planned or deliberate measures such as enhanced and targeted epidemiological surveillance, early warning systems for extreme weather events, vaccination programs, and the development of epidemic early warning systems to address the spread of infectious diseases (McMichael & Lindgren, 2011; Wu et al., 2016). In the health context, adaptation involves different levels of prevention: (1) Primary prevention, which aims to minimize exposure to risks; (2) Secondary prevention which aims to prevent the onset of adverse health outcomes; and (3) Tertiary prevention which aims to reduce morbidity and minimize impacts (Austin et al., 2016). On the other hand, climate change mitigation involves reducing GHG emissions by, for example, cycling or walking instead of using such as cars, which also contributes positively to human health by decreasing illnesses from physical inactivity (WHO, 2015). Figure 4 shows a framework illustrating the linkages between climate change and health, including mitigation and adaptation responses.

A. Global adaptation strategies and initiatives

With the growing influence of climate change on health systems and public health, the World Health Organization (WHO) has been working

FIGURE 5 **DIFFERENT CATEGORIES OF ADAPTATION STRATEGIES ACCORDING TO ADDRESSED HEALTH RISKS**



Source: Adapted from Cheng & Berry, 2013

on a global scale to support countries – especially developing countries – to include the health sector in their National Adaptation Plans (NAP), which were created under the global UNFCCC climate change agenda (WHO, 2014). The health national adaptation process (HNAP) is the health component of the NAP and includes a detailed health adaptation plan designed to achieve national health adaptation goals (WHO, 2014). The WHO also cooperates with other international organizations on global health adaptation projects, such as the program Adaptation to climate change in the health sector, which was commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and was implemented by the German Agency for International Cooperation (GIZ) between 2013 and 2017. The program's objective was to support international and national climate policies to take greater account of the effects of climate change on human health, and to develop innovative climate adaptation measures for the health sector (GIZ, n.d).

On a regional and national scale, countries have implemented various measures addressing climate change adaptation. They can be categorized according to the health risks or outcomes they tackle by addressing heat waves, extreme weather events, air quality and infectious diseases, or they can be categorized according to the tools and/or actions they use including as legislative, technical and advisory actions. Another option for categorization would be to use both health risks/outcomes and adaptation tools/actions. For example, McCarthy et al. (2001) categorized adaptation options into four main categories:

legislative, technical, educational/advisory and cultural/behavioural, presenting examples of how each category can address specific health outcomes such as heat stress, extreme weather events, air quality, vector- and water-borne diseases, as is demonstrated in Table 3.

Austin et al. (2016) presented climate change health-related adaptation options in five categories and offered examples of implemented adaptation strategies from countries of the Organisation for Economic Cooperation and Development (OECD), as illustrated in Table 4.

In another study, Cheng & Berry (2013) reviewed the literature on public health adaptation strategies and categorized them based on the related health risks they address. Figure 5 shows their categorizations and illustrates examples of corresponding adaptation strategies.

B. Adaptation strategies and initiatives in the Arab region

In the Arab region, there seems to be a lack of regional adaptation strategies targeting the health sector. However, some Arab countries have implemented local and national health related adaptation measures as follows:

- Egypt has implemented actions to build institutional and technical capabilities to work on climate change and health and has identified opportunities for further action in climate change adaptation including: (1) Conducting a national assessment of climate change impacts, vulnerability and adaptation for health; (2) Including climate information in an integrated surveillance and response system for climate sensitive health risks; (3) Strengthening adaptive capacity by building climate resilient infrastructure, including health infrastructure; and (4) Conducting further cost estimations for the implementation of heath resilience to climate change. However, Egypt still does not have an integrated national health adaptation strategy (WHO, 2015a).

- Jordan is ranked among the poorest countries in the world in terms of water availability and climate change is expected to increase water scarcity in the country, which is considered the highest priority threat to health in Jordan (WHO, 2013; WHO, n.d). As a response to this, Jordan implemented the project Climate change adaptation to protect human health between 2010 and 2014, which was funded by the GEF Special Climate Change Fund (SCCF). The project aimed to increase adaptive capacity to respond to health risks resulting from water scarcity

BOX 5

CLIMATE CHANGE AND THE ONE HEALTH APPROACH

The One Health approach was formed in 2007 by the American Medical Association and the American Veterinary Medical Association. The approach recognizes that human health, animal health, and environmental/ecosystem health are linked and that human health cannot be protected unless animal health and environmental health are also addressed. The main objective of One Health is to promote, improve, and defend the health and well-being of all species by enhancing cooperation and collaboration between various organizations, institutions and experienced professionals in the areas of human medicine, veterinary medicine, and environmental science (Slenning, 2010; Queenan et al., 2017). The One Health perspective is very relevant to a global challenge such as climate change, since it affects the environment in which humans and animals, as well as the disease vectors and pathogens affecting both groups, exist. Recent incidents involving emerging zoonotic diseases and public health consequences of environmental degradation have led to urgent calls for veterinary medicine, human medicine, and environmental health approaches to be combined and prioritized (Slenning, 2010).

According to the WHO (2017), using the One Health approach in designing and implementing programs, policies, legislation and research is an efficient way to address the emergence of zoonotic diseases. The One Health approach is particularly relevant in areas such as food safety, the control of zoonotic diseases, and combatting antibiotic resistance. For example, to effectively detect, respond to, and prevent outbreaks of zoonotic diseases, epidemiological data and laboratory information should be shared across different sectors and government officials, researchers and workers across local, national, regional and global levels should implement joint responses to such health threats. In addition, different organizations such as WHO, Agriculture Organization of the United Nations (FAO) and the World Organization for Animal Health (OIE) work closely together to promote multi-sectoral responses to different public health threats at the human-animal-ecosystem interface and provide guidance on how to reduce these risks (WHO, 2017).

TABLE 6 EXAMPLES OF CLIMATE CHANGE MITIGATION STRATEGIES AND ACTIONS APPLICABLE TO THE HEALTH CARE SECTOR

Mitigation Strategy	Actions	Health Co-benefits
Improve energy supply and distribution efficiency	Fuel switching; Energy recovery; Distributed generation; Combined heat & power	• Immediate energy savings and operational resilience/reliability • Reduced air pollution exposures • Improved access to reliable health care
On-site renewable energy sources	Solar photovoltaics; Thermal solar energy; Other renewable energies	• Improved operational resilience/reliability • Long-term energy savings • Reduced ambient air emissions
Reduced-energy devices	Non-electric medical devices; Direct-current devices; Energy efficient appliances	• Energy and operations savings and energy security • Improved functionality at night and device reliability • Improved diagnosis of tuberculosis with low-energy • LED microscopes • Increased access to health care and energy security
Passive cooling, heating and ventilation strategies	Natural ventilation in health care settings; Evaporative cooling Desiccant dehumidification; Underground earth-pipe cooling	• Energy and operations savings and energy security • Improved indoor air quality • Decreased transmission of airborne infections • Improved social welfare, productivity and patient health
Facility wastewater and solid waste management	Advanced autoclaving of infectious health care waste; On-site wastewater pre-treatment and sanitation improvements; High-heat incineration of pharmaceuticals with pollution scrubbers	• Savings in waste/water disposal fees • Reduced waste volumes • Improved compliance with local air quality regulations/ guidelines • Improved hygiene around facility • Reduced methane and other emissions • Reduced risks of exposure to infectious agents, and to diarrhea and other waterborne diseases

Source: Adapted from World Bank, 2017

induced by climate change in Jordan and focused on: (1) Strengthening monitoring and surveillance capacity; (2) Developing the necessary institutional and regulatory framework for safe use of wastewater; and (3) Increasing the capacity related to health protection measures and pilot testing these in the field. In addition, Jordan has an approved national health adaptation strategy and has conducted a national assessment of climate change impacts, vulnerability and adaptation for health (WHO, 2015b).

- Tunisia undertook an intersectoral assessment of vulnerability and adaptation to climate change, including human health, over the period 2007-2010, which resulted in the development of an adaptation strategy (WHO, 2013). Furthermore, Tunisia has climate information included in an Integrated Disease Surveillance and Response (IDSR) system, including development of early warning and response systems for climate-sensitive health risks (WHO, 2015c).

C. Global mitigation strategies and initiatives

Unlike climate change adaptation strategies, which operate on a more local and contextualized level and tailor to different objectives through a wide range of actions, mitigation strategies are mainly initiated as a response to countries' commitments to the UNFCCC and the Paris

Mitigation Strategy	Actions	Health Co-benefits
Reduced GHG emissions from anaesthesia gas use and disposal	Waste anaesthetic gas recapture and scavenging	• Anaesthesia cost savings with reuse • Reduced health risks for health workers exposed to gas • Improved health worker productivity
Reduced procurement carbon footprint	Better-managed procurement of pharmaceuticals, medical devices, business products and services..etc	• Resource savings on unused/wasted products • Reduced risks from use of outdated/ expired products
Telehealth/ telemedicine	Home patient telemonitoring and guidance; Emergency response; Health worker advice collaboration via mobile phones	• More cost-effective health care • Reduced risk of travel-related injuries • Improved management of chronic conditions, such as diabetes and heart disease, as well as emergency response • Better access to health care advice in poorly-resourced remote locations • Continuation of patient care when physical visits to clinics are not possible (For example, in the case of a pandemic)
Health facilities in proximity to public transport and safe walking/cycling	Public transport options mapped during planning of buildings to locate new facilities nearby; Employee incentives for public active transport use and facilities	• Reduced traffic injury risk for health workers and hospital/clinic visitors • Potential for active transport by health care workers to reduce risks of hypertension, cardiac disease and diabetes • Improved facility access for health workers and visitors
Conserve and maintain water resources	Water-efficient fixtures, leakage management, water safety; Onsite water treatment and safe water storage in health facilities; Rainwater harvesting, gray water recapture/recycling	• Improved performance due to better access to safe water • Savings in water fees • Reduced water contamination from health facility activities • Reduced disease transmission from unsafe water and drinking water • Improved access to safe, potable water in poorly resourced health facilities

Agreement through Nationally Determined Contributions (NDCs), with the sole objective of reducing GHG emissions. Furthermore, while adaptation measures are mostly driven by direct health risks, mitigation measures and policies are primarily driven by economic costs and energy implications, with the exception of mitigation policies related to air pollution, in which public health is a key driver (Workman et al., 2019). Hence, the focus in this section will be on the general mitigation measures adopted worldwide and their health co-benefits and not on specific strategies and/or programs in certain countries.

Climate change mitigation strategies targeting GHG emission reductions in different sectors such as urban transport, household energy, food and agriculture, and low-carbon electricity generation can have substantial health co-benefits (Cheng & Berry, 2013). However, there are significant differences in the health benefits produced from various mitigation strategies. For example, the adoption of active transport and rapid public transit results in greater immediate health gains than improving fuel efficiency in vehicles (Cheng & Berry, 2013; WHO, 2018b). According to the WHO, the long-term cost of global mitigation efforts is relatively small over the long-term when compared to the cost-savings from the health benefits of these policies, which are often realized in the short-term, thus further offsetting initial costs of investment and providing a strong motivation for further political and individual action (WHO, 2015d; WHO, 2018b). Table 5

TABLE 7 CLIMATE CHANGE MITIGATION ACTIONS IMPACTING HUMAN HEALTH IN ARAB COUNTRIES

Country	International Agreements	Mitigation actions and/or initiatives impacting human health
Algeria	Date of Convention Ratification: 09/06/1993 Date of Kyoto Protocol Ratification: 16/02/2005 Date of Paris Agreement Ratification: 20/10/2016	• Clean Air Initiative: Commit to achieving air quality that is safe for populations and align climate change and air pollution policies by 2030. Financial institutions commit to scale up investment to support climate action, health and sustainable development. • Great Green Wall for Sahara and the Sahel Initiative (GGWSSI): Restore 50 million hectares of land, sequester 250 million tons of carbon and support 300 million people across the Sahel by 2030. • Blue Growth Initiative: Reduce CO_2 emissions by 10 percent in 5 years and 25 percent in 10 years, and reduce overfishing by 20 percent in 5 years and 50 percent in 10 years in 10 developing countries. • Global Fuel Economy Initiative (GFEI): Double vehicle fuel efficiency globally by 2050. • International Solar Alliance (ISA): Mobilize more than USD 1 trillion of investments by 2030 for the massive deployment of affordable solar energy. • Africa Renewable Energy Initiative (AREI): Scale up Africa's renewable energy potential to achieve at least 10 GW of new and additional renewable energy generation capacity by 2020 and at least 300 GW by 2030.
Comoros	Date of Convention Ratification: 31/10/1994 Date of Kyoto Protocol Ratification: 10/04/2008 Date of Paris Agreement Ratification: 23/11/2016	• Climate Ambition Alliance: Net Zero 2050: Commit to achieve net zero CO_2 emissions by 2050. • Enhanced National Climate Plans: Commit to enhance ambition in national climate plans by 2020. • International Solar Alliance (ISA) • SIDS Lighthouses Initiative: Mobilize USD 500 million and deploy 100MW of solar PV, 20MW of wind power, and significant quantities of other renewable energy technology in SIDS by 2020. • Africa Renewable Energy Initiative (AREI)
Egypt	Date of UNFCCC Ratification: 05/12/1994 Date of Kyoto Protocol Ratification: 12/01/2005 Date of Paris Agreement Ratification: 29/06/2017	• Great Green Wall for Sahara and the Sahel Initiative (GGWSSI) • Risk-Informed Early Action Partnership (REAP): Reduce the impact of specific disaster events on agriculture and livelihood through the monitoring of major risks. • Global Fuel Economy Initiative (GFEI) • International Solar Alliance (ISA)
Jordan	Date of Convention Ratification: 12/11/1993 Date of Kyoto Protocol Ratification: 17/01/2003 Date of Paris Agreement Ratification: 04/11/2016	• CCAC: Phasing Down Climate Potent HFCs/HFCs Initiative: Reduce the use and emissions of high-GWP HFCs and enhance energy efficiency in the food cold chain, as well as achieve a 30-50 percent reduction in HFC emissions from refrigerant servicing within 10 years. • Global Fuel Economy Initiative (GFEI)
Kuwait	Date of Convention Ratification: 28/12/1994 Date of Kyoto Protocol Ratification: 11/03/2005 Date of Paris Agreement Ratification: 23/04/2018	• Decarbonizing Shipping: Getting to Zero Coalition: Accelerate the development and deployment of commercially viable zero emission vessels by 2030 and reduce GHG emissions from shipping by at least 50 percent by 2050.
Mauritania	Date of Convention Ratification: 20/01/1994 Date of Kyoto Protocol Ratification: 22/07/2005 Date of Paris Agreement Ratification: 27/02/2017	• Great Green Wall for Sahara and the Sahel Initiative (GGWSSI) • Blue Growth Initiative • Climate Ambition Alliance: Net Zero 2050 • Enhanced National Climate Plans • International Solar Alliance (ISA) • Africa Renewable Energy Initiative (AREI)

