OIC WATER REPORT 2021

Towards Sustainable Water Management

ORGANISATION OF ISLAMIC COOPERATION

STATISTICAL, ECONOMIC AND SOCIAL RESEARCH
AND TRAINING CENTRE FOR ISLAMIC COUNTRIES

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CONTENTS

ACRONYMS

AM	Adaptive Management
CEP	Coastal Eutrophication Potential
COVID-19	Coronavirus Disease of 2019
EBA	Ecosystem-based Approaches
ECA	Europe and Central Asia
ESALA	East and South Asia and Latin America
GDP	Gross Domestic Product
IEA	International Energy Agency
IWRM	Integrated Water Resources Management
LIFDC	Low-Income Food Deficit Countries
MENA	Middle East and North Africa
Mtoe	Million tonnes of oil equivalent
NbS	Nature-based Solution
ND-GAIN	Notre Dame Global Adaptation Initiative
ODA	Official Development Assistance
OIC	Organization of Islamic Cooperation
PPPs	Public-Private Partnerships
RCP 85	Representative Concentration Pathways 8.5
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathways
SV	Seasonal Variability
TPEC	Total Primary Energy Consumption
TWh	Terawatt hour
WASH	Water, Sanitation and Hygiene
WUE	Water-Use Efficiency
WRI	World Resources Institute

FOREWORD

Water is critical for sustaining life on earth, spurring socio-economic development, and attaining peace and security around the world. It is a renewable yet a finite resource, with an extremely uneven distribution across different regions and countries. There are many regions where freshwater resources are inadequate, neither to meet domestic and environmental needs nor to sustain economic development. In such regions, people are suffering from problems of water stress and water scarcity, which are exacerbated by numerous factors like increasing demand, pollution, poor infrastructure, global changes with extreme weather events, and mismanagement. Indeed, most of the available water resources, particularly in developing countries, are not managed properly as overexploitation and wastage are widespread, increasing vulnerability of the human population due to difficulty of access to good quality water. Today, millions of people living in developing countries do not have access to safe and clean water to fulfil their basic needs. Given this state of affairs, OIC member countries agreed to adopt and pursue the OIC Water Vision in 2012, with the primary goals of promoting cooperation to ensure a water-secure future and encouraging sustainable management of water resources.

The OIC Water Report 2021 analyses the current status of water resources and their management in OIC member countries by using the latest available data on major relevant indicators. This edition of the report also highlights the nexus between water and energy and food security along with the impacts of climate change and COVID-19 pandemic on water resources in OIC member countries.

Overall, the report demonstrates that the water sector in many OIC member countries is far from reaching its optimal state, given that 29 countries are undergoing water stress and 18 of them are at critical stress levels. Yet, there has been considerable progress in drinking water and sanitation provisions across the OIC member countries. The proportion of the population with access to basic drinking water increased from 80.8% in 2010 to 84.6% in 2017, while the proportion of the population with access to basic sanitation increased from 58.3% in 2010 to 64.2% in 2017. However, there is still a need for consistent efforts to ensure universal coverage of Water, Sanitation, and Hygiene (WASH) services, particularly in rural and low-income areas.

The report underlines the fact that the development of sustainable water management in OIC member countries is affected by various challenges including, but not limited to, future uncertainty in climate, population growth, rapid urbanization, socio-economic development, and change in consumption patterns. The report addresses these crosscutting issues and challenges through an extensive analysis of topics such as the impact of climate change and the water-energy-food security nexus.

The impact of climate change is one of the most crucial issues that require the attention of water policy makers. It is likely that climate change will make the future supply of water more unpredictable due to an increase in water supply variability. The OIC member countries may experience seasonal water supply variability of at least 1.1 times increment in the near future –a situation that is likely to exacerbate the stress on water security in the group of OIC countries.

The expected increase in food demand and energy production and consumption are among the issues that may have significant impacts on the water sector in OIC countries. This is owing to the fact that agricultural water withdrawal in OIC countries accounts for 86.6% of all water withdrawal. Therefore, ensuring food security through domestic agricultural production would mean an increase in demand for water. The association between water resources and the production and consumption of energy is a similar factor. Countries need water to produce energy and they need energy to deliver water. In this context, the report attempts to estimate the amount of energy utilized in the water sector and the magnitude of water-use in the energy sector. This analysis is important to formulate sound policies for sustainable water management.

Finally, and in line with the OIC Water Vision, the report puts forth some proposed policy actions with a view to contributing to the efforts of the OIC member countries towards achieving a more water-secure setting for their population in the future. The policy recommendations presented in this report specifically address the need to enhance intra-OIC cooperation in this important domain, particularly through the adoption of more sustainable water management practices, harnessing the potency of unconventional waters, and improving water-use efficiencies. If they are to build a better world for their current and future generations, the OIC member countries should work together and, collectively, rise to the challenges facing them in the domain of water security.

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Chapter 1 on Water Resources and Use, Chapter 4 on Climate Change Impacts on Water Sector, Chapter 6 on Energy and Water Nexus, and Chapter 7 on Sustainable Water Resources Management were prepared by Fahman Fathurrahman. Chapter 2 on Drinking Water, Sanitation and Hygiene and Chapter 5 on Water and Food Security Nexus were prepared by Tazeen Qureshi. Introduction, Chapter 3 on COVID-19 and Water, and Chapter 8 on Concluding Remarks and Policy Recommendations were jointly prepared by all team members. Esat Bakımlı also contributed in reviewing the report.

EXECUTIVE SUMMARY

CURRENT STATE AND TRENDS

Disproportionate distribution and availability

Geographically speaking, member countries of the Organization of Islamic Cooperation (OIC) are spread all over the globe with diverse climates, topographies, and ecological systems. Therefore, countries in some regions enjoy a high level of precipitation while others are lacking. OIC member countries in Sub-Saharan Africa (SSA) and East and South Asia and Latin America (ESALA) have higher renewable water availability than countries in Europe and Central Asia (ECA) and Middle East and North Africa (MENA). Countries lacking renewable freshwaters tend to source their water needs through deep aquifers or exploiting unconventional sources such as seawater desalination.

In 2017, OIC countries had 7,261 km^3 renewable water resources, equivalent to 13.3% of the world's total renewable water resources. Renewable water availability in OIC countries is lower than the world average, as demonstrated by total renewable water per capita. Yearly renewable water availability per person in OIC countries was 4,029.0 m^3, compared to the world average of 7,254.2 m^3. These availability levels are likely to decline as the population continues to grow. Globally, for example, water availability has declined by more than half between 1962 and 2014 (Baldino & Sauri, 2018). With the current population growth rate, the availability of water in OIC countries is predicted to shrink by half in about 35 years.

More pressure on water: declining quality, increasing demand

The pressure on water availability is also accompanied by a decline in water quality. Since the 1990s, the quality of water in the majority of rivers across the OIC regions has worsened due to persistent pollution. This is partly due to the lack of wastewater treatment in many OIC countries. Wastewater from human activities is often dumped directly into water bodies, therefore aggravating the decline in water quality.

By the year 2040, the demand for water in most OIC countries is projected to increase by 1.4 to 1.7 times or more. Some key drivers of this increasing demand are population growth, urbanization, improvement of water and sanitation services, and economic growth. On one hand, the agriculture sector, which currently consumes the highest share of water, could experience a decline in its share of overall water demand; however, it will most likely continue to be the most water-consuming sector. On the other hand, socio-economic development and urbanization are expected to increase the demand for water in the municipal and industrial sectors. Burek et al. (2016) projected that the greatest increases would occur in SSA and ESALA sub-regions, where demand could triple.

High stress and overall water risks

According to UN-Water & FAO (2018), countries begin to experience "water stress" at a 25% level, while above 70% is considered as critically stressed. The global water stress level is estimated at 19% for the 2000-2017 period. In 2017, the OIC member countries, as a group, are estimated to have a water stress level of 32.7%, by which they are considered as a region 'experiencing water stress'. At the individual country level, there are 29 OIC countries undergoing water stress, 18 of which are at a critical stress level. Most countries suffering water stress are in arid and semi-arid regions, where water resources are scarce. At the sub-regional level, MENA and ECA are regions with most countries under serious threat of water stress. By 2040, most OIC regions are projected to see an increase in water stress level by at least 1.4 times.

High pressure on water resources has made OIC countries vulnerable and at high risk of water-related hazards (such as drought, declining food production, etc.). Most OIC countries are already exposed to at least medium to high water risk. Areas in some countries are even in 'extremely high' risk condition. If the trend of unsustainable use of water and environmental degradation persists, the economy, food production, and well-being of society will be at risk by 2050. The risk will be higher to vulnerable groups in society, thereby worsening existing inequalities and socio-economic disparities (UN, 2018).

An apparent gap in the development of WASH services

Water, Sanitation, and Hygiene (WASH) services are essential for individual health and well-being and socio-economic progress of a country. Yet, the WASH sector is heavily reliant on water resources – their quantity, quality, and management. In OIC member countries, the overall access to WASH services has improved considerably over the past years. The proportion of population with access to at least basic drinking water increased from 80.8% in 2010 to 84.6% in 2017 and the proportion of population with access to at least basic sanitation increased from 58.3% in 2010 to 64.2% in 2017. Similarly, the population with access to basic handwashing facilities including soap and water increased from 36.3% to 40.6% over the same period. However, there is still room for improvement – especially when it comes to the provision of basic sanitation and hygiene services.

The coverage of WASH services varies considerably in the OIC region –with middle- and low-income economies suffering disproportionately from the absence of adequate WASH services. Inequalities in the provision of WASH services in the OIC region result from a combination of factors including, but not limited to, geographical location (urban/rural), socio-economic status, and individual context-specific features (gender, minority status, etc.). For example, the primary responsibility for managing WASH services and water resources in a household falls on women (ages 15+) and girls (ages below 15). In OIC member countries, more than half of the responsibility for collecting water fall on women in Mozambique, Burkina Faso, Guinea-Bissau, Chad, Togo, Somalia, Niger, Sierra Leone, and Gambia. Similarly, mortality rates attributed to the use of unsafe or inadequate WASH services also differ remarkably across the OIC region. For instance, member countries in SSA (Chad, Somalia, Sierra Leone, Mali, and Niger) have worrying mortality rates. On the contrary, member countries in MENA (Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia) have some of the lowest mortality rates attributed to WASH.

Playing an important role in the improvement of the WASH sector, the total official development assistance (ODA) for water supply and sanitation to OIC countries increased from 2,989.3 million USD in 2010 to 4,287 million USD in 2018. The largest share of this ODA was directed to member countries in MENA, followed by SSA, ESALA, and ECA. Additionally, 29 OIC member countries reported having clearly defined procedures in law or policy for participation by service users/communities in programs on planning and management of water resources between 2017 and 2019. Twelve OIC member countries also reported a high level of participation in such programs.

COVID-19 affected water demand, quality, and utility companies

The COVID-19 pandemic, along with its containment measures, has affected the water sector through the change in water consumption patterns, impacts on water quality, and economic impacts on water utilities. Containment measures such as 'stay-at-home' order and increasing awareness to regularly wash hands have had an impact on the demand and quality of water. Globally, residential water demand in various cities has increased by 10-15%, while non-residential demand has shrunk by 17-32% (Cooley, 2020). There is a similar situation in OIC countries. For example, water demand has increased in Turkey and countries in the MENA region. However, while residential water demand has increased, the overall effect on water demand is likely to vary between communities depending on the relative proportion of residential and non-residential areas and the stringency of the containment measures.

The quality of water is also at risk. An increase in wastewater attributed to strict hygiene and cleaning measures may burden the current wastewater system. In cases where the wastewater systems are not properly established, the risk of pollution to water bodies is likely to heighten. This is aggravated by the inappropriate disposal of medical waste (such as used masks and gloves) that often polluted water bodies.

The COVID-19 pandemic will also affect the economics of water and wastewater utilities. To illustrate, the COVID-19 pandemic has affected the income of various groups in society, who may not be able to pay their water bills. This directly affects the revenue collected by water utilities in various countries. As a result, the pandemic could result in approximately a 15% of reduction in revenues of water utilities (IFC, 2020).

CHALLENGES AND SECTORAL LINKAGES

Water sector is very vulnerable to the impacts of climate change

Water resources are strongly affected by changing climate since it regulates the hydrological cycle in the biosphere. Numerous studies find that climate change will make the future supply of water more erratic and unpredictable due to an increase in water supply variability. OIC countries, especially in SSA, MENA and ESALA regions, are predicted to have an increase in seasonal water supply variability of at least 1.1 times. Furthermore, these regions are the ones already experiencing water stress. Thus, climate change would put more pressure on water security in these regions.

An increasing number and scope of climate hazards such as intense frequency and magnitude of heatwaves, unprecedented rainfalls, thunderstorms and storm surges are to be expected as global average temperature rises. Another consequence of high global temperatures is a rise in water temperatures, which reduces dissolved oxygen in the water and ultimately affects the capacity of water bodies for self-purification.

Compared to the world average, the water sector in OIC countries is more vulnerable and less prepared to cope with the impacts of climate change. This exposes them to higher risks of climate change impacts and threatens the livelihood of societies. At the individual country level, almost 70% of OIC countries are more vulnerable to climate change than the world average. Furthermore, 75% of OIC countries are insufficiently prepared to cope with the impacts of climate change as compared to the world average. Amongst other things, this indicates that OIC countries do not have adequate economic, governance, and social capacities to direct investment towards efforts to adapt to climate change.

Adaptation to climate change in the water sector is crucial for OIC countries to improve their resilience to future hazards. In order to do so, OIC countries need to first understand climate change impacts or vulnerability within their localities. The second step would be to design and select the appropriate interventions and policies in the water sector. Finally, there is a need for evaluation of adaptation options and relevant adjustments in climate change interventions. These efforts will not only contribute to reducing stress in the water sector but also provide various economic and social benefits by increasing food production and resilience for the future. It may also provide added benefits such as improved efficiency, reduced cost, and environmental co-benefits, which could have positive spill over effects on other sectors of the economy.

Water, agriculture, and food security: the intimate bond

The overall status of food security in OIC countries has improved in recent years. There has been a growth in per capita food production and gross food production indicating better availability of food; an improvement in average dietary energy supply adequacy indicating better utilization of food; and an increase in GDP per capita in purchasing power indicating an improvement in accessibility to food. Yet, there are also persisting issues that need to be addressed such as the presence of around 176 million undernourished people in OIC countries indicating hunger, the prevalence of obesity in 17.5% of the adult population indicating malnutrition, and high variability in food production and supply indicating inconsistencies in food production and supply. Additionally, 32 OIC countries are also currently classified as either low-income food deficit countries or countries in crisis requiring external assistance, or both.

Increased demand for food has significant implications for the water sector in OIC countries. This is because agricultural land in OIC countries constitutes one-fourth of the total agricultural land in the world. Additionally, agricultural water withdrawal in OIC countries accounts for 86.6% of all water withdrawal –highest in ESALA (88.9%), followed by ECA (85.2%), MENA (84.9%), and SSA (80.9%). Yet, at the same time, area equipped for irrigation is lowest in the OIC region at 5.9% as compared to non-OIC developing countries (8.2%) and the world average (6.8%). This is partly why the Global Food Security Index (2019) gives OIC countries some of the lowest scores in terms of irrigation infrastructure, with 8 member countries in SSA receiving a score of 0. Indeed, area equipped for irrigation is lowest in SSA (0.7%) and member countries in this region have the highest prevalence of undernourishment in OIC countries (14.8%). It is highly probable that the lack of water resources and irrigation is one of the main factors causing insufficient food production, which in turn leads to a high prevalence of undernourishment in the region.

In terms of water-use efficiency (WUE), which measures the value-added in US dollars per volume of water withdrawn by various economic sectors in a country, 15 OIC countries have WUE values above the world average of 15 USD/m^3, particularly Qatar (195.7), Kuwait (113.6), UAE (89.5), and Bahrain (76.1). On the contrary, there were 33 OIC countries having WUE values lower than the world average –lowest in Somalia, Tajikistan, and the Kyrgyz Republic (less than 1 USD/m^3).

Using efficient irrigation techniques is vital for boosting food production and thereby ensuring food security in the OIC region. However, available data on the irrigation techniques used in OIC countries indicates that surface irrigation, which is the most water-consuming technique, is by far the most widely used technique in 74.4% of the total area equipped for irrigation. Consequently, huge amounts of water diverted for irrigation in these countries are wasted at the farm level through either deep percolation or surface runoff. In contrast, sprinkler irrigation which is more water-saving than surface irrigation is practised in 4.6% of the total area equipped for irrigation in the OIC countries, and localized irrigation technique, which is the most water-saving technique, is practised in only 3.1% of the total area equipped for irrigation in the OIC countries.

What about the water-energy nexus?

There is a strong relationship between water and energy, commonly referred to as the 'water-energy nexus'. On one hand, energy is essential to the supply chain processes of various water services. On the other hand, water is also a crucial input for energy production. In 2018, the total primary energy consumption (TPEC) of OIC countries was 2,026 million tonnes of oil equivalent (Mtoe) or equivalent to 14% of global TPEC. Fossil fuels (natural gas, coal, and oil) and nuclear made up most of the primary energy consumption (83.1% of OIC's TPEC). In sectoral basis, electricity and heat sectors are the most energy-intensive sectors, with a total share of 41.2% of OIC's TPEC.

When it comes to water withdrawal for energy production, electricity generation is by far the largest process, which accounts for 88% of total water withdrawal for energy production in the OIC. This is because thermal power plants -that are water-intensive- make up the majority of the electricity supply mix. Therefore, a continuous supply of water is very crucial to safeguard the electricity supply in the OIC. Water consumption, on the other hand, is largest in fossil fuel production. The OIC region, as one of the biggest global producers of fossil fuels, will require a continuous supply of water to keep its production going. Failing to comply may hamper the production of fossil fuels, which in turn harms the economy and societal well-being.

Energy is also needed in all processes of the water supply chain; extraction, treatment, distribution, wastewater treatment, and discharge. OIC's energy consumption in the water sector is estimated at 378.4 TWh. This is equivalent to around 13% of OIC's total electricity production. Out of this amount, more than 80% is utilized for the supply of water (i.e. water supply and conveyance, water treatment, and distribution). Unconventional water supply (i.e. desalination and recycled water) uses around 42.8 TWh or 11.3% of total energy for water processes, while wastewater treatment makes up around 7 TWh (1.9% of total). Energy demand in the water sector is also expected to increase due to rapid urbanization, which requires the expansion of water and wastewater utilities.

The water-energy nexus creates a challenge where a disturbance in one sector will directly affect the other. Therefore, water security is critical for energy security and vice versa. This calls for the formulation and implementation of water policies that consider its implication on the energy sector.

THE WAY FORWORD

Governance to meet water needs of present and future generations

The myriad of issues faced by OIC countries in the water sector require responsive interventions that efficiently combine technical expertise, prescriptive governance, and effective management. The modern approach to water resources management stresses the need to fulfil the water needs of present and future generations by incorporating sustainable development approaches in the water sector. This can be achieved through multi-sector integration, broader stakeholder involvement, and raising awareness about the importance of economic, social, and ecological values of water (Schoeman et al., 2014). Furthermore, the system also needs to be adaptable to future shocks and uncertainties, including climate change.

There are three emerging approaches to solving water-related problems, namely: Integrated Water Resources Management (IWRM), Ecosystem-based Approaches (EBA), and Adaptive Management (AM). IWRM recognizes the highly interrelated relations between water and other sectors (especially agriculture and energy); therefore, involving various stakeholders to form water policies is deemed necessary. In practice, the application of IWRM consists of basin-scale management of water resources, establishing water rights, water pricing for allocation, and participatory decision-making. EBA embraces the natural conservation principle in solving water-related issues. For instance, conserving upstream water catchment area could safeguard the quantity and quality for the downstream users. With this approach, EBA address water security issues not only by ensuring water quantity and quality but also through reducing the water related-risks and providing social, economic, and environmental co-benefits. AM is characterized as a 'learn by doing' approach where a formal iterative process changes over time depending on the outcomes of the interventions. The main idea is to build a management system that continually adjusts to new situations based on the results of various pre-defined evaluation criteria. This way, AM is able to solve complex problems where future uncertainty is relatively higher.

While the above-mentioned approaches are promising, managing water can prove to be a complication partly due to the involvement of multiple stakeholders across various sectors, a need for region-sensitive policies and approaches, cultural diversities, and political and regulatory mechanisms. When combined with the uncertainty of climate change, policymakers should aim to develop crosscutting and inter-sectoral strategies and interventions for the benefit of society and the environment.

Exploiting the potential of unconventional water resources

Exploiting unconventional sources of water is a very urgent priority for the OIC, especially in countries where freshwater availability is limited. For other countries, exploiting unconventional waters is also important to diversify the supply due to increasing water stress. The OIC, as a group, utilizes 2 km^3 of unconventional waters yearly, which is equivalent to 0.2% of its total water withdrawal, compared to the global average of 3.3%. There is a huge potential in the OIC to utilize unconventional sources of water and improving water security in the region.

Nevertheless, barriers such as lack of technology and expertise, inadequate infrastructure, insufficient policies, and economic limitations are constraining the development of unconventional water resources in OIC countries. Furthermore, there are no coordinated initiatives to boost the development of these resources even though such initiatives are in line with the objectives of the OIC Water Vision and would be beneficial for OIC countries.

Every drop matters

Another important aspect of ensuring sustainable water management is demand-side management of water. Every drop of water counts. The management of water will require improvements in water-use efficiency through calculated use and other water-use reduction measures.

Agriculture, as the most water-intensive sector, is in need of efficiency improvement to meet future food demand. This could be achieved through practising conservation, reusing water, and implementing various modern approaches to increase water use efficiency.

The way water is consumed within urban settings is another aspect that needs to be re-considered. Cities in OIC countries will play important role in the overall water cycle, as OIC countries are expected to urbanize at a faster pace in the near future. Urban settings in OIC countries should be 'water sensitive', that is, cities that can integrate the values of environmental sustainability, supply security, flood control, public health, amenity, liveability and economic sustainability, amongst others (Brown et al., 2009).

Realizing the OIC Water Vision and beyond

To achieve a water-secure future in OIC countries, immediate actions need to be taken. While the OIC Water Vision has been a proper strategic document to achieve such a goal, this report pointed out five specific measures that are of the utmost importance for enhancing the sustainability of water management in OIC countries.

Integrating water governance with climate actions and food-energy policies. As the water sector is most directly affected by climate change, integrating water governance with interventions to mitigate climate change is necessary. Furthermore, the strong linkages between the water sector, food security, and energy sector will require an integrated policy framework addressing inter-sectoral and multi-sectoral cooperation. Integrating climate actions and food-energy policies with water governance would enable understanding and solving conflicting interests and provide coordinated solutions.

Reducing gender inequalities in access to WASH services. OIC member countries need to address gender inequalities in access to and management of WASH services. The adoption of gender-responsive programming in the WASH sector can have numerous benefits for OIC member countries such as reducing inequalities in access to water, protecting women from the violence that results from unsafe sanitation services, and reducing mortality rates attributed to a lack of access to WASH.

Broadening funding opportunities. Financial constraints often become a challenge in the implementation of a sound policy. Stakeholders in the water sector should find innovative ways to fund water projects. In the case where investment cannot be recovered through user-fees (for instance in water supply and sanitation projects), revenue generation should be pursued from another channel. In this regard, public-private partnerships (PPPs) scheme can be a good alternative. Integrating the actions for water with climate and food-energy sectors would allow countries to leverage additional resources and open larger funding options while, at the same time, addressing issues of the overlapping sectors.

Knowledge sharing, collaborative activities in research, policy and management support. Inter-sectoral and multi-stakeholder cooperation within OIC countries should be prioritized. Within the framework of cooperation, member countries can learn from the experience of others and apply the knowledge gained whenever suitable in their localities. Also promoted by the OIC Water Vision, exchange of knowledge, skills, and expertise can enhance the infrastructural, institutional, and human capacities of member countries to solve complex water-related issues. Member countries are also urged to pro-actively pursue the exchange of knowledge and capacity building exercises by benefitting from various OIC institutions, such as the various training programs and workshops offered by SESRIC.

Data collection, set up targets, and key indicators to track progress. Achieving the objectives set by the OIC Water Vision is a taxing task, which requires concentrated policies and interventions at community, local, and national levels. Nevertheless, after 2025, the OIC Water Vision should include concrete objectives, programs, and measurable key indicators to track progress. In this regard, OIC countries could prepare a strategic plan such as a 'Water Action Plan', which includes guidelines on data collection, standardized measurement framework, implementation and monitoring mechanisms. Key indicators and targets could be set to report on the most important priorities in the water sector in the OIC. In this regard, SDGs-related targets can be a good point of departure, especially in aligning the efforts of OIC with the efforts to meet SDG targets.

INTRODUCTION

The sustainable management of water resources is crucial for the OIC member countries to address complex and multidimensional developmental issues including, but not limited to, poverty, gender inequality, economic disparity, food insecurity, and global health pandemics. Access to water is a basic human right but the preservation of this right is highly contingent upon effective and sustainable management of water resources and the development of adequate infrastructure and policy regulations.

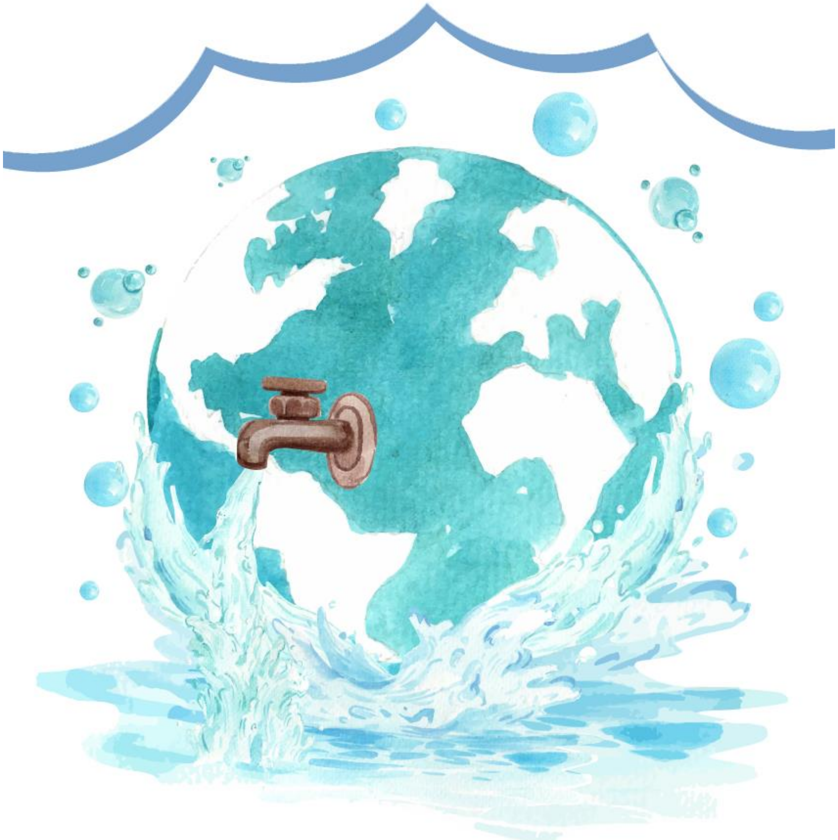
This is why the OIC-2025 Programme of Action emphasizes the need to improve and develop infrastructure and utilization of modern technologies to address challenges pertaining to the optimal use of water resources. This need is enshrined under three different priorities of the OIC-2025 Programme of Action: Priority 5 on Environment, Climate Change and Sustainability, Priority 8 on Agriculture and Food Security, and Priority 12 on Health along with a need to minimize the destructive impact of water and strengthen cooperation in the domain of water resource management.

Similarly, the OIC Water Vision (OIC, 2012) which focuses on OIC member countries' *"working together for a water secure future"* recognizes access to water as an important milestone in improving water security, human health, and overall development in OIC member countries. Both of these strategic documents are in line with the global development agenda on the use and management of water resources such as Agenda 2030 and its Sustainable Development Goal 6, which focuses, amongst other issues, on sustainable management of water resources, wastewater, and ecosystems to ensure the provision of safe drinking water and sanitation for all.