(Adapted from UNFCCC.2020b)

TABLE 7 CONT. **CLIMATE CHANGE MITIGATION ACTIONS IMPACTING HUMAN HEALTH IN ARAB COUNTRIES**

Country	International Agreements	Mitigation actions and/or initiatives impacting human health
Morocco	Date of Convention Ratification: 28/12/1995 Date of Kyoto Protocol Ratification: 05/01/2002 Date of Paris Agreement Ratification: 21/09/2016	• Clean Air Initiative • Mission Innovation • Blue Growth Initiative • Decarbonizing Shipping- Getting to Zero Coalition • Enhanced National Climate Plans • Global Fuel Economy Initiative (GFEI)
Oman	Date of Convention Ratification: 08/02/1995 Date of Kyoto Protocol Ratification: 19/01/2005 Date of Paris Agreement Ratification: 22/05/2019	• International Solar Alliance (ISA)
Palestine	Date of Convention Ratification: 18/12/2015 Date of Paris Agreement Ratification: 22/04/2016	• Clean Air Initiative
Saudi Arabia	Date of Convention Ratification: 28/12/1994 Date of Kyoto Protocol Ratification: 31/01/2005 Date of Paris Agreement Ratification: 03/11/2016	• Mission Innovation: Dramatically accelerate public and private global clean energy innovation, including doubling their current research and development investments in the sector over 5 years. • International Solar Alliance (ISA)
Somalia	Date of Convention Ratification: 11/09/2009 Date of Kyoto Protocol Ratification: 26/07/2010 Date of Paris Agreement Ratification: 22/04/2016	• Great Green Wall for Sahara and the Sahel Initiative (GGWSSI) • Climate Ambition Alliance – Net Zero 2050 • International Solar Alliance (ISA) • Africa Renewable Energy Initiative (AREI)
Sudan	Date of Convention Ratification: 19/11/1993 Date of Kyoto Protocol Ratification: 02/11/2004 Date of Paris Agreement Ratification: 02/08/2017	• Great Green Wall for Sahara and the Sahel Initiative (GGWSSI) • Climate Ambition Alliance: Net Zero 2050 • Enhanced National Climate Plans • International Solar Alliance (ISA) • Clean Energy Corridors in Africa: Meet half of total electricity demand from clean, indigenous, cost-effective renewable resources in Eastern and Southern Africa regions by 2030. • Coalition for Sustainable Energy Access: 1) 100 percent access to sufficient, affordable, modern and renewable energy by all citizens in LDCs by 2030; 2) 100 percent electricity from renewable energy sources in all LDCs by 2050; 3) 100 percent energy efficiency along the value chain by 2040.
Tunisia	Date of Convention Ratification: 15/07/1993 Date of Kyoto Protocol Ratification: 22/01/2003 Date of Paris Agreement Ratification: 10/02/2017	• Clean Air Initiative • Great Green Wall for Sahara and the Sahel Initiative (GGWSSI) • Enhanced National Climate Plans • Global Fuel Economy Initiative (GFEI) • Africa Renewable Energy Initiative (AREI)
United Arab Emirates	Date of Convention Ratification: 29/12/1995 Date of Kyoto Protocol Ratification: 26/01/2005 Date of Paris Agreement Ratification: 21/09/2016	• Clean Air Initiative • Mission Innovation • Global Fuel Economy Initiative (GFEI) • International Solar Alliance (ISA)

offers different examples of mitigation strategies and their health co-benefits.

The importance of considering health in climate change mitigation policies has been highlighted in recent years with policy opportunities arising to advance climate and health goals together. For example, in 2018, world leaders at the United Nations General Assembly committed themselves to tackle the negative health risks of air pollution and agreed that policy, legislation and regulatory measures were required in all nations to decrease morbidity and mortality from related non-communicable diseases (NCDs) (WHO, 2018b). The resulting improvements in local air quality will have a positive impact on both human health and climate change mitigation. Despite these efforts, health may not always be fully accounted for in mitigation policy priorities and decision-making, and as the WHO suggests, a "health-in-all-policies" approach is required (WHO, 2018b). On the other hand, there has also been a need for mitigation actions within the healthcare sector itself. Low-carbon energy solutions in the form of greater energy efficiencies and renewable sources of power generation, and shifting to greener procedures in the health service procurement and delivery chain can benefit health systems in power intensive settings (WHO, 2015d). Moreover, for off-grid hospitals and clinics in rural areas and developing countries, low-carbon energy solutions may also help improve access to energy for vital services, which is a key constraint to the achievement of universal health coverage (WHO, 2015d). Table 6 shows some examples of mitigation strategies and actions that can be applied in the healthcare sector and their health co-benefits.

D. Mitigation strategies and initiatives in the Arab region

Almost all Arab countries have signed and ratified the 1992 UNFCCC and its extension treaty, the Kyoto Protocol, as elaborated in Table 7. The UNFCCC has the main objective of stabilizing GHG concentrations in the atmosphere and setting limits on GHG emissions for individual countries through different climate change mitigation actions (UNFCCC, 2020b.). Table 6 summarizes the mitigation actions implemented by Arab countries that influence human health.

V. CONCLUSION AND RECOMMENDATIONS

Climate change and health are two of the greatest challenges facing the Sustainable Development Goals (SDGs) 2030 Agenda. The impacts of climate change on health are already evident, and are expected to manifest more strongly in the coming years. Direct impacts of climate change (i.e. rising temperatures, extreme weather events and sea level rise) cause health consequences such as cardiovascular diseases (CVD), respiratory diseases, heatstroke, injuries and fatalities. Indirect impacts include the spread of waterborne, foodborne and vector-borne diseases, water and food insecurity, displacement and forced migration, and impacts on mental health and occupational health. Climate change also indirectly affects population health by affecting sustainable development and exacerbating poverty. The association between climate change and health is multifaceted, with many factors involved including environmental, social, economic and resiliency factors. Hence, it is important to understand the various influencing factors at play in order to design effective climate change mitigation and adaptation strategies with direct and clear effects on global health.

The available literature indicates that climate change has already imposed a health burden in the Arab region and causes a public health concern. Increases in overall mortality, mortality and morbidity from communicable diseases and NCDs have been reported in countries of the region. Few Arab countries identified vulnerable populations like children, elderly and outdoor workers and a small number made projections. It can be concluded that the impact of climate change on health is not given adequate attention by stakeholders and researchers in the region and that there is variability in the information provided by countries. Countries should be urged to include health in the national communications and researchers are urged to conduct studies that narrow the gaps in knowledge.

Climate change adaptation measures involve both spontaneous measures such as adjusting to living at higher temperatures, and planned or deliberate measures such as enhanced and targeted epidemiological surveillance, early warning systems for extreme weather events, vaccination programs, and the development of epidemic early warning systems to address the spread of infectious diseases.

The WHO has undertaken many global adaptation initiatives and programs in cooperation with other international organizations, while on a regional and national scale, adaptation strategies and initiatives operate on a more local and contextualized level and tailor to different objectives through a wide range of actions or options. Adaptation options can be categorized according to the health risks or outcomes they address such as measures addressing heat waves, extreme weather events, air quality and infectious diseases, or they can be categorized according to the tools and/or actions including legislative, technical actions, and advisory actions. In the Arab region, there seems to be a lack of regional adaptation strategies targeting the health sector and in many Arab countries there is a need for national adaptation plans. However, some Arab countries have implemented local and national health-related adaptation measures such as Egypt, Jordan and Tunisia.

On the other hand, climate change mitigation strategies are mainly initiated as a response to countries' commitments to the UNFCCC and the Paris Agreement through Nationally Determined Contributions (NDCs) with the sole objective of reducing GHG emissions. While mitigation measures are primarily driven by economic costs and energy implications, the importance of considering health in climate change mitigation policies has been highlighted in recent years with policy opportunities arising to advance climate and health goals together. Climate change mitigation strategies have significant health co-benefits and they target different sectors such as urban transport, household energy, food and agriculture, and low-carbon electricity generation. For example, using clean energy instead of fossil fuels leads to the health benefits of improved urban air quality and decreased CVD and respiratory diseases. According to the WHO, the long-term cost of global mitigation actions is relatively small over the long-term when compared to the cost-savings from the health benefits of these actions, thus providing a strong motivation for further political and individual action. In the Arab region, most countries have ratified the UNFCCC, the Kyoto Protocol and the Paris Agreement and are undertaking a significant number of regional and national mitigation actions. However, more work still needs to be done, especially on the policy front of climate change mitigation measures with direct health benefits.

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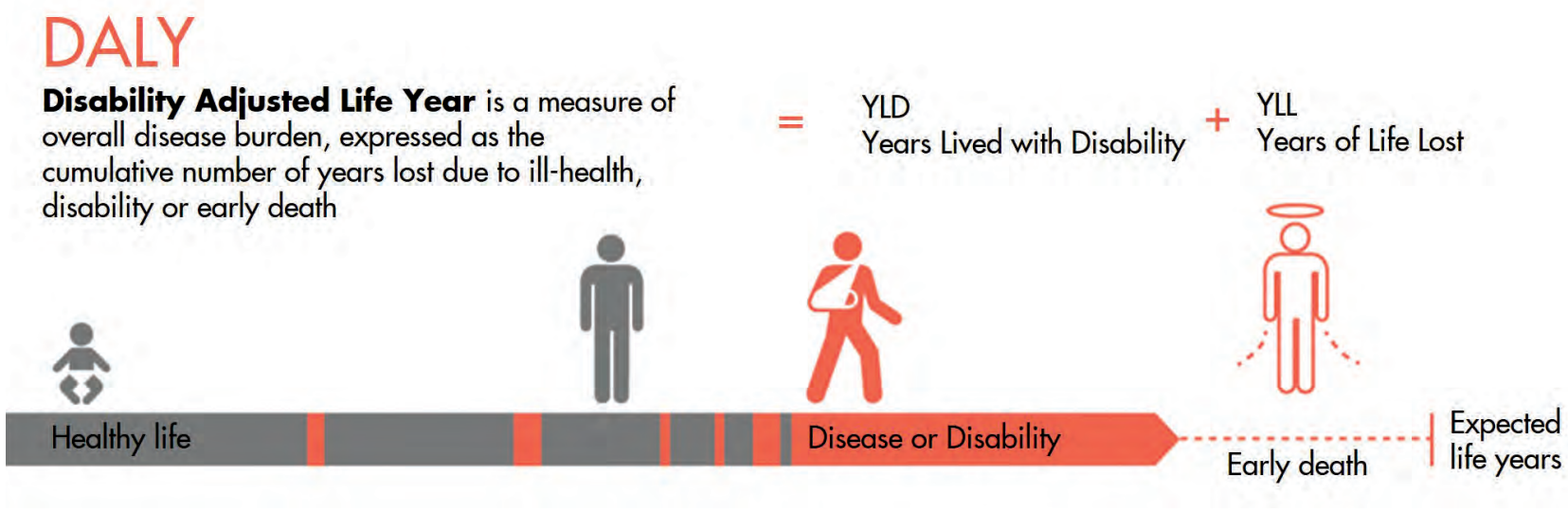
DALY

Disability-Adjusted Life Years (DALYs) is an indicator of the overall disease burden, expressed as the number of healthy life years lost due to diseases causing morbidity or mortality. Assessing DALYs allows the comparison of the burden of diseases that cause early death but little disability with the burden of those that only cause disability.