This report aims to document the current state of the water sector in OIC member countries as well as the challenges that the sector faces and possible remedies. The analysis involves examining the data of OIC countries as a group, with disaggregation for geographical regions and individual member countries, usually in comparison with the developed and non-OIC developing countries as well as the global averages.[1] The report consists of three parts. Part 1 discusses the current state and trends on water resources, WASH services, and the impact of COVID-19 on water. Part 2 examines current issues that need to be addressed in water management, namely, the impacts of climate change, water-food security nexus, and water-energy nexus. Finally, Part 3 concludes the report with approaches for sustainable water management and policy recommendations for OIC member countries.

[1] Country groupings and classifications used in this report can be seen in ANNEX I.

PART 1
CURRENT STATE AND TRENDS



Chapter 1
Water Resources and Use

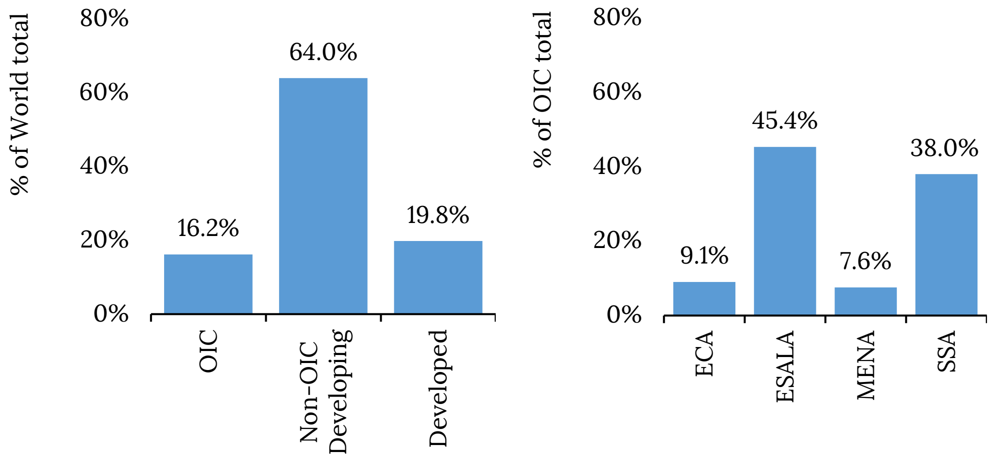
1.1. Distribution and Availability

Precipitation

Member countries of the OIC are a diverse group, belonging to various geographical regions across four continents. This results in a large variance in their climate conditions, the quantity and quality of their physical and natural resources, and development levels. Some countries are located in the desert and semi-arid regions while the others are situated in the wet tropic region. In the desert region, the temperature could change drastically between day and night. Daytime averages reach 38°C, while, during the night, the temperature may drop to 0°C or below. In contrast, the tropic region has an average temperature of 18°C or higher year-round. The tropics also have the characteristic of abundant rainfall and high humidity.

The climatic diversity also has implications for the level of precipitation among the countries. Precipitation is part of the hydrological cycle where surface water and groundwater are replenished. It ensures the sustained availability of water resources all over the world. In OIC countries, precipitation mostly occurs in the form of rainfall, except for the countries with mild and snow climate (such as Turkey, Iran, Albania, and Kazakhstan), which have snowfall during the winter season.

Figure 1.1 Distribution of Long-Term Average Annual Precipitation Volume in the World (left) and by OIC Region (right), 2017

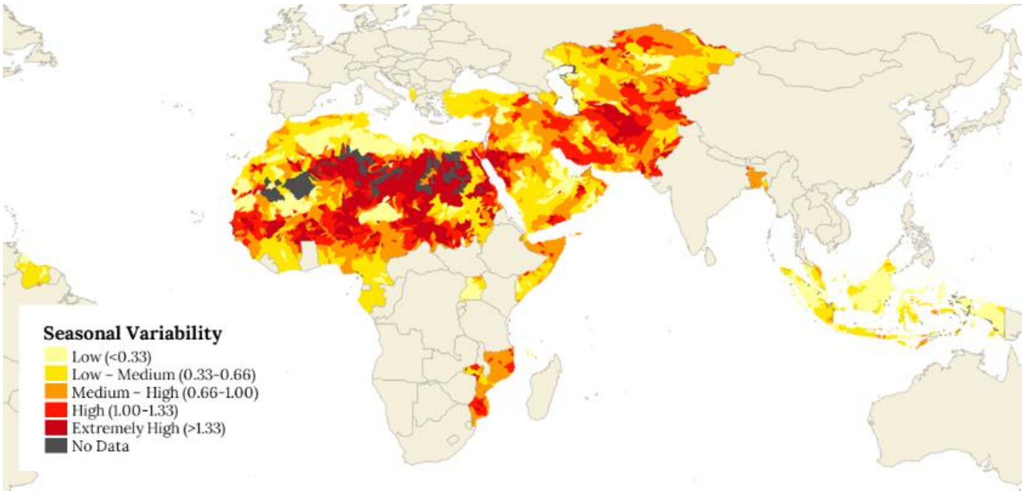


Source: SESRIC staff calculations based on FAO-AQUASTAT Online Database.

Approximately 17,705 km^3 of water fell as precipitation in OIC countries in 2017. This shows that OIC countries, collectively, received about 16.2% of the world's annual precipitation volume of 109,227 km^3 (Figure 1.1, left). During the same period, OIC countries in MENA and ECA regions received the lowest annual precipitation, while ESALA and SSA received the most (Figure 1.1, right).

While the precipitation levels show the average amount of water input to water bodies, the fact that seasonal variability exists cannot be ruled out. Seasonal variability (SV) indicates the degree of fluctuation of water supply between months of the year. A high level of SV may imply drier dry months, wetter wet months, and higher possibility of droughts or intense wet periods (Hofste et al., 2019). As seen in Figure 1.2, many OIC countries have 'high' to 'extremely high' levels of SV, especially SSA and some ESALA countries. This makes the annual water availability in the area less predictable. Seasonal variability has already posed significant negative impacts on rural water supply services in many African countries. Widespread droughts and floods posed a considerable challenge to water availability in many African countries (Twisa & Buchroithner, 2019).

Figure 1.2 Seasonal Water Supply Variability



Source: SESRIC Staff Generated Map Based on WRI (2019).

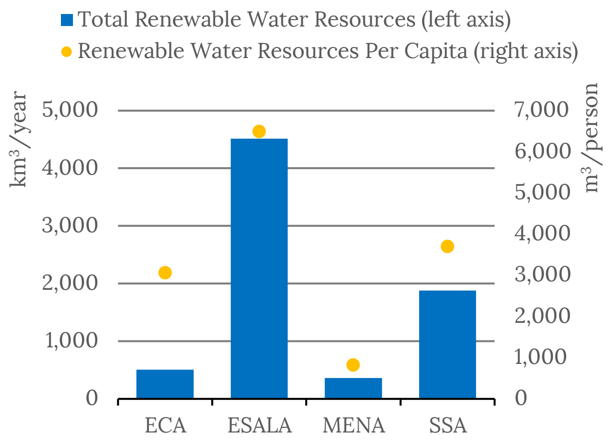
Resources Availability

Water resources are commonly distinguished as renewable and non-renewable water resources. Renewable water resources are freshwater that can get replenished through the hydrological cycle. These resources include surface water and upper aquifer groundwater. Renewable resources are the most utilized water resources for human activities.

OIC countries had a total of 7,261 km^3 renewable water resources in 2017, equivalent to 13.3% of the world's total renewable water resources that year. This share of OIC countries remained much lower than that of non-OIC developing countries, which accounted for more than two thirds (69%) of the world's total renewable water resources.

Relative to population, water resources in OIC countries are also significantly lower than the world average. In 2017, OIC countries, on average, had only 4,029.0 m^3/person of renewable water resources, compared to the world average level of 7,254.2 m^3/person.[2]

Figure 1.3 Renewable Water Resources Availability by OIC Sub-region, 2017



Source: SESRIC staff calculations based on FAO AQUASTAT Database.

Regional diversity of the resources is also quite distinctive in OIC countries, with some regions possessing significantly more water resources than the others do. Figure 1.3 shows the absolute and relative value of renewable water availability in the OIC by region. The availability of water resources is closely linked to a region's climatic conditions, which explains the precipitation levels shown in Figure 1.1. ESALA region has the highest availability of renewable water resources at 4,516.7 km^3/year and accounts for 62.2% of total renewable water resources in the OIC. In comparison, MENA and ECA have the lowest resources at 360.0 and 504.1 km^3/year, respectively. However, given the low population level in ECA, the relative availability of water resources in the region is close to that in SSA although SSA has almost 4 times as much absolute water availability as ECA.

Surface Water

Surface water resources are found on the Earth's surface including rivers, lakes, streams, wetlands, reservoirs, and creeks. While surface water is the least prevalent source of freshwater in the hydrosphere, it is the most easily accessible for human needs and provides important services to the ecosystem. It is also a type of renewable water resource that is replenished in a short period through the hydrological cycle. During the process of replenishment, both the quantity and the quality of surface water are restored. Thus, this type of water resources is very important for the biosphere.

[2] The relative availability of water tends to decline as the population continues to grow. Globally, for example, water availability declined by more than half between 1962 and 2014 (Baldino & Sauri, 2018). Assuming that the absolute quantity of water resources remains constant and taking into account the OIC's population growth of 2% (SESRIC, 2020c), the water availability in OIC will shrink by half in about 35 years.

Surface water accounts for the majority of renewable water resources around the globe. About 83.2% of the world's renewable water resources are surface water and the remaining are groundwater. Similarly, in the OIC, the absolute availability of renewable surface water is at 6,986.7 km^3/year or equivalent to 82.3% of the total renewable water resources. OIC regions are passed by 7 major rivers with large catchment areas (more than 1,000,000 km^2) namely Amazon, Congo, Nile, Ob, Niger, Orinoco, and Zambezi, and another 15 rivers with a catchment area more than 100,000 km^2.[3]

Rivers play an important role in the OIC's economy as a source of water for urban and rural areas, agriculture, and industry. They are also used as a transport hub, a setting for recreation, and a place to discharge wastewater. Furthermore, many communities depend on freshwater fishing to sustain their living.

Groundwater Resources

Groundwater is another water resource that can be utilized for human needs. Based on its replenishable properties, groundwater is distinguished into two types: renewable groundwater and non-renewable groundwater. Renewable groundwater is found in the upper aquifer, and thus replenishes in a short period through the water cycle. In contrast, non-renewable groundwater –also known as fossil water– is located in the deeper aquifer and has been accumulated from previously more humid climatic conditions that existed thousands of years ago.

Renewable groundwater is relatively closer to the earth's surface, thereby easier to extract. However, the quantity of these resources is very limited. In OIC regions, renewable groundwater is estimated at 1,500.8 km^3/year or equivalent to around 17.7% of total renewable water resources in the OIC. Groundwater provides a very important service, especially in the arid and semi-arid regions. The dry-climate MENA region, often with a lack of surface water, has 83.8 km^3/year of renewable groundwater resources. Groundwater provides reliable sources of water during dry years when surface resources are not available.

Despite having low renewable water resources, OIC countries in MENA and SSA are home to many of the world's major aquifers containing non-renewable water resources. The global extraction of non-renewable groundwater is concentrated in Saudi Arabia and Libya, which together account for 77% of the estimated total world extraction of non-renewable groundwater (SESRIC, 2018). In the arid areas of the MENA region, groundwater is a source of life and used for both urban water supply and irrigated agriculture. However, unplanned depletion of non-renewable groundwater reserves can undermine, and potentially erode, the economic and social vitality of OIC countries in MENA. The challenge for these countries is to find a balance between preservation and use.

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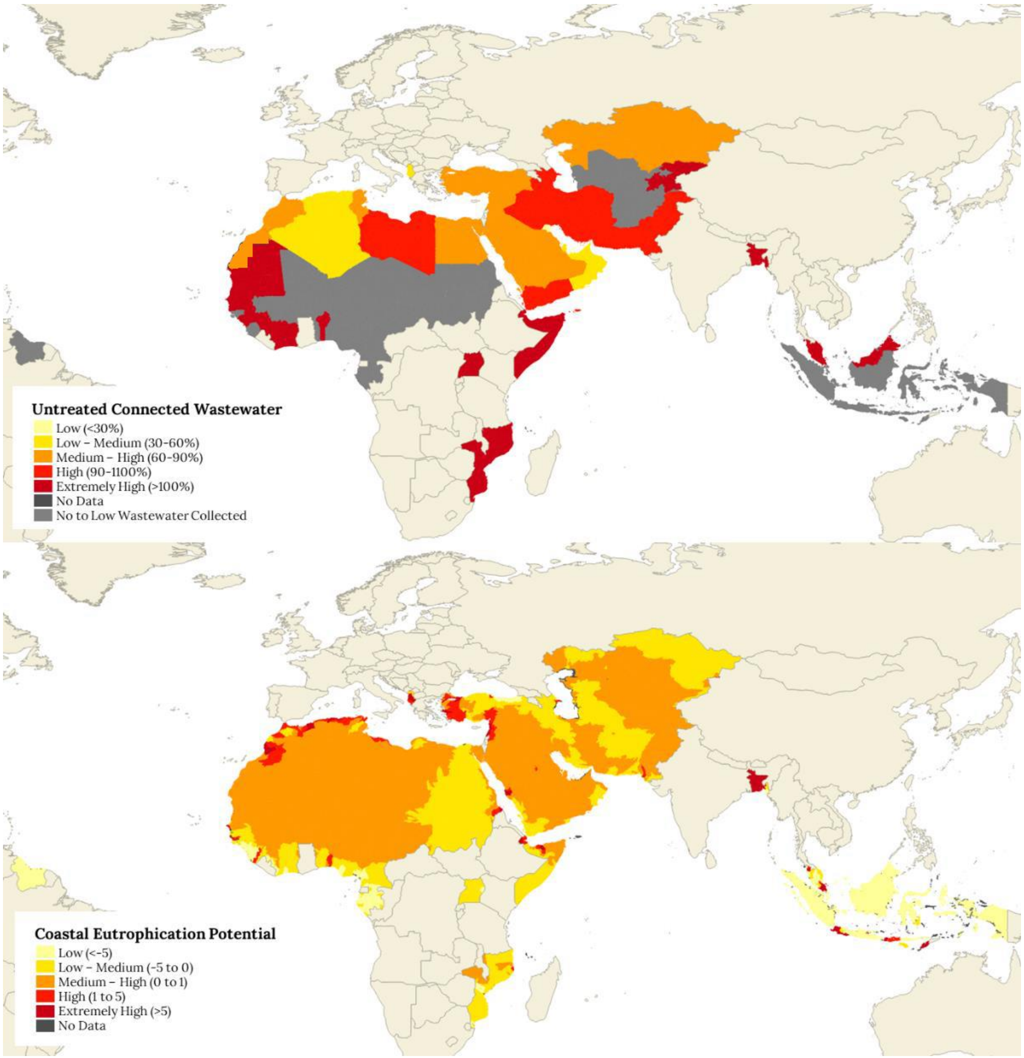
[3] A complete list of the rivers and their properties can be seen in ANNEX II.

Water Quality

An adequate supply of water has to be coupled with good water quality to accomplish water, health, and food security. However, water quality problems occur around the world due to changes in hydromorphology, loss of pristine-quality water bodies, and increasing pollutants and invasive species (UN, 2018). "*Poor water quality directly impacts people who rely on these sources as their main supply by further limiting their access to water (i.e. water availability) and increasing water-related health risks*" (WWAP, 2019, p.15). This will further have a negative implication on society at large. For instance, water-related disease is common in developing countries where wastewater is rarely treated before its discharge into the environment (WWAP, 2017).

Figure 1.4 Untreated Connected Wastewater (upper) and Coastal Eutrophication Potential (lower)



Source: SESRIC Staff Generated Map Based on WRI (2019).

In the majority of rivers around the OIC region, water pollution has worsened since the 1990s. Severe pathogen pollution and increasing level of nutrients and salinity have been recorded on various major rivers across Latin America, Africa, and Asia, where OIC countries are located.

While pathogens pose a health risk for drinking water, populations are also at risk due to direct contact with the polluted water used for various household activities (such as cooking, bathing, and cleaning). The risk is even more daunting for a rural population who often use polluted rivers directly without any treatment. Furthermore, the increase in salinity damages the use of river water for industry, irrigation, and other uses.

Severe nutrient loadings are also affecting many countries in the OIC. Untreated wastewater coming from industry, agriculture, and households are responsible for the increasing nutrient emissions. A high level of nutrients in the water is not only harmful for direct use and the water ecosystem but also burdens the production of clean water. OIC regions are projected to be the hotspots of increasing nutrient pollutions in surface waters, especially where households are growing without adequate wastewater treatment systems (PBL Netherlands Environmental Assessment Agency, 2018).

Figure 1.4 portrays the status of wastewater treatment in OIC member countries via the indicator of “untreated connected wastewater”. This indicator measures the percentage of domestic wastewater that is connected through a sewerage system and not treated to at least a primary treatment level. Higher values indicate higher percentages of wastewater discharged without treatment. Accordingly, some member countries still do not have adequate household wastewater connection (countries in light grey). Furthermore, the other countries that already have wastewater connections often leave a considerable amount of wastewater untreated (countries in red and maroon).

Besides the inadequate treatment of wastewater, which could expose water bodies, the general public, and ecosystems to pollutants such as pathogens and nutrients (Hofste et al., 2019), eutrophication also poses potential risks to water quality. Eutrophication happens when a body of water becomes overly enriched with minerals and nutrients that induce excessive growth of algae. This process may result in oxygen depletion of the water body, which is destructive to surrounding ecosystem. Since excess nutrients in water usually come from human activities, Coastal Eutrophication Potential (CEP) could be a good lead to pinpoint the area that has a lack of wastewater treatment. CEP measures the potential for riverine loadings of nitrogen (N), phosphorus (P), and silica (Si) to stimulate harmful algae blooms in coastal waters (Hofste et al., 2019). Accumulation of N, P, and Si in water bodies would stimulate blooming of algae, which to some extent may result in eutrophication. As seen in Figure 1.4, some coastal areas in OIC member countries have a high level of CEP; for instance, coastal area of Morocco, Tunisia, Turkey, Syria, Bangladesh and several islands in Indonesia.

1.2. Water Demand

The latest estimate shows that water withdrawal in OIC countries amounts to around a thousand km^3 per year, or equivalent to a quarter of total global water withdrawal. Around 75% of water withdrawal in the OIC is carried out in ESALA and MENA, while SSA has the lowest water withdrawal of only around 60 km^3 per year.

OIC member countries, on average, have a significantly lower water demand per capita than that observed in developed countries. The annual total water withdrawal per capita in OIC countries averages at 650 m^3/person; while in developed countries, it reaches up to 867 m^3/person (SESRIC, 2018). Furthermore, among OIC regions, the variations are also large. Water demand per capita is expected to decrease in the future, largely due to increasing population coupled with the impacts of climate change.

Source of Water Demand

In terms of the sources, conventional waters (i.e. fresh surface water and groundwater) are the primary resources accounting for more than 90% of total water withdrawal. As presented in Table 1.1, unconventional water resources are not yet commonly used neither globally nor in OIC countries.

In OIC countries, 99.8% of total water withdrawal is coming from conventional resources, compared to the worlds' usage level at 96.7%. Of all world groups analysed, other developing countries utilize unconventional sources the most, due to their high usage of direct-use of agricultural drainage water. This could be a good example for OIC since the agriculture sector plays a vital role in many OIC countries.

Table 1.1 Water Withdrawal by Source

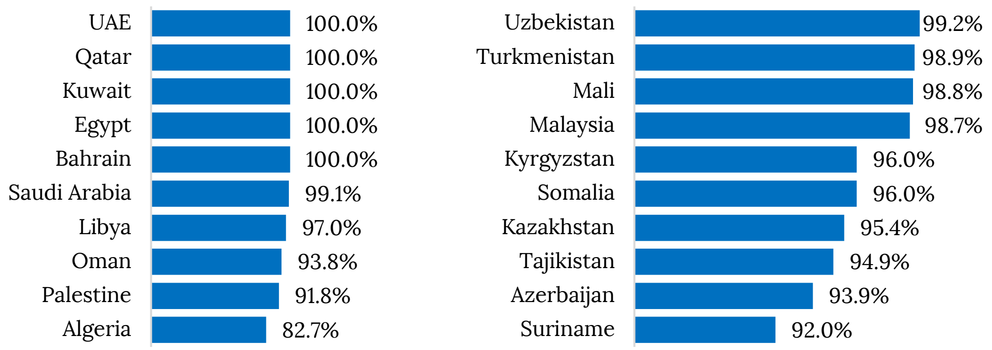
Country Group/Region	Unconventional Sources			Conventional Sources
	Desalinated water produced	Direct use of agricultural drainage water	Direct use of treated municipal wastewater	Fresh surface water and groundwater
OIC	0.1%	0.1%	0.0%	99.8%
ECA	0.4%	0.8%	0.1%	98.6%
ESALA	1.4%	0.0%	0.0%	98.6%
MENA	2.0%	3.9%	1.7%	92.4%
SSA	0.0%	0.0%	0.0%	100.0%
Developed	0.1%	0.0%	0.9%	99.0%
Non-OIC Developing	0.0%	4.9%	0.6%	94.5%
World	0.2%	2.4%	0.6%	96.7%

Source: SESRIC Staff Calculations based on FAO AQUASTAT.

While the use of unconventional water is uncommon in the OIC, MENA region stands out with 7.6% of withdrawal from unconventional sources. Indeed, countries in MENA are by far the world's largest producers of desalinated water. This is quite reasonable since, in the more arid climates, freshwater is scarcer, thereby the use of unconventional resources offers an opportunity to alleviate the scarcity of renewable water resources, improve social welfare, and facilitate economic development.

In terms of the use of conventional sources (i.e. fresh surface water and groundwater), a different pattern is observed in OIC countries. Countries in the drier climate tend to extract groundwater while countries in the wetter climate extract surface water the most. Figure 1.5 illustrates the top 10 OIC countries with the highest share of groundwater and surface water extraction. For example, UAE, Qatar, Kuwait, Egypt, and Bahrain extract freshwater entirely from groundwater. On the other hand, Uzbekistan extract 99.2% of their freshwater through surface water.

Figure 1.5 Top 10 OIC Countries for the Share of Groundwater (left) and Surface Water (right) Withdrawal, 2002-2017



Source: SESRIC Staff Calculations based on FAO AQUASTAT.

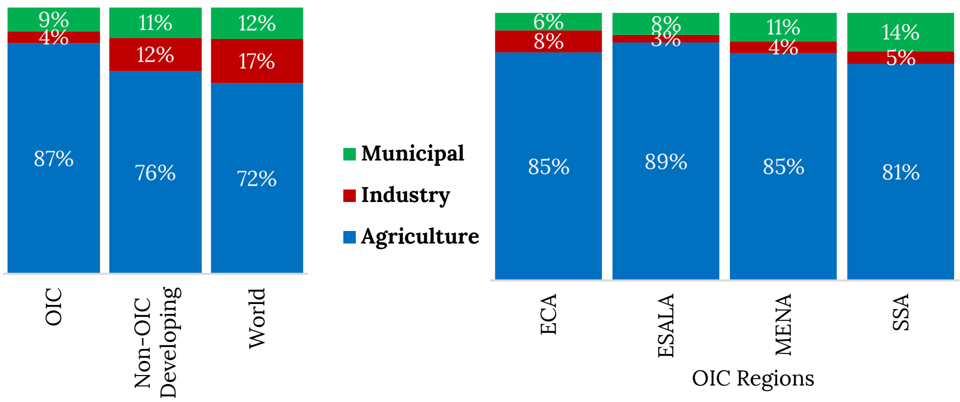
Sectoral Water Demand

In terms of sectoral demand, agriculture accounts for the vast majority of water demand both globally and in the OIC. As shown in Figure 1.6, in the OIC, water withdrawal for the agricultural sector accounts for 87% of total water withdrawal, compared to industrial and municipal demand that account for 4% and 9%, respectively. The global water consumption patterns show lower water demand for agricultural use at around 72%, and higher demand for industrial (17%) and municipal use (12%). Although there exists variability among OIC regions to some extent, they have a similar pattern in general, where agriculture accounts for the largest share at between 81-89%.

The fact that agriculture holds the largest share in OIC's overall water demand shows the intimate link between water and agriculture and food security. The increasing demand for food would therefore significantly increase the water demand. Failing to meet this demand would pose a food security risk to the region. The relationship between water and food security is discussed more thoroughly in Chapter 5.

The industrial sector is the least water-consuming sector in the OIC, nevertheless, plays an important role in the water sector. The majority of water demand for the industrial sector comes from energy production, which accounts for around 75% of water withdrawal in the industry (WWAP, 2014). Current development trends point out to an increase in energy demand, which in turn would need a sufficient supply of water. Burek et al. (2016) projected that the overall water demand from industry would increase across all OIC regions up to eight times by 2050. Correspondingly, the water sector needs industry/energy throughout its value chain. This Water-Energy interaction is an emerging challenge to deal with in the 21st century, particularly in such a vastly growing region as the OIC. This topic is discussed in more detail in Chapter 6.

Figure 1.6 Water Demand by Sector



Source: SESRIC Staff Calculations based on FAO AQUASTAT.

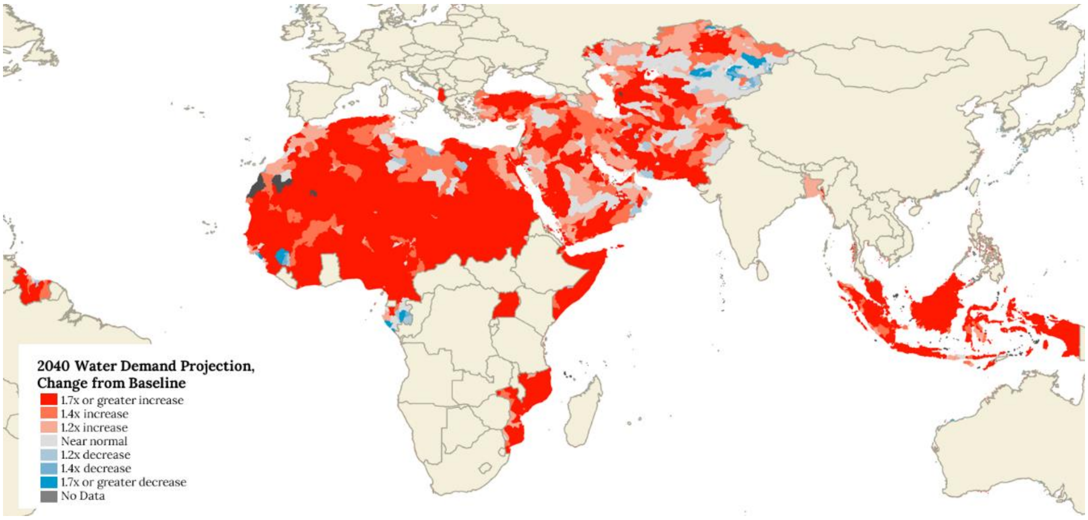
OIC countries are among the fastest urbanizing regions. The OIC population in urban areas grows by more than 3% annually, and by 2035, there would be 343 cities having more than half a million population (SESRIC, 2019a). Therefore, water demand for municipal use would see a significant increase in OIC countries. The greatest increases would occur in SSA and ESALA sub-regions, where it could grow more than triple (Burek et al., 2016). The high growth can mainly be associated with an increase in water supply and sanitation services in urban settlements.

Demand Projection

Globally, water demand has been increasing since the 1980s by around 1% per year (WWAP, 2019). This trend is also seen in OIC countries. A combination of demand drivers such as population growth, socio-economic development, and change in consumption patterns has led to a significant increase in water demand.

As for the future, the projection of water demand in OIC countries by 2040 is shown in Figure 1.7. While there is a diversity in the increase in demand within and between countries, by 2040, most OIC countries could witness water demand grow by 1.4 to 1.7 times or more, relative to its 2010 baseline.[4] To put into context and comparison, Burek et al. (2016) projected that global average water demand would increase by around 20 to 30% by 2050.