FRAME 1 **ILLUSTRATION OF THE DISABILITY ADJUSTED LIFE YEARS AS DEFINED BY THE WHO**



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ACRONYMS AND ABBREVIATIONS

10YFP	Ten Year Framework of Programmes on Sustainable Consumption and Production
AAAID	Arab Authority for Agricultural Investment and Development
AAP	Ambient Air Pollutants
ABSP	Agricultural Biotechnology Support Programme
AC	Air-Conditioning
AC	Alternating Current
ACG	Arab Coordination Group
ACSAD	Arabic Centre for the Studies of Arid Zones and Drylands
ACU	Arab Custom Union
ADA	Arriyadh Development Authority (Riyadh)
ADCO	Abu Dhabi Company for Onshore Oil Operations
ADEREE	The National Agency for Energy Efficiency and the Development of Renewable Energy
ADFD	Abu Dhabi Fund for Development
ADR	Alternative Disputes Resolution
ADSG	Abu Dhabi Sustainability Group
ADWEA	Abu Dhabi Water & Electricity Authority
AED	United Arab Emirates Dirham
AEPC	African Environmental Protection Commission
AEPS	Arctic Environmental Protection Strategy
AEWA	African-Eurasian Waterbird Agreement
AFED	Arab Forum for Environment and Development
AFESD	Arab Fund for Economic and Social Development
AG	Associated Gas
AGDP	Agricultural Gross Domestic Product
AGERI	Agricultural Genetic Engineering Institute
AGP	Arab Gas Pipeline
AGU	Arabian Gulf University
AHD	Aswan High Dam
AHDR	Arab Human Development Report
AIA	Advance Informed Agreement
AIDS	Acquired Immunodeficiency Syndrome
AIECGC	Arab Investment and Export Credit Guarantee Corporation
AKTC	Aga Khan Trust for Culture
Al	Aluminum
ALBA	Aluminium Bahrain
ALECSO	Arab League Educational, Cultural, and Scientific Organization
ALMEE	Lebanese Association for Energy Saving & Environment
ALOA	Association for Lebanese Organic Agriculture
AMCEN	African Ministerial Conference on the Environment
AMF	Arab Monetary Fund
AMU	Arab Maghreb Union
ANME	National Agency for Energy Management
AoA	Agreement on Agriculture (WTO Uruguay Round)
AOAD	Arab Organization for Agricultural Development
AP	Advanced Passive reactor
AP	Additional Protocol
API	Arab Planning Institute
APR	Advanced Power Reactor
APRUE	National Agency for the Promotion and Rationalization of Use of Energy
AREE	Aqaba Residence Energy Efficiency
ARWR	Actual Renewable Water Resources
ASABE	American Society of Agricultural and Biological Engineers
ASDRR	Arab Strategy for Disaster Risk Reduction
ASFSD	Arab Strategic Framework for Sustainable Development
ASPnet	Associated Schools Project Network
ASR	Aquifer Storage and Recovery
ASR	Age-Standardised Rate
AU	African Union
AUB	American University of Beirut
AUM	American University of Madaba (Jordan)
AVL	Automatic Vehicle Location
AWA	Arab Water Academy
AWC	Arab Water Council
AWCUA	Arab Water Countries Utilities Association
b/d	Barrels per Day
BADEA	Arab Bank for Economic Development in Africa
BAU	Business as Usual
Bbl	Oil Barrel
BCH	Biosafety Clearing House
Bcm	Billion cubic meters
BCWUA	Branch Canal Water User Association
BDB	Beyond Design Basis
BDL	Central Bank of Lebanon
BEPS	Base Erosion And Profit Shifting
BGR	German Geological Survey
BLL	Blood Lead Levels
BMI	Body-Mass Index
BMP	Best Management Practices
BMZ	German Federal Ministry of Economic Cooperation and Development
BNEF	Bloomberg New Energy Finance
BOD	Biological Oxygen Demand
boe	Barrels of Oil Equivalent
BOO	Build-Own-Operate
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
BP	British Petroleum
BREEAM	Building Research Establishment Environmental Assessment Method
BRO	Brackish Water Reverse Osmosis

BRS	ARZ Building Rating System
BSI	Biome Solar Industry
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BU	Boston University
C&D	Construction and Demolition
C&I	Commercial and Industrial
CA	Conservation Agriculture
CAB	Centre for Agriculture and Biosciences
CAGR	Compound Annual Growth Rate
CAIP	Cairo Air Improvement Project
CAMP	Coastal Area Management Project
CAMRE	Council of Arab Ministers Responsible for the Environment
CAN	Competent National Authority
CAP	Compliance Assistance Programme
CAPs	Criteria Air Pollutants
CAPEX	Capital Expenditures
CBC	Community-Based Conservation
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CBSE	Center for the Study of the Built Environment (Jordan)
CCA	Climate Change Adaptation
CCE	Climate Change Education
CCAP	Climate Change Action Plan
CCESD	Climate Change Education for Sustainable Development
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Sequestration
CCS	Carbon Capture and Storage
CCS CO_2	Capture and Storage
CCUS	Carbon Capture, Usage and Storage
CD	Compact Disk
CDM	Clean Development Mechanism
CDRs	Certified Emissions Reductions
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CEIT	Countries with Economies in Transition
CEO	Chief Executive Officer
CEP	Coefficient of Performance
CERES	Coalition for Environmentally Responsible Economics
CERs	Credits
CFA	Cooperative Framework Agreement
CFC	Chloro-Fluoro-Carbon
CFL	Compact Fluorescent Light
CFL	Compact Fluorescent Lamp
CG	Coordination Groups
CGE	Computable General Equilibrium
CGIAR	Consultative Group on International Agricultural Research
CH4	Methane
CHN	Centre Hospitalier du Nord -Lebanon
CHP	Combined Heat and Power
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
CIRAD	Agricultural Research for Development
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIWM	Chartered Institution of Wastes Management
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CLO	Compost-Like-Output
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CM	Carbon Management
CMI	Community Marketing, Inc.
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNA	Competent National Authority
CNCA	Public Agricultural Bank
CNG (CNS)	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
$CO_{2e/eq}$	CO_2 equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
COPD	Chronic Obstructive Pulmonary Disease
CoP	Community of Practice
COVID19	Novel Coronavirus Disease of 2019
CPB	Cartagena Protocol on Biosafety
CPC	Calcined Petroleum Coke
CRS	Center for Remote Sensing
CSA	City Strategic Agenda
CSD	UN Commission on Sustainable Development
CSEM	Centre Suisse d'Electronique et de Microtechnique
CSO	Civil society organizations
CSP	Concentrated Solar Power
CSR	Corporate Social Responsibility
CSSE	Center for Systems Science and Engineering
CTAB	Technical Center of Organic Agriculture
CUM	Cubic meters
CVD	Cardiovascular Disease
CZIMP	Coastal Zone Integrated Management Plan
DAC	Development Assistance Committee
DALYs	Disability-Adjusted Life Years
DBFO	Design Build Finance Operate
DBO	Design-Build-Operate
DC	Direct current
DAC	Development Assistance Committee
DED	Dubai Economic Department
DASI	Deloitte Accelerator for Social Innovation in the Middle East
DCFs	Directed Credit Funds
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DEM	Digital Elevation Model
DESA	Department of Economic and Social Affairs
DESD	Decade of Education for Sustainable Development
DEWA	Dubai Electricity and Water Authority
DFID	UK Department for International Development
DHW	Domestic Hot Water
DII	DESERTEC Industrial Initiative
DMN	Moroccan National Meteorological Office
DNE	Daily News Egypt
DOE	United States Department of Energy
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSIRE	Database of State Incentives for Renewables & Efficiency
DTC	Dubai Transport Corporation
DTCM	Dubai Department for Tourism and Commerce Marketing
DTIE	UNEP Division of Technology, Industry, and Economics
DTO	Dublin Transportation Office
DUBAL	Dubai Aluminum Company Limited
E3G	Third Generation Environmentalism
EAD	Environment Agency AbuDhabi

EBRD	European Bank for Reconstruction and Development
ECA	Economic Commission for Africa
ECAs	Energy Conversion Agreements
ECE	Economic Commission for Europe
ED	Electrodialysis
EDCO	Electricity Distribution Company
EDF	Environmental Defense Fund
EDL	Electricité du Liban
EDM	Al- BiaWal-Tanmia - Environment & Development magazine
EE	Energy Efficiency
EE	Environmental Education
EFA	Education for All
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
EEPP	Egyptian Environmental Policy Program
EF	Ecological Footprint
EGBC	Egyptian Green Building Council
EGPC	Egyptian General Petroleum Corporation
EGS	Environmental Goods and Services
EIA	Energy Information Administration
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EIU	Economist Intelligence Unit
EJ	Electro Joules
EMA	Europe, the Middle East, and Africa
EMAL	Emirates Aluminium Company Limited
EMAS	Eco-Management and Audit Scheme
EMR	Eastern Mediterranean Region
EMRO	WHO Regional Office for the Eastern Mediterranean
EMS	Environmental Management System
ENEC	Emirates Nuclear Energy Corporation
ENPI	European Neighborhood and Partnership Instrument
ENSO	El Niño-Southern Oscillation
EOR	Enhanced Oil Recovery
EPA	US Environmental Protection Agency
EPC	Engineering Procurement and Construction
EPD	European Patent Office
EPDRB	Environmental Program for the Danube River Basin
EPI	Environment Performance Index
EPSA	Exploration and Production Sharing Agreement
ESAUN	Department of Economic and Social Affairs
ESBM	Ecosystem-Based Management
ESCO	Energy Service Companies
ESCOs	Energy Service Companies
ESCWA	United Nations Economic and Social Commission for Western Asia
ESD	Education for Sustainable Development
ESG	Environmental, Social and Governance
ESDU	Environment and Sustainable Development Unit
ESI	Environment Sustainability Index
ESMAP	World Bank Energy Sector Management Assistance Program
ETFs	Earmarked Tax Funds
ETM	Enhanced Thematic Mapper
EU	European Union
EU ETS	European Union Emission Trading System
EVI	Environmental Vulnerability Index
EWRA	Egyptian Water Regulatory Agency
EWI	Estimated Weekly Intake
EWS	Emirates Wildlife Society
FACE	Free Air Carbon Enrichment
FANR	The Federal Authority for Nuclear Regulation (UAE)
FAO	Food and Agriculture Organization of the United Nations
FBD	Foodborne Diseases
FDI	Foreign Direct Investment
FEBEA	European Federation of Ethical and Alternative Banks
FEMIP	Facility for Euro-Mediterranean Investment and Partnership
FFEM	French Fund for Global Environment
FiBL	Research Institute of Organic Agriculture
FIFA	Fédération Internationale de Football Association
FIT	Feed-in-Tariff
FL&W	Food Lost and Wasted
FOEME	Friends of the Earth Middle East
FPEC	Future Pioneers for Empowering Communities
FSP	Food Security Program
FSU	Former Soviet Union
F-T	Fischer-Tropsch process
FTE	Full Time Equivalent
FTIAB	Packaging and Newspaper Collection Service (Sweden)
G7	Group of Seven: Canada, France, Germany, Italy, Japan, United Kingdom, United States
G8	Group of Eight: Canada, France, Germany, Italy, Japan, Russian Federation,United Kingdom, United States
GAM	Greater Amman Municipality
GAP	Good Agricultural Practices
GAP	Global Action Plan
GAPs	Good Agricultural Practices
GAS	Guarani Aquifer System
GATT	General Agreement on Tariffs and Trade
GAVI	Global Alliance for Vaccine and Immunization
GBC	Green Building Council
GBIF	Global Biodiversity Information Facility
GCC	Gulf Cooperation Council
GCED	Global Citizenship Education
GCF	Green Climate Fund
GCM	General Circulation Model
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GE	General Electric
GECF	Gas Exporting Countries Forum
GEF	Global Environment Facility
GEMR	Global Education Monitoring Report
GEMS	Global Environment Monitoring System
GEO	Global Environment Outlook
GERD	Gross Domestic Expenditure on Research and Development
GFEI	Global Fuel Economy Initiative
GFs	Green Funds
GFU	Global Facilitation Unit for Underutilized Species
GGGI	Global Green Growth Institute
Gha	Global hectare
GHGs	Greenhouse Gases
GIPB	Global Partnership Initiative for Plant Breeding Capacity Building
GIS	Geographical Information Systems
GIWA	Global International Waters Assessment
GJ	GigaJoule
GLASOD	Global Assessment of Soil Degradation