Figure 1.7 Projected Change in Water Demand by 2040



Source: SESRIC Staff Generated Map Based on WRI (2019).

Water demand in the OIC will continue to grow significantly over the next decades. This growth would mainly be attributed to increases in industrial and domestic sectors (Burek et al., 2016; IEA, 2016). Nevertheless, agriculture would continue to have the largest share in overall water demand, though to a lesser extent. Therefore, agriculture will still hold an important role as the largest user of water in the coming decades. The competing uses of water between sectors are important challenges, especially in OIC countries where the agriculture sector holds an important role in the economy. Therefore, the overall water development strategy should include a sustainability approach considering demand in various sectors, including the need for environmental sustainability.

1.3. Water Security and Risk

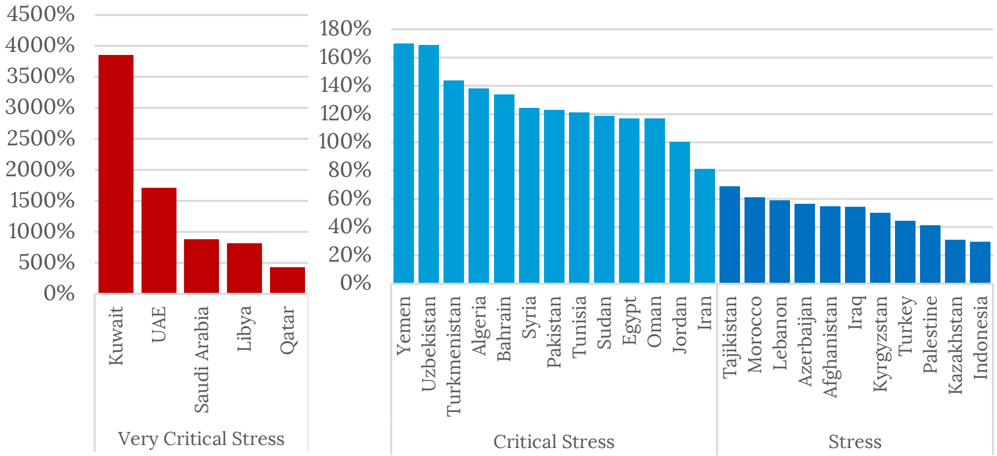
Water Stress

Water security is defined as: "*The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a*

[4] The projection was based on Shared Socioeconomic Pathways 2 (SSP 2): Middle of the Road and Representative Concentration Pathways 8.5 (RCP 85) : concentration of carbon that delivers global warming at an average of 8.5 watts/m^2 across the planet

climate of peace and political stability" (UN-Water, 2013, p.1). The definition emphasizes various key components of water security as well as positioning water in the central stage in achieving a larger sense of sustainable development and human well-being.

Figure 1.8 OIC Countries Experiencing Water Stress (%), 2017



Source: SESRIC Staff calculation based on FAO AQUASTAT.

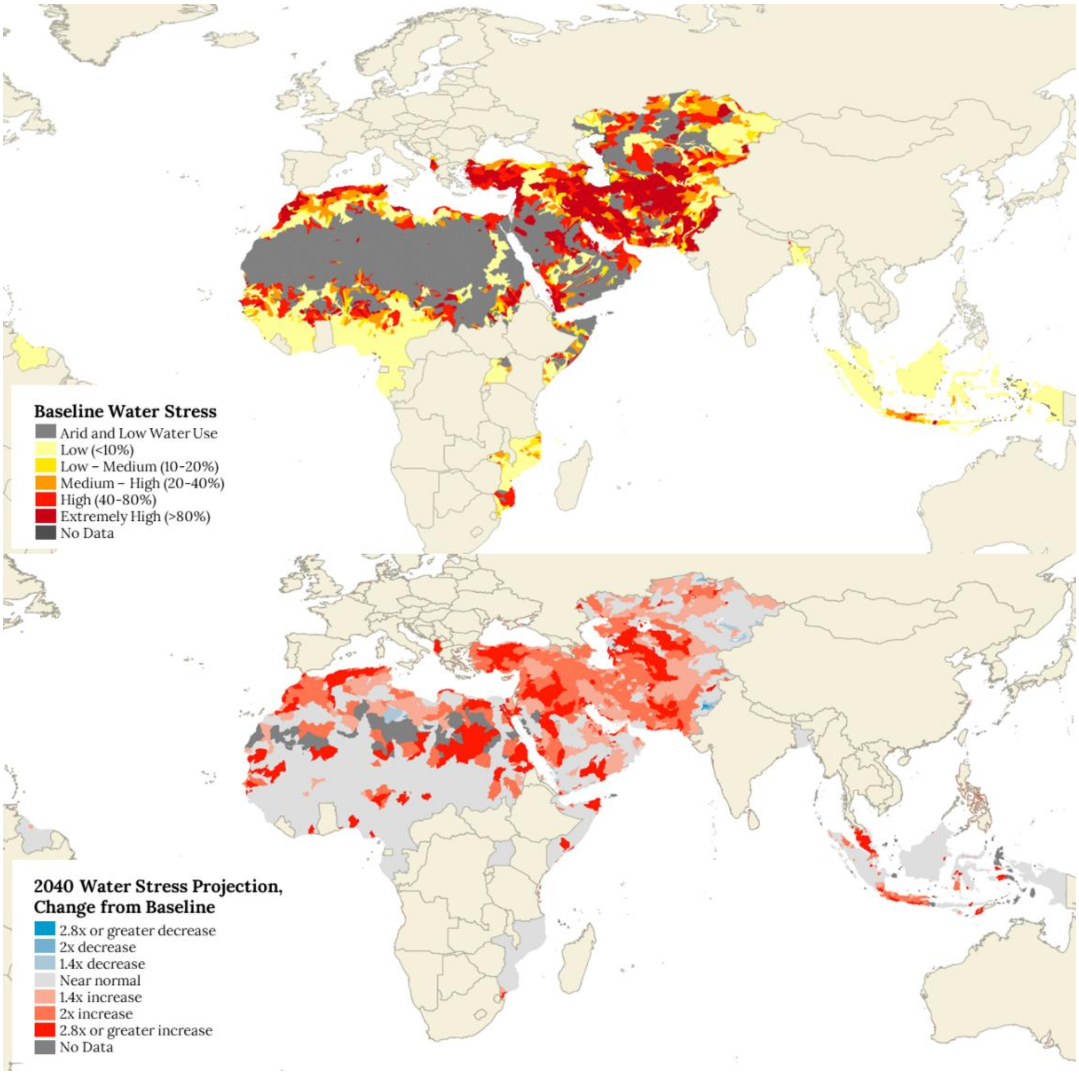
There are many measures of water security. While the previous report (SESRIC, 2018) presented water security in terms of scarcity, it can also be measured in terms of water stress. The level of water stress measures the proportion of water withdrawal by all sectors to the available water resources, taking into consideration water requirements for sustaining the natural environment as well. The indicator provides information on whether water is sufficient to consume for both environment and society at large, thereby indicating the water security status of the region. A high level of water stress not only hinders the sustainability of the natural environment but also could have negative impacts on socio-economic development and food security due to competing water use. This indicator is also used to track progress towards SDG Target 6.4.[5]

By definition of the indicator, countries begin to experience water stress at a 25% level, while above 70% is considered as critically stressed (UN-Water & FAO, 2018). During the 2000-2015 period, UN-Water & FAO (2018) estimated the global water stress at 13%. The OIC, however, is estimated to have a water stress indicator value of 32.7%, which is considered as experiencing water stress. At the individual country level, there are 29 OIC member countries undergoing water stress, 13 of which are in critical stress levels and five countries are in a very critical stress level (see Figure 1.8). Most countries that suffer water stress are the ones in arid and semi-arid regions, where water resources are

[5] SDG Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

scarce. At the sub-regional level, MENA and ECA are the regions with most countries under serious threat of water stress.

Figure 1.9 Water Stress in Baseline (upper) and Projected Change in Water Stress by 2040 (lower)



Source: SESRIC Staff Generated Map Based on WRI (2019).

The aggregated data presented above sometimes does not reflect the difference of water stress across various basins within the country. For example, Indonesia, within the aggregated water stress data, is accounted as a medium-high (20-40%) water stress country. However, at the local level, some regions within the country are experiencing high to extremely high water stress (more than 40%). It is thus important to see the water stress situation from the basin perspective. Figure 1.9 illustrates the water stress in OIC countries in a more detailed spatial resolution.

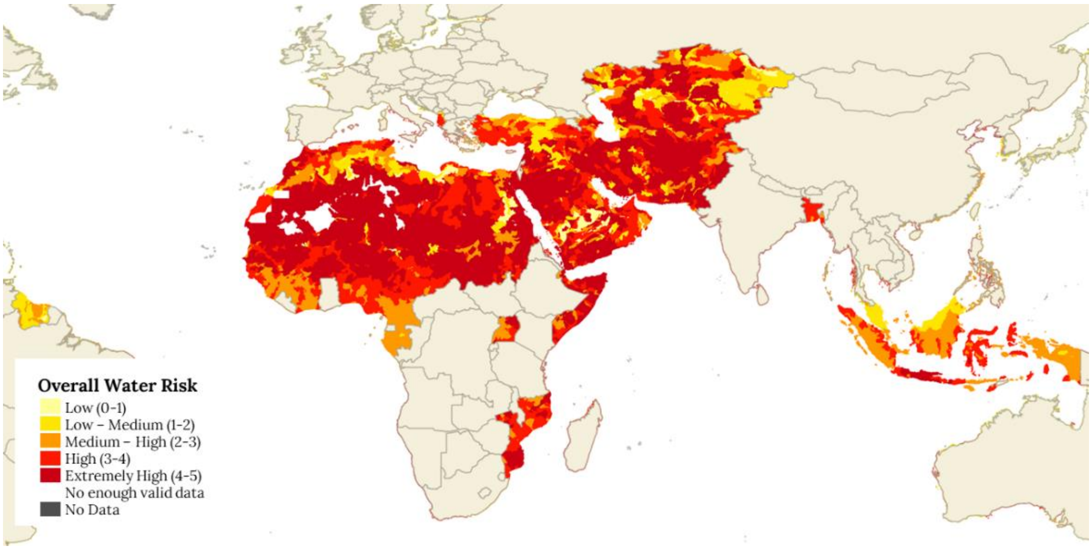
Most of the regions with high water stress levels coincide with centres of economic activity. To illustrate, most of the central economic areas in MENA and ECA countries have at least "high" water stress level.

Water stress level is increasing over time as water demand grows due to population increase and change in consumption patterns. On the other hand, the impacts of climate change would most likely change the availability of water in the future. The lower part of Figure 1.9 illustrates the projected change of water stress level in the OIC, based on the business as usual scenario.[6] Accordingly, most OIC regions will see an increase by at least 1.4 times as much as the baseline level. By the year 2040, the regions that are already experiencing water stress will be more distressed, while some regions will start to undergo water stress.

Overall Water Risk

Water-related risk is one of the most important components of safeguarding water security. The ability to understand the water-related risks and uncertainties is an initial step to practise sustainable water management. Some of the properties of high-risk regions are area with low precipitation, high population growth in the water-scarce area, and area with international competition. Furthermore, water governance of the region is also an important aspect to consider for overall water risk.

Figure 1.10 **Overall Water-related Risk**



Source: SESRIC Staff Generated Map Based on WRI (2019).
Note: Higher values indicate higher risk.

To see the water-related risk more precise, a quantitative analysis based on an index is used. World Resources Institute (WRI) developed a composite "overall water risk" score

[6] Business as usual scenario based on SSP 2 and RCP 85

by aggregating 13 water risk indicators, including physical quantity, quality, and regulatory & reputational risk categories (Hofste et al., 2019). Figure 1.10 illustrates the overall water risk calculated for OIC member countries, where we can see the diversity of water risks between and within OIC countries. In general, most OIC countries are already exposed to at least medium-high water risk. Immediate attention needs to be directed to countries with ‘high’ to ‘extremely high’ risks. If the trend of unsustainable use of water and environmental degradation keeps occurring, the economy, food production, and well-being of society will be at risk by 2050. The risk will be higher to vulnerable groups in society, thereby widening the gap of inequality even further (UN, 2018).

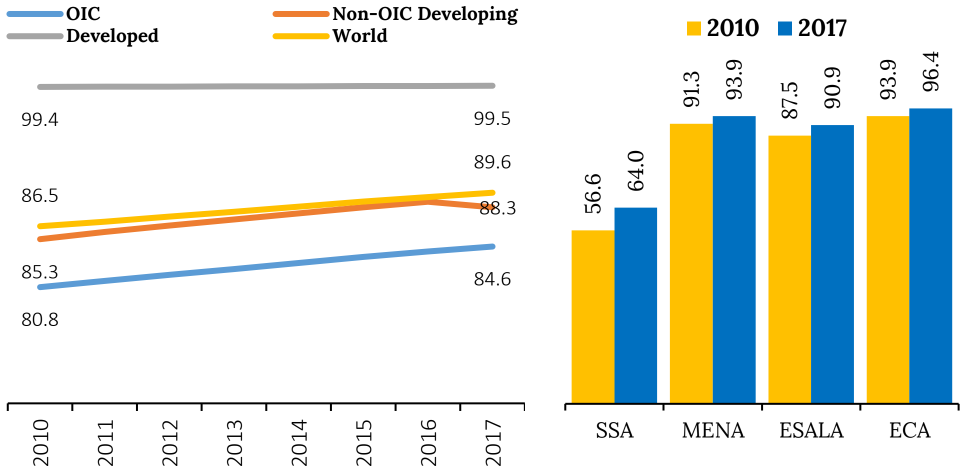
Chapter 2
Drinking Water, Sanitation, and Hygiene

2.1. State of Drinking Water, Sanitation, and Hygiene Services

Universal access to drinking water, sanitation, and hygiene is important not only for an individual's health and wellbeing, but also for socio-economic progress because of its direct impact on poverty, hunger, and inequality. For instance, the UN's Annual Water Report 2019 (UN-Water, 2020a) finds that access to drinking water and sanitation has an impact on development, peace, and humanitarian relief. However, an adequate WASH infrastructure is heavily reliant on the amount of water resources and the management of these resources.