GLAAS	Global Analysis and Assessment of Sanitation and Drinking-Water
GLCA	Global Leadership for Climate Action
GM	Genetically Modified
GME	Gazoduc Maghreb Europe
GMEF	Global Ministerial Environment Forum
GMO	Genetically Modified Organism
GMP	Green Moroccan Plan
GNI	Gross National Income
GNP	Gross National Product
GPC	Green petroleum Coke
GPEDC	Global Partnership for Effective Development Cooperation
GPS	Global Positioning System
GPRS	Green Pyramid Rating System
GRI	Global Reporting Initiative
GRID	Global Resource Information Database
GSDP	General Secretariat for Development planning-Qatar
GSI IISD	Global Subsidies Initiative
GSLAS	General Secretariat of League of Arab States
GSR	Global Status Report
Gt	Gigaton
GTZ	German Technical Cooperation (Gesellschaft für Technische Zusamm)
GVC	Civil Volunteers' Group (Italy)
GW	Gigawatt
GW	Greywater
GW_e	Gigawatt electrical
GWI	Global Water Intelligence
GWP	Global Warming Potential
GWP	Global Water Partnership
GW_{th}	Gigawatt-thermal
ha	Hectares
HAB	Harmful Algal Bloom
HACCP	Hazardous Analysis and Critical Control Points
HAPs	Hazardous Air Pollutants
HCFC	hydrochlorofluorocarbons
HDI	Human Development Index
HFA	Hyogo Framework for Action
HFCs	Hydrofluorocarbons
HFO	Heavy Fuel Oil
HiAP	Health in All Policies
HICs	High-Income Countries
HIV	Human Immunodeficiency Virus
HLW	High Level Waste
HNAP	Health National Adaptation Process
HNWI	High Net Worth Individuals
HPMPs	HCFC phase-out management plans
HVAC	Heating, Ventilation, and Air-Conditioning
I/M	Inspection and Maintenance
IAP	Indoor Air Pollution
IAASTD	International Assessment of Agricultural Knowledge Science and Technology for Development
IAEA	International Atomic Energy Agency
IAS	Irrigation Advisory Service
IC	Irrigation Council
ICAM	Integrated Coastal Area Management
ICARDA	International Center for Agricultural Research in Dry Areas
ICBA	International Center for Biosaline Agriculture
ICC	International Chamber of Commerce
ICEE	International Conference on Environmental Education
ICGEB	International Center for Genetic Engineering and Biotechnology
ICLDC	Imperial College London Diabetes Centre
ICM	Integrated Coastal Management
ICPDR	International Commission for the Protection of the Danube River
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDA	International Desalination Association
IDB	Islamic Development Bank
IDECO	Irbid District Electricity Company
IDP	Internally Displaced Persons
IDPs	Internally displaced people
IDRC	International Development Research Center
IDSC	Information and Decision Support Center
IEA	International Energy Agency
IEADSM	International Energy Agency Demand-side Management
IEEE	Institute of Electrical and Electronic Engineers
IEEF	Inclusive Economic Empowerment Finance Facility
IFA	International Fertilizer Industry Association
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
IGCC	Integrated Gasifier Combined Cycle
IHME	Institute for Health Metrics and Evaluation
IHP	International Hydrology Program
IIED	International Institute for Environment and Development
IIIEE	Lund University International Institute for Industrial Environmental Economics
IIIP	Integrated Irrigation Improvement Project
IIP	Irrigation Improvement Project
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
ILW	Intermediate Level waste
IMC	Istituto Mediterraneo Di Certificazione
IMF	International Monetary Fund
IMO	International Maritime Organization
INDC	Intended Nationally Determined Contributions
InWEnt	Capacity Building International-Germany
IO	Input-Output
IOC	International Oil Companies
IPCC	Intergovernmental Panel on Climate Change
IPF	Intergovernmental Panel on Forests
IPM	Integrated Pest Management
IPNS	Integrated Plant Nutrient System
IPP	Independent Power Producer
IPR	Intellectual Property Rights
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IRENA	International Renewable Energy Agency
IRESEN	Institut de Recherche en Energie Solaire et en Energies Nouvelles
IRR	Internal Rate Of Return
ISCC	Integrated Solar Combined Cycle
IsDB	Islamic Development Bank
ISESCO	Islamic Educational, Scientific, and Cultural Organization
ISIC	UN International Standard Industrial Classification
ISO	International Organization for Standardization
ISWM	Integrated Solid Waste Management

ITC	Integrated Tourism Centers
ITC	International Trade Center
ITSAM	Integrated Transport System in the Arab Mashreq
IUCN	International Union for Conservation of Nature
IUCN	World Conservation Union (International Union for the Conservation of Nature and Natural Resources)
IWMI	International Water Management Institute
IWPP	Independent Water And Power Producer
IWRB	International Waterfowl and Wetlands Research Bureau
IWRM	Integrated Water Resources Management
JAEC	Jordan Atomic Energy Commission
JBAW	Jordan Business Alliance on Water
JCEDARE	Joint Committee on Environment and Development in the Arab Region
JD	Jordanian Dinar
JEPCO	Jordan Electric Power Company
JI	Joint Implementation
JMWI	Jordan Ministry for Water and Irrigation
JNRC	Jordan Nuclear Regulatory Commission
JREEEF	Jordan Renewable Energy and Energy Efficiency Fund
JVA	Jordan Valley Authority
KA-CARE	King Abdullah City for Atomic and Renewable Energy
KACST	King Abdulaziz City for Science and Technology
KAHRAMAA	Qatar General Electricity and Water Corporation
KAUST	King Abdullah University of Science and Technology
KEPCO	Korea Electric Power Corporation
KFAED	Kuwait Fund for Arab Economic Development
KFUPM	King Fahd University of Petroleum and Minerals
KfW	German Development Bank
KISR	Kuwait Institute for Scientific Research
KSA	Kingdom of Saudi Arabia
KW	Kilowatt
kWh	Kilowatt-hour
LADA	Land Degradation Assessment of Drylands
LAS	League of Arab States
LATA	Lebanese Appropriate Technology Association
LAU	Lebanese American University
LBNL	Lawrence Berkeley National Laboratory
LCC	Life Cycle Costing
LCEC	Lebanese Center for Energy Conservation
LCOE	Levelized Costs of Electricity
LDCs	Least Developed Countries
LDN	Land degradation neutrality
LED	Light-Emitted Diode
LEED	Leadership in Environmental Design
LEMA	Suez Lyonnaise des Eaux, Montgomery Watson and Arabtech Jardaneh
LEU	Low-enriched Uranium
LGBC	Lebanon Green Building Council
LLF	Lives & Livelihoods Fund
LICs	Low-Income Countries
LLW	Low Level Waste
LMBAs	Land and Marine Based Activities
LMEs	Large Marine Ecosystems
LMG	Like Minded Group
LMICs	Low Middle-Income Countries
LMO	Living Modified Organism
LNG	Liquefied Natural Gas
LowCVP	Low Carbon Vehicle Partnership
LPG	Liquefied Petroleum Gas
LRA	Litani River Authority
LV	Low Voltage
MAAR	Syrian Ministry of Agriculture and Agrarian Reform
MAD	Moroccan Dirham
MALR	Ministry of Agriculture and Land Reclamation
MAP	UNEP Mediterranean Action Plan
MARPOL	International Convention for the Prevention of Pollution from Ships
MASEN	Moroccan Agency for Solar Electricity
mb/d	million barrels per day
MBT	Mechanical-biological treatment
MCM	Million Cubic Meters
MD	Membrane Distillation
MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreement
MECTAT	Middle East Centre for the Transfer of Appropriate Technology
MED	Multiple-Effect Distillation
MEdIES	Mediterranean Education Initiative for Environment and Sustainability
MED WWR WG	Mediterranean Wastewater Reuse Working Group
MED-ENEC	Energy Efficiency in the Construction Sector in the Mediterranean
MEES	Middle East Economic Survey
MEMAC	Marine Emergency Mutual Aid Centre
MENA	Middle East and North Africa
MEPS	Minimum Energy Performance Standards
MERS	Middle-East Respiratory Syndrome
METAP	UNEP Mediterranean Environmental Technical Assistance Program
MEW	Lebanese Ministry of Energy and Water
MGD	Million Gallon per Day
MHT	Mechanical Heat Treatment
MICE	Meetings, Incentives, Conferences, And Events
MICs	Middle-Income Countries
MIGA	Multilateral Investment Guarantee Agency
MIO-ECSDE	Mediterranean Information Office for Environment, Culture and Sustainable Development
MJ	Mega Joule
MIST	Masdar Institute of Science and Technology
MMBTU	One Million British Thermal Units
MMCP	Making the Most of Commodities Programme
MNA	Multinational Approaches
MoCCE	Ministry of Climate Change and Environment
MP	Microplastic
MPL	Maximum Permissible Limit
MOQ	Maersk Oil Qatar
MOU	Memorandum of Understanding
MOX	Mixed-Oxide
MPA	Marine Protected Area
MPAP	Multi-Stakeholder Policy Formulation and Action Planning
MPAR	Ministry of Planning and Administrative Reform
MSF	Multi-Stage Flash
MSF	Multi-Stakeholder Forum
MSP	Mediterranean Solar Plan
MSW	Municipal Solid Waste
Mt	Metric tons
MT	Million ton
Mt	Megatons

$MtCO_2$	Million tons of CO_2
Mtoe	Million tons of oil equivalent
MTPY	Metric Tons Per Year
MV	Medium Voltage
MW	Megawatt
MW_h	Megawatt-hour
MW_p	Megawatt-peak
MWRI	Ministry of Water Resources and Irrigation
MW_{th}	Megawatt-thermal
MVR	Measurement, Reporting and Verification
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Actions
NARI	National Agricultural Research Institutes
NARES	National Agricultural Research and Extension Systems
NAP	National Adaptation Process
NASA	National Aeronautics and Space Administration
NBC	National Biosafety Committee
NBDF	Nile Basin Discourse Forum
NBF	National Biosafety Framework
NBI	Nile Basin Initiative
NBM	Nile Basin Management
NC	National Communication
NCDs	Non-Communicable Diseases
NDC	Nationally Determined Contributions
NEPCO	National Electric Power Company
NCSR	Lebanese National Council of Scientific Research
ND	Neighborhood Development
NDW	Moroccan National Drought Watch
NEA	Nuclear Energy Agency
NEAP	National Environmental Action Plan
NEEAP	National Energy Efficiency Action Plan
NEEP	National Energy Efficiency Program
NEEREA	National Energy Efficiency and Renewable Energy Action (Lebanon)
NERC	National Energy Research Centre
NF	Nano-Filtration
NFC	Nile Forecast Center
NFP	National Focal Point
NGCCs	Natural-Gas-Fired Combined Cycles
NGGP	National Green Growth Plan
NGO	Non-Governmental Organization
NGV	Natural Gas Vehicles
NGWA	Northern Governorates Water Authority (Jordan)
NIF	Neighborhood Investment Facility
NMC	Northern Mediterranean countries
NMVC	Non-Methane Volatile Compounds
NOAA	National Oceanic and Atmospheric Administration
NOC	National Oil Company
NOEC	Net Oil Exporting Countries
NOGA	National Oil and Gas Authority (Bahrain)
NOIC	Net Oil Importing Countries
NORDEN	Nordic Council of Ministers
NOx	Nitrogen Oxides
NPK	Nitrogen, Phosphates and Potash
NPP	Nuclear Power Plant
NPP	Net Primary Productivity
NPPA	Nuclear Power Plant Authority
NPT	Non-Proliferation treaty of nuclear weapons
NRC	National Research Council
NREL	National Renewable Energy Laboratory
NREAP	National Renewable Energy Action Plans
NRW	Non-Revenue Water
NSAS	Nubian Sandstone Aquifer System
NSR	North-South Railway project
NUS	Neglected and underutilized species
NWRC	National Water Research Center (Egypt)
NWSAS	North Western Sahara Aquifer System
OA	Organic Agriculture
O&M	Operation and Maintenance
OAPEC	Organization of Arab Petroleum Exporting Countries
OAU	Organization for African Unity
ODA	Official Development Assistance
ODP	Ozone Depletion Potential
ODS	Ozone-Depleting Substance
ODDD	Organisation de Développement Durable
OECD	Organization for Economic Co-operation and Development
OFID	OPEC Fund for International Development
OIC MCs	Organization of Islamic Conference Member Countries
OIES	Oxford Institute for Energy Studies
OME	Observatoire Méditerranéen de l'Energie
OMW	Olive Mills Wastewater
ONA	Omnium Nord-Africain
ONE	National Electricity Office
ONEP	National Office of Potable Water
OPEC	Organization of Petroleum Exporting Countries
OPEX	Operational Expenditures
OSS	Sahara and Sahel Observatory (Observatoire du Sahara et du Sahel)
OWG	Open Working Group
PACD	Plan of Action to Combat Desertification
PAHs	Polyaromatic Polycyclic Hydrocarbons
PARC	Pan Arab Research Centre
PAYT	Pay-As-You-Throw
PBCs	Performance-Based Contracts
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PCFPI	Per Capita Food Production Index
PCFV	Partnership for Clean Fuels and Vehicles
PEA	Palestinian Energy and Natural Resources Authority
PERG	Global Rural Electrification Program
PERSGA	Protection of the Environment of the Red Sea and Gulf of Aden
PFCs	Perfluorocarbons
PHEIC	Public Health Emergency of International Concern
PICs	Pacific Island Countries
PIF	Public Investment Fund
PIM	Participatory Irrigation Management
PJ	Peta Joule
PM	Particulate Matter
PMU	Program Management Unit
PNA	Palestinian National Authority
PNEEI	Tunisian National Program of Irrigation Water Conservation
POPs	Persistent Organic Pollutants
PPA	Power Purchase Agreement
PPE	Personal Protection Equipment
PPIAF	Public-Private Infrastructure Advisory Facility
PPM	Parts Per Million
PPM	Process and Production Methods

PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PPP	Public-Private Partnership
PRM	Persons with Reduced Mobility
PSPER	Promotion of Sustainability in Postgraduate Education and Research Network
PRY	Potential Researcher Year
PTSs	Persistent Toxic Substances
PTWI	Provisional Tolerable Weekly Intake
PV	Photovoltaic
PWA	Palestinian Water Authority
QNFSP	Qatar National Food Security Programme
QP	Qatar Petroleum
QSAS	Qatar Sustainable Assessment System
R&D	Research and Development
RA	Risk Assessment
RADEEMA	Régie autonome de distribution de l'eau et de l'électricité de Marrakech
RB	Raised Bed
RBA	Results-Based Approach
RBF	Results-based financing
RBO	River Basin Organization
RBP	Restrictive Business Practices
RCE	Regional Centre of Expertise on Education for Sustainable Development
RCM	Regional Circulation Model
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
RDF	Refuse Derived Fuel
RDGA	Red Sea and Gulf of Aden
RE	Renewable Energy
REC	Renewable Energy Credits
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
REN21	Renewable Energy Policy Network for the 21st Century
Rep	Republic
RET	Renewable Energy Technologies
RISE	Regulatory Indicators for Sustainable Energy
RM	Risk Management
RO	Reverse Osmosis
ROPME	Regional Organization for the Protection of the Marine Environment of the sea area surrounded by Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates
RPS	Renewable Portfolio Standard
RSA	ROPME Sea Area
RSC	Royal Society of Chemistry (UK)
RSCN	Royal Society for the Conservation of Nature
RSGA	Red Sea and Gulf of Aden
RUAF	Resource Centers Network on Urban Agriculture and Food Security
S&T	Science and Technology
SAIC	Science Applications International Corporation
SAP	Strategic Action Program
SASO	Saudi Standards, Quality and Metrology Organization
SCP	Sustainable Consumption and Production
SCPI	Sustainable Crop Production Intensification
SCADA	Supervisory Control and Data Acquisition software
SCP/RAC	Regional Activity Centre for Sustainable Consumption and Production
SD	Sustainable Development
SDGs	Sustainable Development Goals
SDIAR	Sustainable Development Initiative in the Arab region
SEA	Strategic Environmental Assessment
SEEA	System of Environmental and Economic Accounting
SEEC	Saudi Energy Efficiency Cen
SEGC	Chinese Shanghai Electric Generation Group
SEMC	Southern and Eastern Mediterranean Countries
SFD	Saudi Fund for Development
SHS	Solar Home System
SIR	Shuttle Imaging Radar
SIWI	Stockholm International Water Institute
SL	Syrian Pound
SLM	Sustainable Land Management
SLR	Sea Level Rise
SME	Small and Medium-Size Enterprises
SMS	Short Messaging Service
SNA	System Of National Accounts
SoE	State of the Environment
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux
SOx	Sulfur Oxides
SPD	Sozialdemokratische Partei Deutschlands
SPM	Suspended Particulate Matter
SRES	Special Report on Emission Scenarios
SRTM	Shuttle Radar Topography Mission
SSA	Sub-Saharan Africa
SSR	Self-Sufficiency Ratio
SRIs	Socially Responsible Investments
STI	Science, Technology and Innovation
SWCC	Saline Water Conversion Corporation
SWH	Solar Water Heating
SWRO	Seawater Reverse Osmosis
SWIM	Sustainable Water Integrated Management
SWIM SM	Sustainable Water Integrated Management Support Mechanism
SWM	Solid Waste Management
T&D	Transmission and Distribution
TAC	Technical Advisory Committee
TAR	Third Assessment Report
Tcm	Trillion cubic meters
TDM	Transportation Demand Management
TDS	Total Dissolved Solids
TES	Thermal Energy Storage
TFP	Total Factor Productivity
TFEC	Total Final Energy Consumption
THQ	Target Hazard Quotient
TIES	The International Ecotourism Society
TII	Thermal Insulation Implementation
Toe	Tons of Oil Equivalent
TOSSD	Total official support for sustainable development
TPES	Total Primary Energy Supply
TRAFFIC	Trade Records Analysis for Flora and Fauna in International Commerce
TRI	Toxics Release Inventory
TRIPs	Trade-Related Aspects of International Property Rights
TRMM	Tropical Rainfall Measuring Mission
TPH	Total Petroleum Hydrocarbon
tU	tones of Uranium

TVET	Technical and Vocational Education and Training
TWh	Terawatt-hour
UA	Urban Agriculture
UAB	Union of Arab Banks
UAE	United Arab Emirates
UCLA	University of California at Los Angeles
UCS	Union of Concerned Scientists
UF	Ultrafiltration
UfM	Union for the Mediterranean
UHC	Universal health coverage
UHCPV	Ultra-High Concentration Photovoltaic
UHI	Urban Heat Island
UIS	UNESCO Institute for Statistics
UK	United Kingdom
UMA	Union du Maghreb Arabe (Arab Maghreb Union)
UMICs	Upper Middle-Income Countries
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCHS	United Nations Centre for Human Settlements (now UN-Habitat)
UNCLOS	United Nations Convention on the Law of the Sea
UNCOD	United Nations Conference on Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-ROSTAS	UNESCO Regional Office for Science and Technology for the Arab States
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commission for Refugees
UNICE	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction
UNLD	United Nations Literacy Decade
UNWTO	United Nations World Tourism Organization
UPC	Abu Dhabi Urban Planning Council
UPI	United Press International
USA	United States of America
USAID	United States Agency for International Development
USCCSP	United States Climate Change Science Program
USEK	Université Saint-Esprit De Kaslik
USEPA	United States Environmental Protection Agency
USJ	Saint Joseph University
USPTO	United States Patent and Trademark Office
UV	Ultraviolet (A and B)
VAT	Value-Added Tax
VC	Vapor Compression
VCM	Volatile Combustible Matter
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VRS	Vapor Recovery System
WACC	Weighted Average Cost of Capital
WaDImena	Water Demand Initiative for the Middle East and North Africa
WAJ	Water Authority of Jordan
WASH	Water, Sanitation and Hygiene
WALIR	Water Law and Indigenous Rights
WANA	West Asia and North Africa Region
WB	West Bank
WBCSD	World Business Council for Sustainable Development
WBG	World Bank Group
WBGU	German Advisory Council on Global Change
WCD	World Commission on Dams
WCED	World Commission on Environment and Development
WCMC	UNEP World Conservation Monitoring Center
WCP	World Climate Programme
WCS	World Conservation Strategy
WDM	Water Demand Management
WDPA	World Database on Protected Areas
WEEE	Waste of Electronic and Electrical Equipment
WEF	World Economic Forum
WEF	Water-Energy-Food
WEF	World Education Forum
WEI	Water Exploitation Index
WETC	Wind Energy Technology Centre
WF	Water Footprint
WFN	Water Footprint Network
WFP	World Food Programme
WGP-AS	Water Governance Program in the Arab States
WGEO	World Green Economy Organization
WHA	World Health Assembly
WHC	Word Heritage Convention
WHO	World Health Organization
WIPP	Waste Isolation Pilot Plant
WMO	World Meteorological Organization
WNA	World Nuclear Association
Wp	Watt-peak
WRI	World Resources Institute
WSSCC	Water Supply and Sanitation Collaborative Council
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WTTC	World Travel and Tourism Council
WUA	Water User Association
WUE	WUE Water Use Efficiency
WWAP	World Water Assessment Program
WWC	World Water Council
WWF	World Wide Fund for Nature
WWF	World Water Forum
WWI	First World War
WWII	Second World War
YASAD	Yemenite Association for Sustainable Agriculture and Development
YR	Year
YLL	Years of Life Lost
ZT/CA	Conservation Agriculture/Zero Tillage

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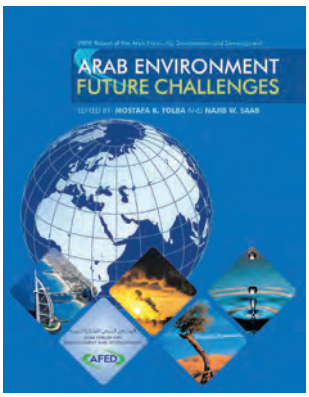
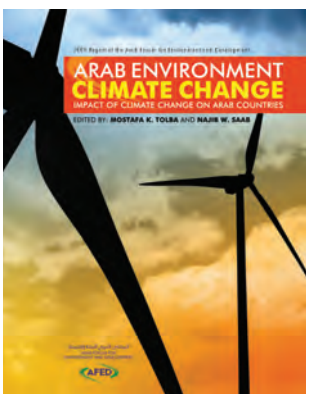


Arab Environment: Future Challenges

2008 Report of the Arab Forum for Environment and Development

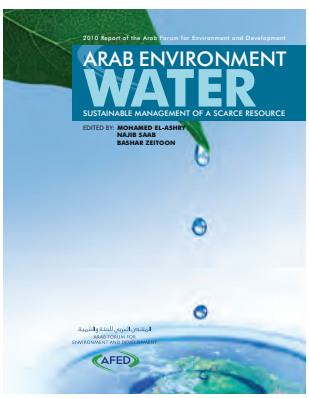
For the first time, a comprehensive independent expert report on Arab environment is released for public debate. Entitled *Arab Environment: Future Challenges*, this ground-breaking report has been commissioned by Arab Forum for Environment and Development (AFED), and written by some of the most prominent Arab experts, including authors, researchers and reviewers. Beyond appraising the state of the environment, based on the most recent data, the policy-oriented report also evaluates the progress towards the realization of sustainable development targets, assesses current policies and examines Arab contribution to global environmental endeavors. Ultimately, the report proposes alternative policies and remedial action.



Arab Environment: Climate Change

2009 Report of the Arab Forum for Environment and Development

Impact of Climate Change on the Arab Countries is the second of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). The report has been designed to provide information to governments, business, academia and the public about the impact of climate change on the Arab countries, and encourage concrete action to face the challenge. The report analyzes the Arab response to the urgent need for adaptation measures, and uses the latest research findings to describe the vulnerabilities of natural and human systems in the Arab world to climate change and the impacts on different sectors. In an attempt to help shape adequate policies, the report discusses options for a post-Kyoto regime and outlines the state of international negotiations in this regard.



Arab Environment: Water

2010 Report of the Arab Forum for Environment and Development

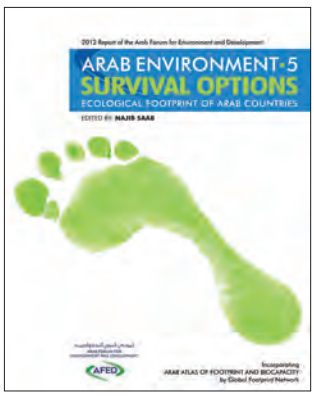
Water: Sustainable Management of a Scarce Resource is the third of a series of annual reports produced by the Arab Forum for Environment and Development (AFED). It follows the publication of two reports, Arab Environment: Future Challenges in 2008 and Impact of Climate Change on Arab countries in 2009. The 2010 report is designed to contribute to the discourse on the sustainable management of water resources in the arab world and provides critical understanding of water in the region without being overly technical or academic in nature. The unifying theme is presenting reforms in policies and management to develop a sustainable water sector in Arab countries. Case studies, with stories of successes and failures, are highlighted to disseminate learning. This report contributes to the ongoing dialogue on the future of water and catalyzes institutional reforms, leading to determined action for sustainable water policies in Arab countries.

Arab Environment: Green Economy

2011 Report of the Arab Forum for Environment and Development

Green Economy: Sustainable Transition in a Changing Arab World is the fourth of a series of annual reports on the state of Arab environment, produced by the Arab Forum for Environment and Development (AFED). This report on options of green economy in Arab countries represents the first phase of the AFED green economy initiative. Over one hundred experts have contributed to the report, and discussed its drafts in a series of consultation meetings. The report is intended to motivate and assist governments and businesses in making a transition to the green economy.

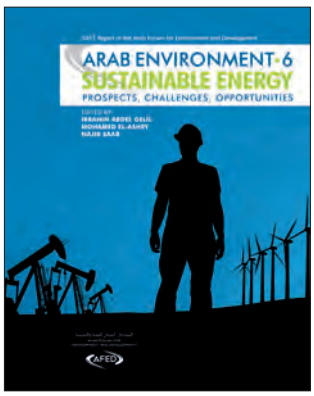
It articulates enabling public policies, business models, green investment opportunities, innovative approaches, and case studies, and addresses eight sectors: agriculture, water, energy, industry, cities and buildings, transportation, tourism, and waste management.



Arab Environment: Survival Options

2012 Report of the Arab Forum for Environment and Development

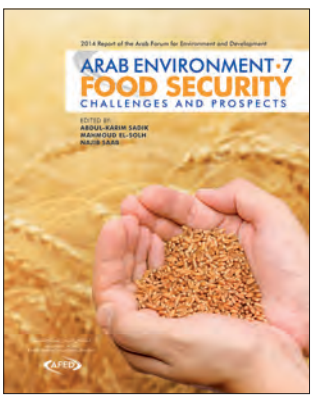
Survival Options - Ecological Footprint of Arab Countries is the fifth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of the Arab environment. It examines sustainability choices in Arab countries, based on a survey of people's demand of natural capital and available supply. The report discusses potential paths to sustainability based on ecological constraints. As a basis for the analysis, AFED has commissioned the Global Footprint Network, the world leader in this field, to produce an Arab Ecological Footprint and Biocapacity Atlas using the most recent data available. The Atlas covers the 22 members of the League of Arab States, as region, sub-regions and individual countries. The analysis focuses on the challenges posed by the state of food security, water and energy, while considering main drivers such as population and patterns of production and consumption. Ultimately, it prescribes regional cooperation and sound management of resources as the main options for survival in a region characterized by stark variations in ecological footprint, natural resources and income.



Arab Environment: Sustainable Energy

2013 Report of the Arab Forum for Environment and Development

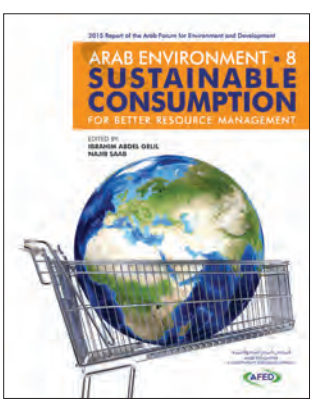
Sustainable Energy is the sixth in the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of Arab environment. The report highlights the need for more efficient management of the energy sector, in view of enhancing its contribution to sustainable development in the Arab region. The AFED 2013 report aims at: presenting a situational analysis of the current state of energy in the Arab region, shedding light on major challenges, discussing different policy options and, ultimately, recommending alternative courses of action to help facilitate the transition to a sustainable energy future. To achieve its goals, the AFED 2013 report addresses the following issues: oil and beyond, natural gas as a transition fuel to cleaner energy, renewable energy prospects, the nuclear option, energy efficiency, the energy-water-food nexus, mitigation options of climate change, resilience of the energy sector to climate risk, and the role of the private sector in financing sustainable energy.