A rise in the global population inevitably results in an increased demand for water in the WASH sector. This increase in demand can have a considerable impact on a country's ecosystem because it often entails an increase in energy-intensive pumping, treatment, and transportation of water (UN-Water, 2020a). Furthermore, poor water resource management in the WASH sector can also pose additional risks in developing countries where water is unaffordable, inaccessible, or physically scarce –especially in crises such as the COVID-19 pandemic where access to safe WASH services is a critical intervention that can curb the spread of the contagious virus.

Figure 2.1 Proportion of Population with Access to at Least Basic Drinking Water around the World (left) and in OIC Sub-Regions (right) (%), 2010-2017



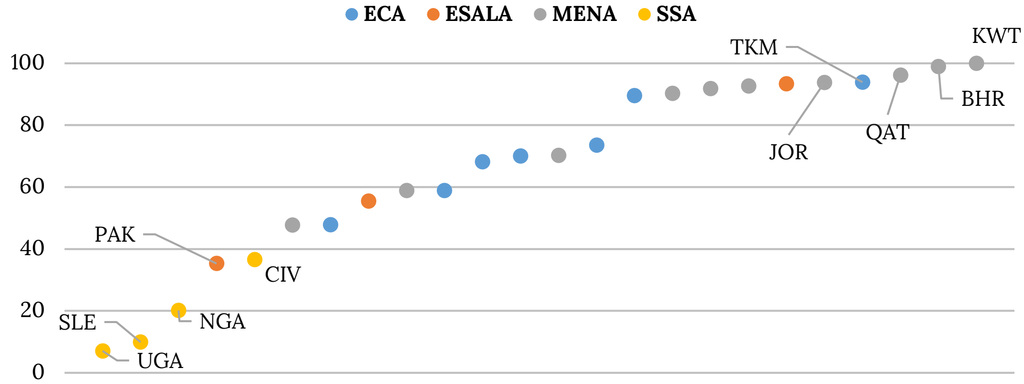
Source: World Bank's World Development Indicators.

Access to drinking water, sanitation, and hygiene has improved immensely since the early 2000s. According to the latest data from the World Bank's World Development

Indicators, the proportion of the global population with access to at least basic drinking water[7] increased from 86.5% in 2010 to 89.6% in 2017 (Figure 2.1). This, nevertheless, implies that around 0.7 billion people were still lacking this essential service. In OIC member countries, 84.6% of the population had access to at least basic drinking water in 2017 – relatively low as compared to non-OIC developing countries (88.3%) and developed countries (99.5%). Regionally, there were disparities in the coverage of basic drinking water amongst various OIC regions. For instance, as Figure 2.1 shows, member countries in MENA, ECA, and ESALA achieved a 90% or higher coverage of basic drinking water service whereas those in SSA recorded a coverage level of only 64%. In fact, in Chad, Burkina Faso, and Uganda, less than 50% of the population had access to at least basic drinking water in 2017.

In a similar vein, data from 2017 shows that around 2.2 billion people around the world (29.4% of the world population) do not have access to safely managed drinking water.[8] As for OIC member countries, Figure 2.2 shows that less than 50% of the population had access to safely managed drinking water in Uganda (7.1%), Sierra Leone (9.9%), Nigeria (20.1%), Pakistan (35.3%), Cote d'Ivoire (36.5%), Lebanon (47.7%), and Tajikistan (47.9%). At the same time, this ratio reached above 90% in Kuwait (100%), Bahrain (99%), Qatar (96.2%), Turkmenistan (93.9%), Jordan (93.8%), Malaysia (93.3%), Tunisia (92.7%), Iran (91.8%), and Oman (90.3%).

Figure 2.2 Proportion of Population with Access to Safely Managed Drinking Water in OIC Countries (%), 2017



Source: World Bank's World Development Indicators.
Note: Refer to ANNEX I for country codes.

As compared to access to drinking water, the coverage of basic and safely managed sanitation around the world is relatively lower; even though the proportion of population

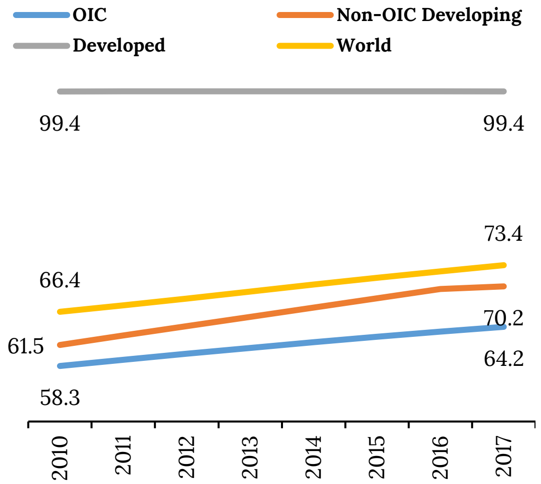
[7] It is defined as access to basic drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip including queuing (WHO and UNICEF, 2017a).
[8] Safely managed water is described as water "from an improved source which is located on premise, available when needed, and free from faecal and priority chemical contamination" (WHO and UNICEF, 2017a, p. 12). Such sources are designed and constructed with a consideration for safely delivering water to premises and include "piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water" (WHO and UNICEF, 2017a, p. 10),

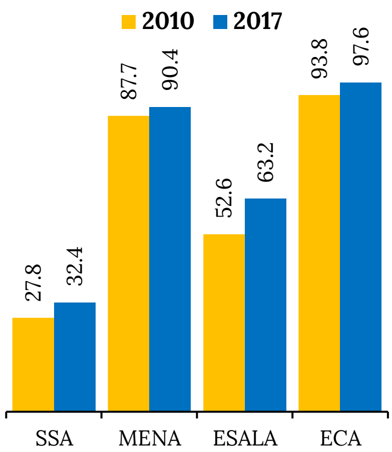
using at least basic sanitation increased by 7 percentage points between 2010 and 2017. However, the proportion of population with at least basic sanitation was lowest in OIC member countries at 64.2%. In comparison, 70.2% of population in non-OIC developing countries and 99.4% in developed countries had access to at least basic sanitation.

Among the OIC regions, the proportion of people with access to at least basic sanitation was highest in ECA at 97.6%, followed by MENA with 90.6%, ESALA with 63.2%, and SSA with 32.4% (Figure 2.3). Yet, less than half of the population had access to at least basic sanitation in all OIC member countries in SSA (except Senegal) plus Afghanistan and Bangladesh.

Similar to access to basic sanitation, the proportion of population using safely managed sanitation[9] around the world also increased by 7.9 percentage points between 2010 and 2017. Yet, in 2017, approximately 4.1 billion people (55% of world's population) continued to not have access to safely managed sanitation – almost double the number of people without access to safely managed drinking water service.

Figure 2.3 Proportion of Population with Access to at Least Basic Sanitation around the World (left) and in OIC Sub-Regions (right) (%), 2010-2017





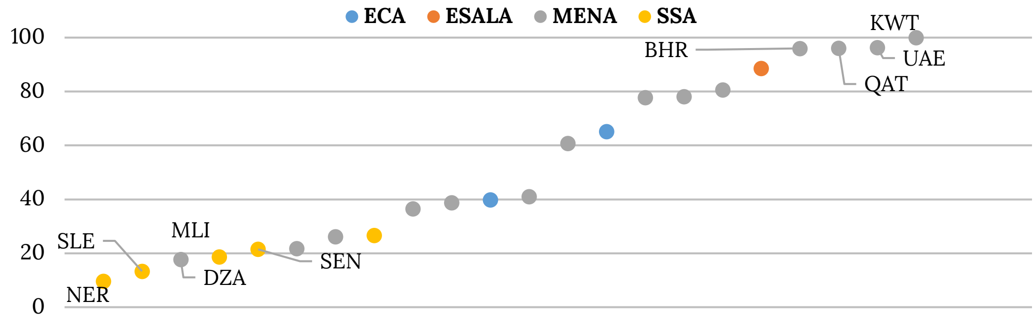
Source: World Bank's World Development Indicators.

Much like the coverage of indicators above, the coverage of safely managed sanitation also differs largely across OIC member countries. As shown in Figure 2.4, less than 50% of population has access to safely managed sanitation in Niger (9.6%), Sierra Leone (13.3%), Algeria (17.7%), Mali (18.7%), Senegal (21.5%), Lebanon (21.8%), Libya (26.1%),

[9] Safely managed sanitation refers to "improved facilities which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site" (WHO and UNICEF, 2017b, p. 4). Improved facilities include mechanisms "designed to hygienically separate excreta from human contact and include: flush/pour flush to piped sewer system, septic tanks or pit latrines, ventilated improved pit latrines, composting toilets or pit latrines with slabs" (WHO and UNICEF, 2017b, p. 8).

Nigeria (26.7%), Djibouti (36.4%), Morocco (38.8%), Albania (39.9%), and Iraq (41.1%). On the contrary, Kuwait (100%), United Arab Emirates (96.3%), Qatar (96%), and Bahrain (96%) recorded the highest proportion of population with access to safely managed sanitation.

Figure 2.4 Proportion of Population with Access to Safely Managed Sanitation in OIC Countries (%), 2017

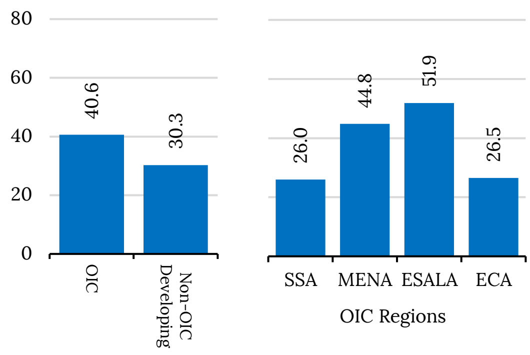


Source: World Bank's World Development Indicators.
Note: Refer to ANNEX I for country codes.

Another crucial element of safe and adequate WASH services is access to basic handwashing facilities that include soap and water. This element is of special relevance to global health emergencies and pandemics, such as the unprecedented COVID-19 pandemic. Along with daily disinfection, cleaning of surfaces, provision of clean water, sanitation and waste management, environmental cleaning, and decontamination processes, regular handwashing is one of the essential measures for improving hygiene (WHO and UNICEF, 2020), which plays a critical role in reducing the spread of COVID-19.

According to the World Bank's World Development Indicators, in 2017, the accessibility of basic handwashing facilities with soap and water was relatively better in OIC member countries than in the other developing countries. During the same period, the proportion of population with access to basic handwashing was 40.6% in OIC member countries, and this ratio remained above

Figure 2.5 Proportion of Population with Access to Basic Handwashing Facilities including Soap and Water in the Developing World (left) and in OIC Sub-Regions (right) (%), 2017



Source: World Bank's World Development Indicators.

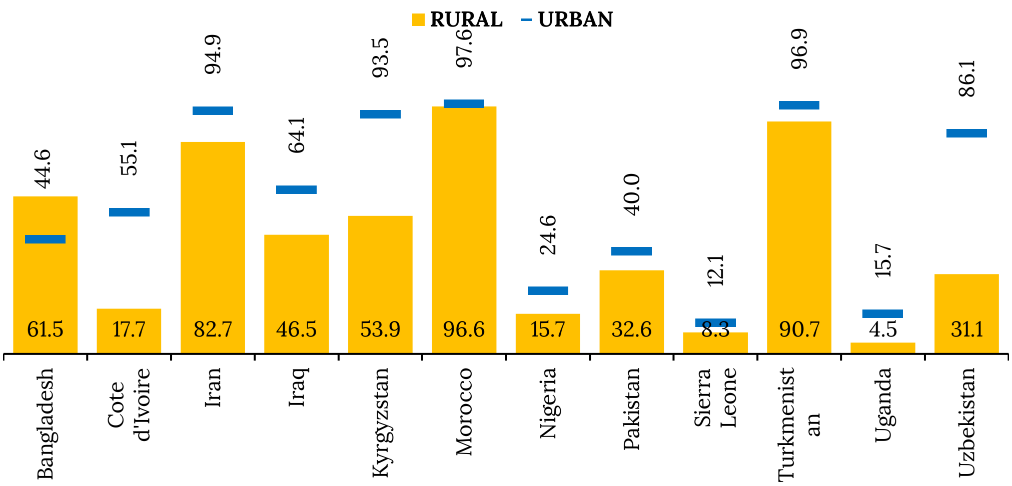
that of non-OIC developing countries throughout the period under consideration[10] (Figure 2.5, left).

Regional breakdown of the OIC data shows that, as of 2017, the lowest coverage of basic handwashing service including soap and water was in SSA (26%), followed by ECA (26.5%), MENA (44.8%), and ESALA (51.9%) (Figure 2.5, right). Individually, 19 OIC member countries had a coverage for less than half of their population, namely Chad (5.8%), Guinea-Bissau (6.4%), Gambia (7.9%), Cameroon (9.4%), Somalia (9.8%), Togo (10.5%), Benin (11%), Burkina Faso (11.9%), Guinea (17.4%), Sierra Leone (19.3%), Cote d'Ivoire (19.4%), Uganda (21.2%), Sudan (23.4%), Senegal (24.1%), Bangladesh (34.8%), Afghanistan (37.7%), Nigeria (41.9%), Mauritania (43%), and Yemen (49.5%).

2.2. Inequalities and Disparities in WASH Coverage

Around the world, reducing and eliminating inequalities in access to WASH services has garnered wide attention in recent years owing to the 'leave no one behind' motto promoted by the SDGs. Structural inequalities in the coverage of WASH services perpetuate discrimination that is based on a person's *"geographical location, socio-economic status, or individual context-specific features"* (WHO and UNICEF, 2019a, p. 13). However, measuring such inequalities is often a difficult task obstructed by the sparsity and lack of national-level data and statistics.

Figure 2.6 Rural-Urban Disparities in Safely Managed Drinking Water in OIC Countries (% of population), 2017



Source: World Bank's World Development Indicators. Note: The chart shows only the countries with available data.