Arab Environment: Food Security

2014 Report of the Arab Forum for Environment and Development

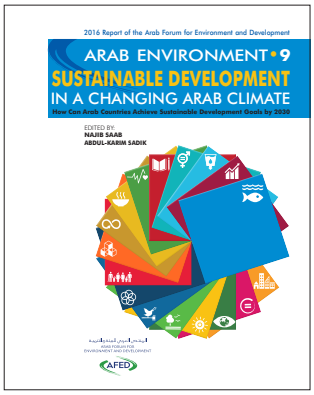
Food Security is the seventh in the series of annual reports on the state of Arab environment, produced by the Arab Forum for Environment and Development (AFED). The report highlights the need for more efficient management of the agriculture and water sectors, in view of enhancing the prospects of food security. *Food security* is of great concern to Arab countries. They have been pursuing a target of higher food self-sufficiency rate, but achieving this goal remained beyond reach. While they have limited cultivable land and scarce water resources, they did not use their agricultural endowments in an effective and efficient manner. Lack of appropriate agricultural policies and practices led to diminishing the bio-capacity of the resources to regenerate their services and threatened agricultural sustainability. AFED hopes that its report on Food Security will help Arab countries adopt the right policies and commit to long-term investments, allowing them to secure a sustainable supply of food to meet ever-growing needs.



Arab Environment: Sustainable Consumption

2015 Report of the Arab Forum for Environment and Development

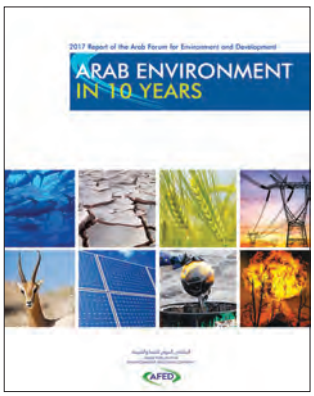
Increasing production alone cannot solve the need of food for hungry people and water for thirsty people, nor will it provide power to dark villages. Equally, solely building more waste dumps and incinerators cannot solve the trash crisis. Inadequate consumption patterns are at the core of the problem, and any feasible solution requires a fundamental change in the way we consume resources and produce waste. Thus, the 2015 AFED Annual Report, *Sustainable Consumption for Better Resource Management*, discusses how changing consumption patterns can help preserve resources and protect the environment, ultimately leading to sustainable development. While it is true that changing consumption patterns requires adequate policies based on expert studies, the support of consumers is a prerequisite for successful implementation. AFED carried out a wide-ranging public opinion survey, which found that the Arab public is ready to pay more for energy and water and to change their consumption patterns if this will help preserve resources and protect the environment.



Arab Environment: Sustainable Development in a Changing Arab Climate

2016 Report of the Arab Forum for Environment and Development

This AFED report on "*Sustainable Development in a Changing Arab Climate*" highlights the policy options available for the Arab countries to realize the Sustainable Development Goals by the 2030 target set by the United Nations, in light of the new political, economic, and social developments. The report recommends an alternative approach, based on integrating sustainable development principles within the anticipated rebuilding efforts. It calls upon local, regional, and international aid organizations not to limit their efforts to providing safety and basic necessities to those affected, but rather to use the relief plans as a launch pad for promoting new approaches to development, rooted in a transition to green economy.

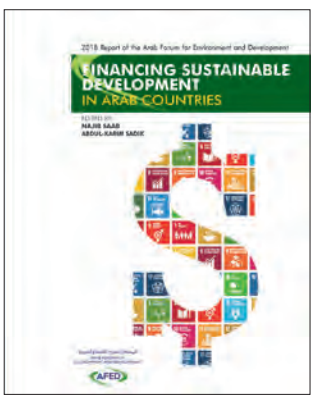


Arab Environment In 10 Years

2017 Report of the Arab Forum for Environment and Development

Arab Environment In 10 Years crowns a decade of the series of annual reports produced by the Arab Forum for Environment and Development (AFED) on the state of Arab environment. It tracks and analyzes changes focusing on policies and governance, including level of response and engagement in international environmental treaties. It also highlights developments in six selected priority areas, namely water, energy, air, food, green economy and environmental scientific research.

This report found that the state of environment in the Arab countries over the past ten years has been characterized by disparities. While progress was slow and the situation deteriorated in many aspects, there were advances in others, especially regarding matters related to governance and commitment to international treaties, particularly regarding climate change.



Financing Sustainable Development in Arab Countries

2018 Report of the Arab Forum for Environment and Development

Financing Sustainable Development in Arab Countries identifies financing needs, gaps, options and mechanisms, while focusing on potential financing sources and addressing enhancement of their roles. The report found that Arab countries would need a minimum of USD 230 billion annually to support the achievement of the SDGs. The financing gap in Arab countries with deficit has been estimated at over USD 100 billion, comprising a cumulative total of over USD 1.5 trillion through 2030. This does not only call for new funding requirements but also the greening of budgets and the redirecting of existing budgetary allocations from conventional investments to sustainable ones, including addressing climate change concerns.

Environmental Education for Sustainable Development in Arab Countries

2019 Report of the Arab Forum for Environment and Development

Environmental Education for Sustainable Development in Arab Countries is the topic of the 2019 annual report of the Arab Forum for Environment and Development (AFED). It provides the first comprehensive survey of environmental contents in school and university curricula across the Arab countries, in view of identifying gaps and recommending pathways to enhance the role of education in advancing environmental protection and implementing the Sustainable Development Goals (SDGs). The report found that during the last decade, Arab universities witnessed a rapid increase in programs related to the environment and sustainable development. Collectively, the 57 universities surveyed offer 221 degree programs on environmental topics. Postgraduate programs are typically research-An AFED survey of school textbooks and curricula found that environmental topics most popular in Arab schools are ecosystems, natural resources, pollution and sustainable development oriented.

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في الخطوات نحو مراعاة أكبر للمخاطر البيئية على صحة الإنسان، والتي يمكن تجنّبها إلى حدٍ كبير. في إطار التعاون الإقليمي، يتعين على وزارات الصحة والبيئة في المنطقة العربية تأكيدً أهمية الترابط بين الصحة البشرية العامة والبيئة الطبيعية. ويجب أن تتحمل معاً مسؤوليات الحوكمة والمراقبة، وتحفيز القطاعات ذات الصلة على اتخاذ الإجراءات الوقائية والتدخلات التصحيحية.

في ما يخص توفير خدمات المياه الصالحة للشرب، على الدول العربية تطوير وتنفيذ برامج المياه والصرف الصحي التي تشمل المراقبة الشاملة لكمية إمدادات المياه ونوعيتها. وفي ما يتعلق بتلوث الهواء، يجب تحديث معايير جودة الهواء لتتوافق مع المعايير الدولية المرتبطة بالصحة، كما يجب سدّ فجوات البيانات للحصول على تقويم دقيق لتأثير تلوث الهواء على معدلات انتشار الأمراض والوفيات في المنطقة. ومن الضروري وجود شبكة من محطات المراقبة العاملة في جميع الدول العربية لمراقبة جودة الهواء. ومع أخذ تأثيرات تغيُّر المناخ الخاصة بالمنطقة في الاعتبار، يجب تطوير استراتيجيات فعالة ومصممة خصيصاً للحدّ من مسببات تغيُّر المناخ والتكيُّف معه، تكون ذات آثار مباشرة وواضحة على صحة السكان العرب، مع اتخاذ إجراءات فورية في شأن تدابير التكيُّف، ذلك أنه لم يعد ممكناً مواجهة بعض الأثار من طريق تخفيف الانبعاثات فقط. والملاحظ أن الآثار السلبية للزيادة في توليد النفايات في المنطقة، وسوء إدارتها اللاحقة، تتفاقم نتيجة نقص التشريعات. لذا يجب تطوير التشريعات، في موازاة إطار شامل للرصد وتقويم تأثير النفايات على صحة الإنسان. كذلك يجب توجيه مزيد من الاهتمام إلى حالة البيئة البحرية في المنطقة ومخاطرها المحتملة على صحة الإنسان. فالرصد المنتظم لمستويات المعادن الثقيلة في أنواع الأسماك، على سبيل المثال، ضروري لمنع المخاطر الصحية ولضمان شروط السلامة الغذائية. وينبغي أيضاً معالجة القمامة البحرية، التي تؤدي إلى زيادة اللدائن الدقيقة. ولتحقيق نتائج حقيقية، لا بد من وجود آليات مناسبة لإنفاذ المعايير والقوانين.

ثمة حاجة إلى تبادل الخبرات في التخصصات المتعلقة بالصحة والبيئة عبر البلدان العربية، مع تكثيف التعاون الإقليمي، بما يشمل التأهب للطوارئ لمواجهة الكوارث الصحية والبيئية. ويبقى إنشاء نظام رعاية صحية أولية، بما في ذلك التثقيف الصحي، مهمة ملحّة. وفي نهاية المطاف، تبقى الحاجة إلى استراتيجيات إقليمية تحدد أهدافاً مشتركة لتحقيق أهداف التنمية المستدامة.

لطالما كان الترابط بين البيئة الطبيعية وصحة الإنسان مصدر قلق جدي، لكن خطر تفشّي الأوبئة يضعه اليوم في مركز الصدارة. الآن، أكثر من أي وقت مضى، بات واضحاً أن البيئة الطبيعية الصحية هي شرط أساسي لصحة البشر.

والمحار، مما يؤدي إلى عواقب على صحة الإنسان. ويُذكر أن البحر المتوسط يُعتبر من أكثر المناطق تضرراً في العالم من حيث التلوث بالمواد البلاستيكية الدقيقة.

ثمة حاجة إلى مزيد من البحث لاستكشاف التأثير المباشر لحالة البيئة البحرية على صحة الإنسان في المنطقة العربية، مع التركيز على مسببات الأمراض ونقل السموم إلى الإنسان ومقاومة مضادات الميكروبات.

تغيُّر المناخ

تم الاعتراف بتغيُّر المناخ كخطر صحي عالمياً، وفي المنطقة العربية على وجه التحديد. وتشمل الآثار الصحية المباشرة لتغيُّر المناخ، التي تظهر من ارتفاع درجات الحرارة والظواهر الجوية المتطرفة وارتفاع مستوى سطح البحر، أمراض القلب والأوعية الدموية وأمراض الجهاز التنفسي وضربات الشمس. وتشمل الآثار غير المباشرة انتشار الأمراض المنقولة من طريق المياه والأغذية والحيوانات والحشرات، وانعدام الأمن المائي والغذائي، والنزوح والهجرة القسرية، والتأثيرات على الصحة العقلية والمهنية. كما يؤثر تغيُّر المناخ أيضاً على نحو غير مباشر على الصحة بإعاقة التنمية المستدامة وتفاقم الفقر. وتفيد المعلومات المتاحة أن تغيُّر المناخ فرض بالفعل عبئاً صحياً في المنطقة العربية، مما أدى إلى زيادة الوفيات ونسبة انتشار الأمراض من الأمراض المعدية وغير المعدية. ومن المتوقع أن تؤدي زيادة الحرارة درجة مئوية واحدة إلى زيادة معدل الوفيات بنسبة 3 في المئة.

لم يحظ تأثير تغيُّر المناخ على صحة السكان العرب بالاهتمام الكافي حتى الآن. هناك أيضاً تباين واضح في جودة المعلومات التي وفّرتها مختلف البلدان وكميتها، ما يوجب الحثّ على تضمين تقارير البلاغات الوطنية المقدمة دورياً إلى الهيئات الدولية المعنية بالمناخ الآثار الصحية، وحضّ الباحثين على إجراء دراسات لتضييق الفجوات المعرفية. ومع استثناءات قليلة في بعض البلدان العربية، فإن قضايا الصحة العامة مفقودة عموماً ضمن الاستراتيجيات الوطنية للتكيُّف مع تغيُّر المناخ. كما تفتقر المنطقة إلى حد كبير إلى خطط التكيُّف الوطنية التي تتناول الاستجابات التشريعية والعملية، بناءً على المخاطر الصحية المتوقعة، لموجات الحر والظواهر الجوية الشديدة وتلوث الهواء والأمراض المعدية. فالملاريا، التي تصيب بالفعل ثلاثة ملايين شخص سنوياً في المنطقة العربية، ستصبح أكثر توالداً وانتشاراً وتدخل مناطق جديدة، حيث ستقصّر درجات الحرارة المرتفعة فترة الحضانة. ومن المهم للمنطقة أن تكتسب فهماً أفضل للعوامل المختلفة التي تؤثر على نتائج تغيُّر المناخ على الصحة، من أجل تصميم استراتيجيات فعالة للتخفيف والتكيُّف، تلبّي الحالة الخاصة بكل بلد، مع تأثيرات مباشرة وواضحة على صحة السكان.

خلاصة وتوصيات

لم يعد في الإمكان إنكار تأثير المخاطر البيئية على صحة الإنسان. وعند النظر إلى المنطقة العربية على وجه التحديد، نجد ان الافتقار إلى المياه المأمونة، وزيادة توليد النفايات وسوء طرق التخلص منها، وتغيُّر المناخ، وتلوث البيئة البحرية، كلّها عوامل ذات تأثير سلبي ملحوظ على صحة السكان. بالإضافة إلى ذلك، فإن المنطقة قد شهدت تأثير جائحة كورونا الأخيرة على صحة الإنسان والبيئة معاً. وأظهر الوباء، في الحد الأدنى، أن تحقيق هدف «الصحة للجميع» ضرورة، ليس فقط للوصول إلى خدمات الرعاية الصحية والصرف الصحي، ولكن أيضاً للتعجيل

كما ان قطاع الرعاية الصحية نفسه يعدّ مساهماً رئيسياً آخر في تدفّق النفايات الخطرة، إذ أدى توسُّعه في المنطقة العربية إلى ازدياد إنتاج النفايات الطبية أيضاً. وفي عدد كبير من البلدان المحدودة الدخل، لا قوانين تحكم هذا النوع من النفايات، مما يعني أن النفايات الطبية لا تُفصَل غالباً عن بقية النفايات. وقد زادت جائحة كورونا استعمال العناصر ذات الإستخدام الواحد، مثل الأقنعة والقفازات وعبوات تعقيم اليدين، التي ينتهي جزء كبير منها في البحار وعلى الشواطئ.

لقد ارتبط نقص التشريعات مباشرة بضعف إدارة النفايات الصلبة في المنطقة العربية. ويترافق النقص التشريعي مع البطء في برامج استبدال مرافق النفايات القديمة بأخرى جديدة يمكن أن تقلّل المخاطر الصحية المرتبطة بها وتوقف انتشار الملوثات. كما يتعين على حملات التوعية العامة تحفيز مشاركة الجمهور في قضايا إدارة النفايات، مع التركيز على المخاطر الصحية التي يمكن الوقاية منها.

يُعدّ اعتماد نهج دائري لإدارة النفايات، يقوم على الحدّ من الإستهلاك وإعادة الاستخدام والتدوير، أمراً بالغ الأهمية لاضعاف التأثير الضار للنفايات على صحة الإنسان والطبيعة. ويتطلب إنشاء برنامج فعّال لتقليل انتاج النفايات في المنطقة العربية العمل مع مختلف ذوي المصلحة المشاركين في سلسلة النفايات، بما في ذلك المنازل والمصنّعون والحكومات، من طريق الدفع في اتجاه تعديل أنماط الاستهلاك.

البيئة البحرية

في السنوات الأخيرة، باتت العلاقة المتبادلة بين البيئة البحرية وصحة الإنسان في المنطقة العربية أكثر وضوحاً، بفعل زيادة عدد الأشخاص الذين ينتقلون إلى المناطق الساحلية. فإلى عوامل أخرى، أثّر التصريف المباشر لمياه الصرف الصحي غير المعالجة في المناطق الساحلية، والتنقيب عن النفط واستخراجه في البحر، والمواد البلاستيكية الدقيقة، على صحة السكان العرب.

تُنتج الدول العربية حالياً نحو 12 بليون متر مكعب من مياه الصرف الصحي سنوياً، يُعالج أقل من 60 في المئة منها، ويعاد استعمال نصف كمية المياه المعالجة فقط. أما الكمية المتبقية، من مياه مبتذلة أو معالجة، فتصرف في البحار ومجاري الأنهار. وتؤدي مياه الصرف الصحي إلى انتشار مسببات الأمراض بين البشر. ويُعزى تكاثر الطحالب الضارة، الذي قتل تكراراً آلاف الأطنان من الأسماك، ولا سيما في منطقة الخليج، إلى زيادة المغذيات من مياه الصرف الصحي، المعالجة وغير المعالجة، المترافقة مع ارتفاع درجات حرارة المياه. كما يؤدي استهلاك المأكولات البحرية الملوثة بسموم الطحالب إلى عدد كبير من متلازمات التسمم بالمأكولات البحرية. ويمكن لبعض السموم الناتجة من العوالق النباتية البحرية أن تكون قاتلة للغاية.

وقد تسبّب التنقيب عن النفط واستخراجه ونقله، في منطقة تُعدّ مصدراً رئيسياً للنفط، في تلوث كبير للبيئة البحرية، كما تسبب في تلوث الأسماك، التي يستهلكها البشر لاحقاً، بالمعادن الثقيلة. ومع أن معظم تركيزات البترول والمحروقات والمعادن المسجّلة في البيئة البحرية للدول العربية تقع ضمن الحدّ المسموح به للاستهلاك البشري، فقد تم تحديد بعض النقاط الساخنة للتلوث في المناطق المحلية المتأثرة بالتلوث النفطي من المصافي والنشاطات الصناعية والتجريف المكثّف، إلى جانب النشاطات الترفيهية.

كما يمكن أن تتراكم الجسيمات البلاستيكية الدقيقة في السلسلة الغذائية من طريق الأسماك

العربية علامة فارقة نحو تطوير البُنى التحتية والأنظمة البيئية التي تستجيب للحاجات الصحية والتنموية. ويتعين على الحكومات العربية تطوير وتنفيذ برامج المياه والصرف الصحي، والتزام التمويل، وتعزيز الظروف والإجراءات التي تجعل تنفيذ السياسات والقوانين والخطط القوية ممكنة، عموماً. ذلك أن الإرادة السياسية وتحديد الأولويات هما من الدوافع الأساسية للتغيير.

الهواء

أدّى النمو الاجتماعي والديموغرافي والاقتصادي في العالم العربي إلى زيادة الطلب على الطاقة والسيارات في السنوات الأخيرة. وقد ساهم ذلك، إلى عوامل أخرى، في زيادة تلوث الهواء إلى معدلات باتت تشكّل خطراً كبيراً على السكان. وغالباً ما تتجاوز المستويات المسجّلة لتلوث الهواء ما بين خمسة و10 أضعاف الحدود التي وضعتها منظمة الصحة العالمية. وتعدّ مدن عربية عدة من المدن الـ20 الأكثر تلوثاً في العالم. وفي كثير من البلدان في المنطقة العربية سُجّل ارتفاع كبير في عدد الوفيات التي تُعزى إلى تلوث الهواء الداخلي والخارجي. كذلك، فإن العبء الإجمالي للمرض الناجم عن تلوث الهواء آخذ في الازدياد، مع ارتفاع معدل انتشار أمراض القلب والرئة، والإصابة بالسرطان، والمزيد من حالات الربو. كما ازداد استهلاك الكهرباء بنسبة 75 في المئة، مما أدى إلى انبعاث 766 مليون طن من ثاني أوكسيد الكربون عام 2015، مقابل 436,6 مليون طن عام 2006. وتُعدّ الدول العربية الآن من أكبر المساهمين العالميين في انبعاثات أول أوكسيد الكربون وأوكسيد النيتروجين، نتيجة الاستخدام غير الفعّال للوقود، والتحكم غير المنظّم في انبعاثات العوادم، والزيادة الكلّية في عدد المركبات بفعل التوسع الحضري والنمو السكاني.

على رغم أن المعلومات المتاحة عن تلوث الهواء مثيرة للقلق، لا تزال ثمة فجوات كبيرة في البيانات تمنع إجراء تقويم دقيق لتأثيره على صحة الإنسان في المنطقة العربية. فالمنطقة تتعامل إلى حد كبير مع قوانين عفاها الزمن، مع تقاعس في تطبيق القوانين وغياب لمراقبة مستمرة لجودة الهواء. ومن أجل إدارة جودة الهواء على نحو صحيح في المنطقة، يتعين تحسين تقويمات المخاطر الصحية بناءً على دراسات رصد الهواء والنمذجة. فإدارة المخاطر ستزوّد صانعي السياسات العرب الأدوات الصحيحة للسيطرة على التهديدات الصحية، وتخصيص الموارد، وترتيب البدائل العلاجية، مما يؤدي في النهاية إلى الحدّ من تأثير تلوث الهواء على الصحة العامة. لقد أشاع ظهور فيروس كورونا وانتشاره إحساساً إضافياً بالضرورة الملحّة لتحسين نوعية الهواء، إذ أظهرت الدراسات أدلّة على العلاقة بين تلوث الهواء وزيادة الحالات وحدّتها.

النفايات

يتزايد توليد النفايات الصلبة في المنطقة العربية بمعدّل يُنذر بالخطر، نظراً إلى النمو السكاني والتوسع الحضري والتغيُّرات في أنماط الاستهلاك والإنتاج، مما دفع أنظمة التخلُّص من النفايات إلى حافة الخطر. كما أن إلقاء النفايات بلا معالجة في الأراضي المكشوفة وعلى الشواطئ منتشر على نطاق واسع في الدول العربية، ذلك أن التخلص من 53 في المئة من كل النفايات يحصل برميها عشوائياً وبطريقة غير صحية. وقد أدّى التجميع غير السليم للنفايات والتخلّص غير المناسب منها إلى تلوث خطير للهواء والتربة والمياه، ويمكن أن تكون لهذا آثار كبيرة على صحة السكان ورفاههم. فقد وجدت الدراسات انتشاراً كبيراً لاضطرابات الجهاز التنفسي، مثل ضيق التنفس والتهاب الحلق والسعال، إلى جانب ارتفاع درجة الحرارة والتهابات العين والتهابات الجهاز الهضمي، من مجموعة مشاكل صحية تُعزى إلى حد كبير إلى إدارة النفايات على نحو غير ملائم.

تأثير طويل الأمد، خصوصاً من حيث زيادة أمراض الجهاز التنفسي وأنواع معينة من السرطان. كما أن الاستخدام غير المنضبط للذخائر في الحروب والصراعات المتتالية في المنطقة العربية انعكس على صحة الملايين، إلى جانب تعطيل الخدمات الصحية وانتشار الأمراض في المخيمات التي تؤوي ملايين النازحين واللاجئين.

تشير التقديرات إلى أن أكثر من **676** ألف مواطن عربي سوف يفقدون حياتهم قبل الأوان سنة **2020** نتيجة التعرض للمخاطر البيئية التقليدية، مثل تلوث الهواء، ونقص المياه النظيفة والصرف الصحي، وتغيُّر المناخ، والتي تختلط بدورها بمسببات أخرى مثل المواد الكيميائية والنفايات السامة، إلى التعرض للمخاطر المهنية. وسيرتفع هذا الرقم مع ظهور مزيد من عوامل الخطر البيئية وتأثيراتها، بما فيها الجوع وسوء التغذية. إن التحديات التي تواجهها المنطقة العربية تستدعي تحولاً كبيراً في طريقة إدارة أولويات الصحة البيئية. ومع أن النُهج الحالية مهّدت الطريق، إلا انها لم تُثبت كفايتها للحدّ على نحو مستدام وفعّال من المخاطر البيئية على الصحة العامة، وبناء بيئات داعمة وتمكينية لإيصال الخدمات الصحية إلى جميع الناس.

على الدول العربية أن تعمل بمزيد من الجدية لتحقيق أهداف التنمية المستدامة، والتعاون في ما بينها للاتفاق على سياسات بيئية قوية مشتركة، كما يجب تصميم استراتيجيات أكثر فاعلية للحدّ من تغيُّر المناخ والتكيُّف، تُركّز على الصحة إجمالاً، وبصورة عامة، تحسين تقويمات المخاطر الصحية وجمع البيانات لتزويد صانعي السياسات العرب الأدوات الصحيحة لمواجهة التحديات البيئية والصحية المحيطة.

المياه

يُعدّ الافتقار إلى خدمات المياه والصرف الصحي والنظافة الصحية الآمنة أحد المخاطر البيئية الرئيسية التي تواجه السكان العرب. وقد سلّطت جائحة كورونا الضوء على أهمية خدمات المياه والصرف الصحي والنظافة في المنطقة. ويُعدّ توفير إمدادات المياه السليمة الكافية، والصرف الصحي المناسب ومرافق غسل اليدين، إلى جانب زيادة الوعي، أموراً ضرورية للحدّ من انتشار أي عدوى، بما في ذلك فيروس كورونا المستجد. لكن البيانات الأخيرة تنطوي على أرقام مقلقة، إذ يفتقر نحو **50** مليون عربي إلى خدمات مياه الشرب الأساسية، كما ان **74** مليون شخص في المنطقة لا يحصلون على خدمات الصرف الصحي الأساسية. وتشير التقديرات إلى أن خدمات المياه والصرف الصحي والنظافة السيئة هذه هي السبب في **40** ألف وفاة مبكرة سنوياً، كان في الإمكان تجنّبها.

يُعتبر توفير إمدادات المياه السليمة والصرف الصحي، لهدف نهائي يتمثّل في إرساء عمليات مستدامة للإدارة المتكاملة لموارد المياه، من التحديات ذات الأولوية القصوى التي تواجه معظم البلدان العربية. فهناك تسع دول فقط من أصل **22** دولة عربية تسير على الطريق الصحيح لتحقيق الهدف السادس من أهداف التنمية المستدامة من حيث المياه النظيفة والصرف الصحي. وتواجه المنطقة عدداً كبيراً من العوائق التي تمنع التقدم نحو تحقيق هذا الهدف، بما في ذلك الصراعات وعدم الاستقرار، التي أثّرت على أنظمة إدارة المياه. فعلى سبيل المثال، تحوّلت البُنى التحتية للمياه أهدافاً للتدمير أثناء الحروب. أضف أن التدفّق الهائل للاجئين في المنطقة العربية يزيد ضعف موارد المياه الشحيحة أصلاً.