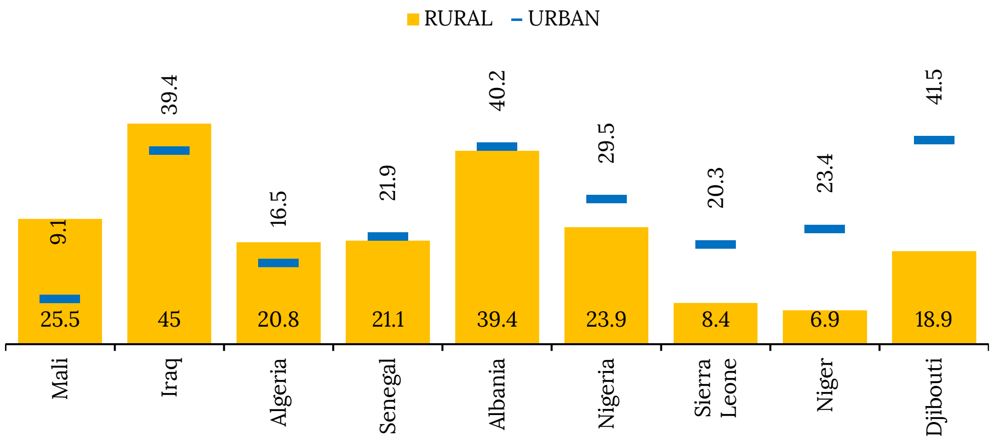
An overview of data on OIC member countries – provided by World Bank's World Development Indicators – shows that the disparity in access to WASH services is not limited to OIC regions; rather, it also extends to urban-rural areas within member

[10] It is important to note here that data on access to basic handwashing facilities is generally deficient, which is also why leading international agencies including WHO and UNICEF's JMP do not report world averages for this indicator.

countries. In fact, in some cases, urban-rural disparities persist in member countries from regions that have otherwise performed relatively better in terms of overall service coverage trends – as discussed in the previous section.

For example, even though the coverage of basic and safely managed drinking water service is relatively higher in ECA, the proportion of the population with safely managed drinking water in Uzbekistan was as high as 86.1% in urban areas as compared to a mere 31.1% in rural areas (Figure 2.6). Similarly, in the Kyrgyz Republic, 93.5% of the urban population had access to safely managed drinking water as opposed to 53.9% of the rural population. Similarly, member countries in SSA had some of the lowest urban-rural disparities in coverage of safely managed drinking water even though the overall coverage of WASH services in SSA was comparatively poorer.

Figure 2.7 Rural-Urban Disparities in Safely Managed Sanitation in OIC Countries (% of population), 2017



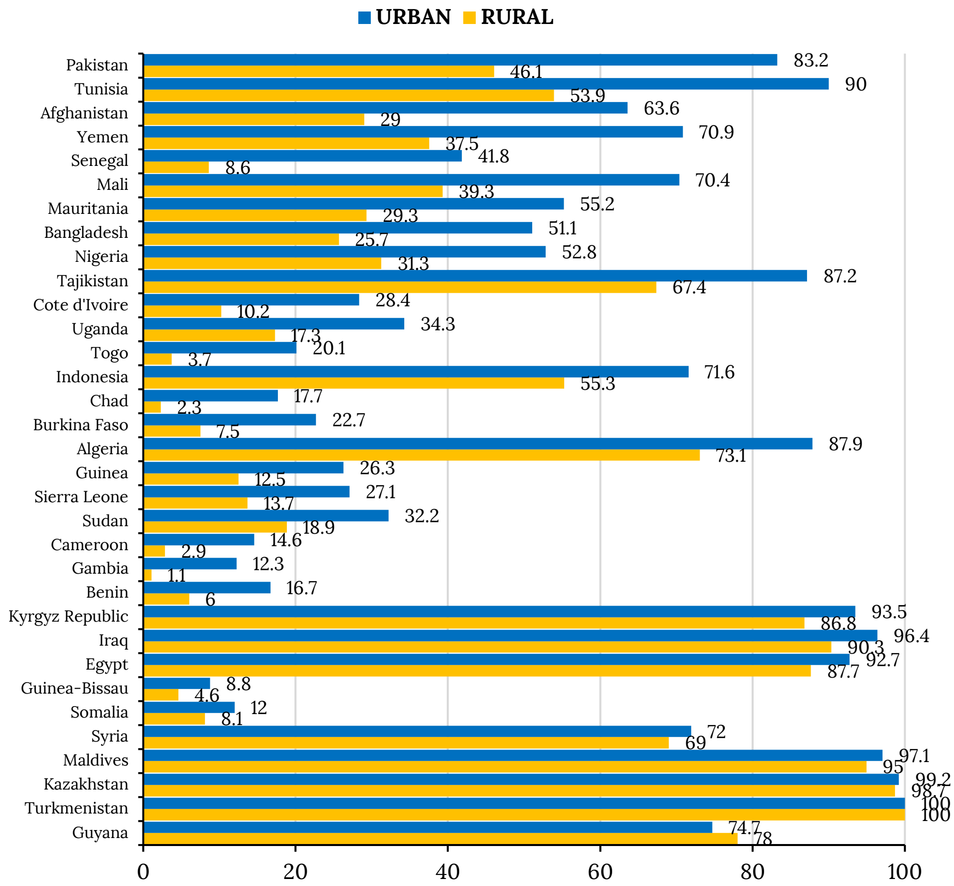
Source: World Bank's World Development Indicators. Note: The chart shows only the countries with available data.

In a similar vein, data from 9 OIC member countries shows that the coverage of safely managed sanitation is relatively better in urban areas as compared to rural areas. For instance, urban-rural coverage rates for safely managed sanitation were, respectively, 41.5% - 18.9% in Djibouti, 23.4% - 6.9% in Niger, and 20.3% - 8.4% in Sierra Leone. On the contrary, in Mali, Iraq, and Algeria, the coverage of safely managed sanitation was higher in rural areas than in urban areas, as shown in Figure 2.7. In Mali, rural sanitation coverage was at 25.5% and urban at 9.1%; in Iraq, rural sanitation coverage was at 45% and urban at 39.4%; and in Algeria, rural sanitation coverage was at 20.8% and urban at 16.5%.

As compared to the data on drinking water and sanitation, there is sufficient disaggregated data on urban-rural coverage of basic handwashing facilities in 33 OIC member countries. According to this data, urban-rural disparities persist in access to hygiene services as well – as shown in Figure 2.8. In 2017, the difference in the proportion of the population with access to basic handwashing facilities between urban and rural areas was highest in Pakistan (37.2%), followed by Tunisia (36.1%), Afghanistan (34.6%), Yemen (33.3%), Senegal (33.2%), and Mali (31.1%) while the lowest disparity was recorded for Turkmenistan (0%) and Kazakhstan (0.5%). Guyana was the only country where rural coverage (78%) exceeded urban coverage (74.7%).

Regional and urban-rural disparities in access to WASH services are also reflected in the variation in mortality rates attributed to unsafe water, unsafe sanitation, and lack of hygiene in OIC member countries. The use of unsafe and inadequate WASH services results in the spread of diseases via pathogens ingested and/or circulated by the use of such services. For example, diarrhoea and respiratory infections are the main diseases that can spread with unsafe water or by insects such as mosquitoes that are abundant in areas without proper sewage or waste management systems (WHO, 2019b). However, the burden of disease and deaths ensuing from the use of unsafe WASH services is, more often than not, preventable with the adoption of proper and prompt interventions.

Figure 2.8 Rural-Urban Disparities in Basic Handwashing Facilities including Soap and Water in OIC Countries (% of population), 2017

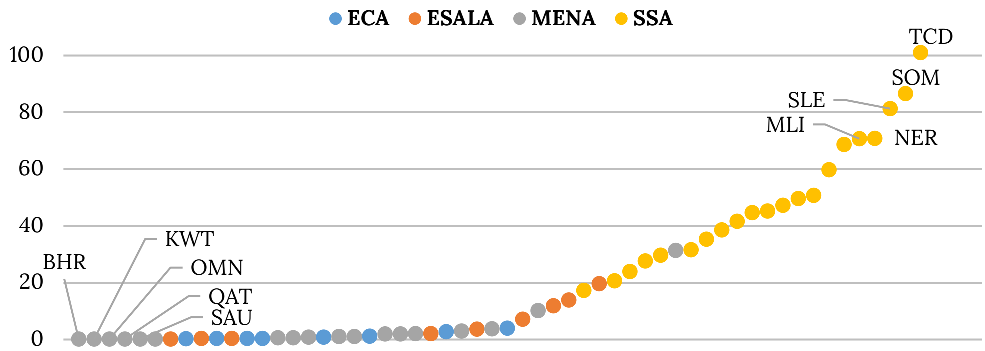


Source: World Bank's World Development Indicators. Note: The chart shows only the countries with available data.

In 2016, the global mortality rate attributed to unsafe water, unsafe sanitation, and lack of hygiene was 11.76 persons per 100,000 people. Twenty-five OIC member countries had mortality rates exceeding this world average. These countries included all member countries in Sub-Saharan Africa (SSA) plus Afghanistan, Bangladesh, Pakistan, and Djibouti. Among them, Chad (101), Somalia (86.6), Sierra Leone (81.3), Niger (70.8), and Mali (70.7) had the highest mortality rates attributed to unsafe WASH– as shown in Figure 2.9.

At the other end of the spectrum, thirty-one OIC member countries had mortality rates below the global average. These countries included a majority of member countries in ECA and MENA. Of the member countries in ESALA, Brunei Darussalam, Guyana, Indonesia, Malaysia, Maldives, and Suriname also recorded mortality rates below the global average. Overall, it appears that the income and development levels of countries determine the variation in WASH coverage – and the mortality rates attributed to the use of unsafe WASH services – to some extent.

Figure 2.9 Mortality Rates Attributed to the Use of Unsafe WASH Services in OIC Countries (per 100,000 population), 2016

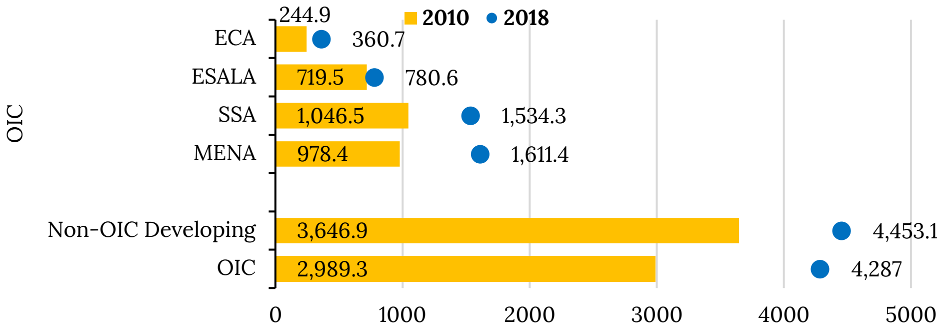


Source: World Bank's World Development Indicators.
Note: Refer to ANNEX I for country codes.

International official development assistance (ODA) to the WASH sector has increased steadily since the 1970s – especially for middle- and low-income economies. In 2014-15 alone, the OECD recorded 14.3 billion USD of total ODA commitments to the WASH sector in developing countries. Development assistance plays an important role in the improvement of the WASH sector in middle- and low-income economies because the variability in coverage of WASH services is largely determined by the income and development level of the country. For instance, high-income countries are more likely to have adequate WASH infrastructure, policies, and investments, which enable them to offer universal access to WASH services for their entire population. At the same time, in middle- and low-income countries, a lack of adequate infrastructure, investment, or lack of policy frameworks may result in deficient coverage of WASH services. Some countries are also likely to offer better service provision in urban centres as compared to rural areas.

As per data from 2018, total official development assistance for water supply and sanitation increased markedly between 2010 and 2018 (Figure 2.10). ODA to OIC countries increased from 2,989.3 million USD in 2010 to 4,287 million USD in 2018. Similarly, in non-OIC developing countries, ODA for water supply and sanitation increased from 3,646.9 million USD in 2010 to 4,453.1 million USD in 2018. Amongst OIC regions, the largest share of ODA was directed to MENA (37.6% of OIC ODA or 1,611.4 million USD), followed by SSA (35.8% or 1,534.3 million USD), ESALA (18.2% or 780.6 million USD), and ECA (8.4% or 360.7 million USD).

Figure 2.10 Total Official Development Assistance for Water Supply and Sanitation (constant 2018 million USD), 2010 vs. 2018

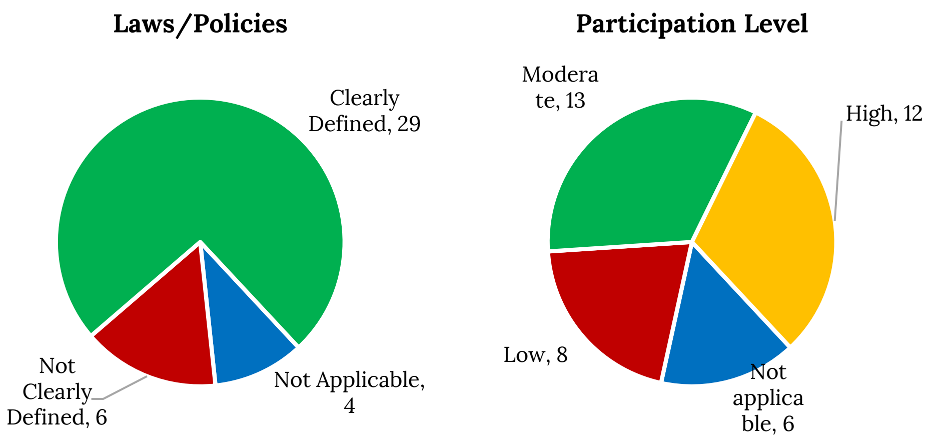


Source: SDG Indicators Database, August 2020 update. (n: OIC = 53, Non-OIC Developing = 101).

Lastly, in addition to capital constraints, lack of policies, political will and action, and accountability are some of the major obstacles to improving the accessibility of WASH services. Policy frameworks that regulate WASH services need to take into account various factors including, but not limited to, integrated water resource management, investments in infrastructure, “quality, pricing, and health and safety” (Irish Aid, 2009, p. 10). In order to do so, governments need to work with private sector service providers and service users to define appropriate interventions to tackle challenges related to WASH coverage.