سيشكّل تحقيق الهدف السادس من أهداف التنمية المستدامة، والمتعلق بالمياه، في المنطقة

ملخص تنفيذي
البيئة العربية 13
الصحة والبيئة في البلدان العربية

التقرير السنوي للمنتدى العربي للبيئة والتنمية (أفد) - 2020

نظرة عامة

الصحة والبيئة مترابطتان عضوياً، وفقاً لمعادلة تقوم على استحالة وجود مجتمع إنساني يتمتع بصحة سليمة إذا كانت البيئة الطبيعية ملوثة، في مقابل استحالة الوصول إلى بيئة سليمة في مجتمع تتدهور فيه صحة الإنسان. فالحفاظ على التوازن بين كليهما أمر ضروري، ولا سيما في ضوء التحديات الناشئة نتيجة أنماط الحياة الحديثة والقضايا المناخية والصحية المستجدة. إن معدل الوفيات المنسوبة إلى العوامل البيئية آخذٌ في الارتفاع، وهو يقدّر حالياً بنحو 23 في المئة من مجموع الوفيات في المنطقة العربية. كما ان الأخطار البيئية مسؤولة عن نحو 23 في المئة من العبء الإجمالي للأمراض في المنطقة أيضاً. يهدف تقرير المنتدى العربي للبيئة والتنمية (أفد) عن الصحة والبيئة في البلدان العربية إلى تسليط الضوء على المخاطر الصحية البيئية الرئيسية التي تواجهها المنطقة، مع التشديد على التوصيات والدروس التي يمكن تعلّمها من الأزمات البيئية والصحية، السابقة والحالية، بما في ذلك جائحة كورونا (كوفيد-19).

تواجه المنطقة العربية مجموعة من العوامل الخطرة، بينها ممارسات التنمية غير المستدامة، وحالات الطوارئ الإنسانية الناجمة عن النازحين واللاجئين، والتوسّع الحضري السريع، وتضاؤل الموارد الطبيعية، وتدهور الأراضي، وزيادة التفاعل البشري مع الحيوانات. وقد أدّت عوامل الخطر هذه إلى العديد من العواقب الملحوظة، كتلوث الهواء وإدارة مياه الصرف الصحي والنفايات الصلبة على نحو غير ملائم، وأخيراً وباء كورونا المستجد. يُعدّ تلوث الهواء من أكثر المشكلات البيئية شيوعاً في البلدان العربية، وتتزايد الوفيات الناتجة من سوء نوعية الهواء بشكل ملحوظ. كما ان العصرنة والنمو السكّاني يولّدان أيضاً المزيد من النفايات، التي تُعالج بعد ذلك بطريقة سيئة، الأمر الذي يزيد المخاطر الصحية تفاقماً. إلى ذلك، كشفت جائحة كورونا المستمرة منذ نهاية 2019 ضعف أنظمة الرعاية الصحية في المنطقة العربية، والقدرة المحدودة في معظم البلدان على التعامل مع الأزمات الصحية الطارئة. كما أظهرت الجائحة أنه لا يمكن الحفاظ على صحة الناس فقط باستهداف المجموعات التي يمكنها تحمّل تكاليف خدمات الرعاية الصحية. فالهدف الثالث من أهداف التنمية المستدامة هو وجوب توفير «الصحة للجميع»، ولا للقادرين فحسب.

تشكّل المواد الخطرة والسامة تحدياً صحياً كبيراً في المنطقة العربية، نتيجة الإدارة غير الملائمة وتدابير السلامة المتساهلة، إلى جانب الافتقار إلى القوانين الصارمة. وفي إطار الحوادث الطارئة، لا يزال ينبغي معرفة الأثر النهائي للعواقب الصحية لانفجار 4 آب (أغسطس) 2020 في مرفأ بيروت، بفعل تخزين نيترات الأمونيوم على نحو غير آمن. ومن المتوقع أن يكون للإنفجار

2020، بسببٍ التعرض لأخطار بيئية تقليدية. وتشمل الأمراض المدفوعة بالأسباب البيئية – والأكثر تأثراً بها في البلدان العربية – أمراض القلب والأوعية الدموية، والإسهال، والتهابات الجهاز التنفسي، والسرطان. أما العوامل الرئيسية للأخطار البيئية لهذه الأمراض فهي تلوث الهواء الخارجي والداخلي، وعدم توافر المياه النظيفة، والتلوث البحري، والتمدد الحضري غير المنضبط، وتدهور الأراضي، والتعرُّض للنفايات والمواد الكيميائية الضارة. كما أن التوسُّع غير المقيّد للأنشطة السكنية والصناعية والزراعية في اتجاه الموائل الطبيعية سيؤدي إلى ارتفاع معدّلات انتقال الأمراض، وخاصة الفيروسات، من الحيوانات إلى البشر.

يدعو الهدف الثالث من أهداف التنمية المستدامة السبعة عشر إلى ضمان حياة صحية وتعزيز الرفاهية للجميع بحلول سنة 2030. ويتطلب تحقيق هذا الهدف معالجة عبء الأمراض المرتبط بالبيئة، حيث أن التعرُّض للأخطار البيئية عامل رئيسي يؤثر على صحة الإنسان. هناك حاجة إلى نهج بيئي متكامل للصحة العامة، يعترف بالتفاعلات المعقّدة بين العوامل البيولوجية والسلوكية والبيئية والاجتماعية. فالحدّ من العبء البيئي للأمراض ممكن من خلال التدابير المصممة والمنفذة بطريقة شاملة.

يناقش تقرير "أفد" 2020 العوامل البيئية الرئيسية التي تؤثر على مختلف جوانب صحة الإنسان في البلدان العربية، ويقترح خطة عمل تمكّن المنطقة من تحقيق الهدف الثالث من أهداف التنمية المستدامة. ويمكن وضع هذه التوصيات في سياق متكامل للتنمية المستدامة، من خلال معالجة الصحة في الإطار الاجتماعي والاقتصادي والبيئي. وتتناول فصولٍ التقرير السبعة العلاقة بين الصحة والمياه والهواء والنفايات وتلوث المحيطات وتغيُّر المناخ، فضلاً عن التقدم والعقبات باتجاه تحقيق محتوى الصحة البيئية لأهداف التنمية المستدامة.

يود "أفد" شكر جميع الشركاء والخبراء والباحثين الذين ساهموا في هذا التقرير، بما في ذلك الجامعات والمنظمات الدولية والباحثين في مجال الصحة البيئية. وقد كان لأعضاء "أفد" الأكاديميين من الجامعات في المنطقة العربية دور رئيسي في تطوير التقرير. كلية العلوم الصحية في الجامعة الأميركية في بيروت، التي تستضيف المؤتمر أيضاً، كانت الشريك الأساسي في إعداد التقرير. كما ساهم باحثون من جامعة الخليج العربي في البحرين، وجامعة القاهرة وجامعة الإسكندرية في مصر. وشارك في التقرير المركز الإقليمي لصحة البيئة التابع لمنظمة الصحة العالمية.

ونتوجه بشكر خاص إلى الرعاة الذين دعموا إنتاج التقرير، ولا سيما مؤسسة الكويت للتقدم العلمي والبنك الإسلامي للتنمية ومنظمة الأغذية والزراعة (فاو).

نأمل أن يساعد هذا التقرير، من خلال تسليط الضوء على العلاقة المتبادلة بين البيئة والصحة، في تعزيز الإدارة البيئية في البلدان العربية بطريقة تحمي صحة الإنسان على نحو أفضل، وأن يُساهم أيضاً في تنشيط النُظم الصحية للاستجابة الفعالة لتأثير العوامل البيئية.

بيروت، 10 تشرين الثاني (نوفمبر) 2020

نجيب صعب
الأمين العام
المنتدى العربي للبيئة والتنمية

تمهيد

الصحة والبيئة في البلدان العربية

التقرير السنوي للمنتدى العربي للبيئة والتنمية (أفد) - 2020

الصحة والبيئة في زمن كورونا

أثر البيئةعلى صحة الإنسان ورفاهية عيشه ليس بالأمر الجديد. إلا أن الترابط بين الاثنين يكتسب اهتماماً أكبر الآن، بينما العالم واقعٌ في قبضة جائحة فيروس كورونا الذي يعود، مثل كثير من الفيروسات، إلى أصول حيوانية. وهذا يطرح ضرورة الإدارة المتوازنة بين الإنسان والطبيعة. بالنظر إلى هذا السياق، فإن موضوع التقرير السنوي الثالث عشر لسنة 2020 للمنتدى العربي للبيئة والتنمية (أفد)، بعنوان "الصحة والبيئة في البلدان العربية"، يأتي في الوقت المناسب، استجابةً لأبرز التحديات الصحية التي تواجه الإنسانية.

إعداد التقرير بحدّ ذاته كان مسعىً صعباً، ليس فقط بسبب ظروف العمل الضاغطة التي خلقها الوباء، والتي وضعت قيوداً على التفاعل الطبيعي بين الباحثين، ولكن أيضاً بسبب انعكاسات الانهيار المالي وعدم الاستقرار السياسي في لبنان على عمل "أفد". وقد تفاقم ذلك بسبب انفجار مرفأ بيروت في 4 آب (أغسطس) 2020، الذي أثّر بشدة على عمل الأمانة العامة للمنظمة وشركائها في بيروت، وألحق أضراراً بمكاتب "أفد"، إلى جانب المأساة الإنسانية والاقتصادية التي أصابت الموظفين. وبالتوازي مع الوضع غير المستقر في المنطقة، أدى هذا الأمر إلى انخفاض مقلق في التمويل من قبل الشركاء والجهات الراعية التقليدية، مما يتجاوز أثره إنتاج هذا التقرير إلى تهديد عمل "أفد" واستمرارية المنتدى نفسه كمنظمة إقليمية فاعلة.

هذا التقرير هو الثالث عشر في سلسلة "وضع البيئة العربية" التي أطلقها "أفد" عام 2008. وقد ألهمت هذه السلسلة، التي سلطت الضوء على التحديات البيئية والحلول الموصى بها، تغييرات في السياسات وتبادل المعرفة، وحفزت الكثير من الإجراءات عبر المنطقة العربية. تناولت السلسلة مواضيع رئيسية، بما في ذلك تغيُّر المناخ، والمياه، والطاقة، والاقتصاد الأخضر، والبصمة البيئية، والاستهلاك المستدام، وتمويل التنمية المستدامة، والتعليم البيئي، من بين أمور أخرى.

يمكن التخفيف من ظهور وانتشار وتأثير العديد من الأمراض والأوبئة من خلال إدارة الأخطار البيئية، مما يجعل من الضروري معالجة الأسباب البيئية الأساسية الكامنة. وفي حين أن هذه حقيقة عالمية، إلا أنها أكثر أهمية في المنطقة العربية، حيث الأخطار البيئية أعلى ومعدلات التنمية أبطأ في معظم البلدان.

خلال العقود الأخيرة، حقق العالم انخفاضاً في الأمراض المعدية، بينما شهد في الوقت نفسه ارتفاعاً هائلاً في الأمراض والأضرار الصحية الناجمة عن الظروف البيئية السيئة. وقدّرت منظمة الصحة العالمية أن أكثر من 676 ألف مواطن عربي سيفقدون حياتهم قبل الأوان سنة

HEALTH AND THE ENVIRONMENT
IN ARAB COUNTRIES
2020 Report of the Arab Forum for Environment and Development

The AFED 2020 annual report discusses the main environmental drivers that impact various aspects of human health in the Arab countries, and proposes an action plan leading to the region meeting sustainable Development Goal 3, encompassing good health for all. These are placed within an integrated context of sustainable development, by tackling health in terms of social, economic and environmental aspects. The report's seven chapters deal with the relationship between health, water, air, waste, ocean pollution and climate change, as well as progress and obstacles in achieving the environmental health content of the SDGs. The impact of COVID-19 is discussed throughout the report.

The emergence, spread and impact of many diseases and illnesses can be mitigated by the management of environmental risks, which makes it necessary to tackle the underlying environmental causes. While this is a global fact, it is more significant in the Arab region, where environmental risks are higher and rates of development, in most countries, are slower.

This report is the 13th in the series on the State of Arab Environment, launched by AFED in 2008. The series, which has highlighted environmental challenges and recommended solutions, has inspired policy changes, knowledge sharing, and actions across the Arab region. It has covered major topics, including climate change, water, energy, green economy, ecological footprint, sustainable consumption, financing sustainable development, and environmental education, among others.

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Arab Forum for Environment and Development (AFED) is an international not-for-profit, non-governmental, membership-based organization headquartered in Beirut, Lebanon. Members include corporations, universities, research centers, media networks, and civil society alongside government entities as observers. Since 2007, AFED has been a public forum for influential eco-advocates. Over the last eleven years, it has become a major dynamic player in the global environmental arena.

The flagship contribution of AFED is an annual report written and edited by experts on the state of Arab environment, tracking developments and proposing policy measures. Other initiatives include a regional Corporate Environmental Responsibility (CER) program, capacity building, public awareness, and environmental education.

AFED enjoys Consultative Status with the United Nations Economic and Social Commission (ECOSOC), and has an observer member status with the United Nations Environment Program (UNEP), the League of Arab States (LAS), and many other regional and international organizations and conventions. As an Arab think tank, it has played a major role in international negotiations on environment and development, including advising governments and regional organizations on matters such as climate change, green economy and sustainable development.

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