Within OIC member countries, the OIC Water Vision lays the groundwork for policy frameworks on the use of water in the WASH sector. This is partly why a large number of OIC member countries currently do have procedures in law or policy for participation by service users/communities in programs on water resources planning and management. As shown in Figure 2.11 (left), 29 OIC member countries had clearly defined laws/policies for user participation in water resource planning and management programs in 2017-19. These countries were Albania, Azerbaijan, Bangladesh, Burkina Faso, Chad, Cote d'Ivoire, Gabon, Gambia, Guinea, Indonesia, Iran, Jordan, Lebanon, Malaysia, Maldives, Mali, Mauritania, Morocco, Mozambique, Niger, Nigeria, Oman, Pakistan, Palestine, Sierra Leone, Sudan, Tajikistan, Uganda, and Uzbekistan. In contrast, such procedures are not defined in 6 OIC member countries of Afghanistan, Comoros, Guyana, Kyrgyz Republic, Senegal, and Syria. As for the level of participation in such programs, available data shows that it was low in 8 member countries, moderate in 13 member countries, and high in 12 member countries[11] (Figure 2.11, right).

Figure 2.11 Number of OIC Countries with Laws/Policies for Participation by Users/Communities in Programs on Water Resource Planning and Management (left) and Participation Level of Users/Communities (right), 2019



Source: SDG Indicators Database, August 2020 update. Note: The data is for the latest year available between 2017 and 2019.

2.3. Gender in Water Supply and Sanitation

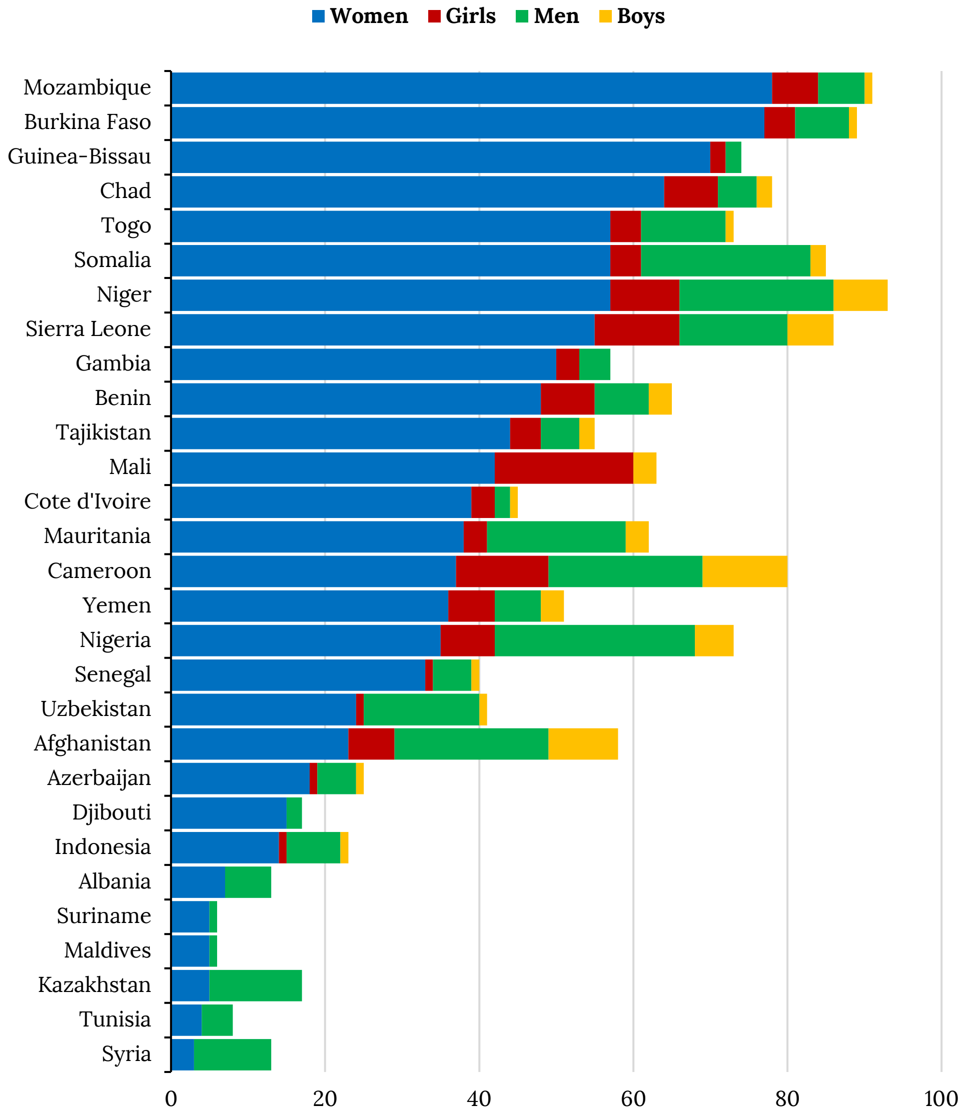
In numerous societies around the world, the responsibility for managing household water, sanitation, and hygiene falls on the shoulders of girls and women. Within the household, women's responsibilities on water resource management include taking care of the family, elderly, and sick; cleaning, washing, and waste disposal; preparing and storing food and water; and personal hygiene. In low-income neighbourhoods and countries, SIDA (2015) finds that women are more likely to primarily collect, transport, and use water. Similarly, the UN, in its *Millennium Development Goals Report 2012*, expresses that women bear the main burden for collecting water in Sub-Saharan Africa. According to a study of 25 countries in Sub-Saharan Africa, where three-third of the population didn't have water on their premises and, therefore, had to collect water from some distance, it is estimated that "*women spend at least 16 million hours each day per round trip; ; men spend 6 million hours; and children, 4 million hours*" (UN, 2012, p.54).

Similarly, data from 29 OIC member countries shows that the primary responsibility for water collection falls on the shoulders of girls (ages below 15) and women (ages 15+) as shown in Figure 2.12. Regardless of the ratio of households with water off premises,

[11] Low: Bangladesh, Chad, Comoros, Gabon, Guinea, Guyana, Iran, and Pakistan.
Moderate: Afghanistan, Indonesia, Jordan, Lebanon, Maldives, Mauritania, Niger, Nigeria, Oman, Palestine, Senegal, Sudan, and Togo.
High: Azerbaijan, Burkina Faso, Cote d'Ivoire, Gambia, Malaysia, Mali, Morocco, Mozambique, Syria, Tajikistan, Uganda, and Uzbekistan.

in 26 out of those 29 countries, households primarily rely on women to collect water. For instance, in Mozambique and Burkina Faso, where around 90% of households depend on off-premise water sources, women are responsible for water collection in more than three-fourth of the households. More than half of the households in Mozambique (78%), Burkina Faso (77%), Guinea-Bissau (70%), Chad (64%), Togo (57%), Somalia (57%), Niger (57%), and Sierra Leone (55%) also rely on women. Even in countries where dependency on water off-premises is considerably low, women may still bear the primary responsibility to collect water, as in Suriname and Maldives.

Figure 2.12 Primary Responsibility for Water Collection by Gender and Age (%), 2017



Source: UNICEF, Gender and Water, Sanitation and Hygiene Website.
Note: Men/Women are ages 15+ and Girls/Boys are below 15 years of age.

Additionally, while women are primarily responsible for collecting, storing, and managing water for WASH, the lack of safe water and sanitation facilities affects them disproportionately. COHRE (2008) finds that women, as compared to men, are more likely to resort to open defecation and urination in unguarded or remote areas outside of their towns and villages after dark – which also makes them vulnerable to assault and rape. Women often compensate for their lack of access to adequate sanitation facilities by altering their diets and water intake – which has significant impacts on their health. Unsafe and unhygienic sanitation facilities are also a leading cause of disease transmission amongst women in poorer households (Masgon and Gensch, 2019).

The hours that women spend on managing WASH services impinge on the time that they can spend on education and/or income generation. This is partly why a lack of safe and adequate WASH services contributes to the perpetuation of poverty and inequality in low-income households. Yet, even with their considerable knowledge and expertise on WASH management, there is an underrepresentation of women in policy-making and decision-making mechanisms pertaining to water resource management. According to Masgon and Gensch (2019), this underrepresentation is a direct outcome of *"a combination of discrimination, lack of political will or attention, and inadequate legal structures"* that ignores women's knowledge of WASH management and undermines their participation in water resource planning programs.

More importantly, women's participation in WASH planning programs has a direct impact on improving gender equality. According to UNICEF (2017, p.2), gender-responsive programming in the WASH sector has numerous benefits including, but not limited to, *"reducing the burden of access to water, improving hygiene facilities, providing dignified sanitation facilities to women, reducing mortality rates attributed to unsafe WASH services, and preventing violence against women that occurs when women have to use unsafe water collection points or sanitation facilities"*. In OIC member countries, gender-responsive programming can be made possible by ensuring that women's perspectives are incorporated in the planning, design, management, and monitoring of WASH facilities.

Chapter 3
COVID-19 and Water

3.1. COVID-19 in OIC Countries

The COVID-19 pandemic is affecting almost all countries and territories around the world with millions of cases of infections and deaths. The disease, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was originated initially in December 2019 in Wuhan, China. Since then, it spread swiftly through respiratory droplets from an infected person.

The pandemic also affected OIC countries, some of which reported relatively high confirmed cases such as in Iran, Indonesia, Bangladesh, Saudi Arabia, Pakistan, and Turkey. To contain the spread of infections, the majority of OIC member countries have imposed strict public health and safety measures like ensuring effective social distancing, lockdowns, curfews, and border closures. These measures have serious socio-economic implications, especially for the low and middle-income OIC member countries with a high incidence of poverty, informal employment and low social security coverage.

Table 3.1 **COVID-19 Risk Index Classification of OIC Member Countries**

Risk Level	OIC Member Countries
Very High (3)	Afghanistan, Chad, Somalia
High (25)	Bangladesh, Benin, Burkina Faso, Cameroon, Comoros, Cote d'Ivoire, Djibouti, Gabon, Gambia, Guinea, Guinea-Bissau, Lebanon, Mali, Mauritania, Mozambique, Niger, Nigeria, Pakistan, Palestine, Senegal, Sierra Leone, Sudan, Togo, Uganda, Yemen
Medium (21)	Albania, Algeria, Azerbaijan, Bahrain, Egypt, Guyana, Indonesia, Iran, Iraq, Jordan, Kuwait, Kyrgyzstan, Libya, Maldives, Morocco, Suriname, Syria, Tajikistan, Tunisia, Turkey, Uzbekistan
Low (8)	Brunei Darussalam, Kazakhstan, Malaysia, Oman, Qatar, Saudi Arabia, Turkmenistan, United Arab Emirates

Source: INFORM COVID-19 Risk Index, 2020.

OIC member countries are disproportionately vulnerable to the COVID-19. For instance, based on an assessment of 'hazard and exposure, vulnerability, and lack of coping capacities', the INFORM COVID-19 Risk Index classifies Afghanistan, Chad, and Somalia as OIC member countries at a 'very high' risk of being overwhelmed by COVID-19's health and humanitarian impacts. As shown in Table 3.1, the index classifies 28 OIC member countries as either very high or high risk, which may lead to their need for additional international assistance.

The socio-economic impacts[12] of the pandemic in OIC countries are daunting. OIC countries' economy, on average, is projected to contract by more than 2% in 2020. The unemployment rate also increases, adding around 8 million people without a job. Around 400 million learners in OIC countries are also affected due to various containment measures. Furthermore, the pressure on food security intensifies as estimate shows that the pandemic would double the severe food insecure population. This is equivalent to almost 300 million food-insecure OIC population (16.4% of the total OIC population) (SESRIC, 2020b).

3.2. Impacts on Water Sector

The pandemic affected the water sector in three ways, namely, changing consumption pattern, impact on water quality, and economic impact on water utilities.

Changes in Water Consumption Patterns

The first obvious impact of the COVID-19 pandemic (along with its containment measures) is the changing of water consumption patterns. During the 'lockdown' or 'stay-at-home' order to contain the spread of the virus, there is an increase in residential water demand while non-residential demand decreases. Residential water demand in various cities around the world increased between 10-15%, while non-residential demand shrunk by 17-32% (Cooley, 2020). In OIC countries, containment measures imposed in Turkey resulted in a surge in residential water demand by 60% (Daily Sabah, 2020), while Tunisia saw an increase in water consumption at 15% (UfM, 2020). In the water-scarce Arab region, on average, household water demand is estimated to increase by 5% as a result of COVID-19 mitigation measures, which is equivalent to an increase in monthly water spending of 150-250 million US$ (UN-ESCWA, 2020).

The growing water demand in the household is due to a change in people's behaviour and water consumption pattern amid the containment measures. People stay at home more, consume more water for daily needs (such as cooking, showering, cleaning, etc.), and spend less time outside. Moreover, the campaign of regular and thorough hand wash to minimize the risk of infection also has a role. People are more aware of the importance to keep their hands clean, while at the same time new permanent or portable hand wash facilities are being set up in public places, contributing to an increase in water demand. However, in many OIC countries, these facilities are rarely available (see Chapter 2), putting the population at a greater health risk.

While households see an increase in water demand, the effect on overall water demand could vary between communities. It depends on the relative proportion of residential and non-residential water use and the stringency of the containment measures. More

[12] Detail discussions on COVID-19 impacts on OIC member countries can be seen in SESRIC (2020b)

residential communities saw a slight increase in total water demand, while some larger metropolitan areas could even reduce the total water demand as in the case of Boston and Austin in the USA (Cooley, 2020).

Impacts on Water Quality

The pandemic could also present challenges in terms of water quality. The use of more water for cleaning (hands in particular) to reduce the risk of infections will increase the quantity of wastewater. This will burden the existing wastewater system and may require extra cost for the expansion of the treatment facilities (Sivakumar, 2020). In areas without proper wastewater treatment facilities, the increase in wastewater will further deteriorate the water bodies where wastewater is discharged to. Furthermore, it is also observed that there is an increase in pollution to water bodies from medical wastes (such as used masks).

The flow of disinfected/treated water in buildings makes plumbing free of corrosion, leached minerals, and bacteria. During the lockdown, where many offices and buildings were not operational and shutdown their water system, corrosion, bacteria, and the residual disinfectants can be present in the plumbing system. When the building is re-opened, the water system could be contaminated through the mould, Legionella, leaching of lead and other metals, and the presence of disinfection by-products. (Cooley, 2020).

Impacts on Water Utility

The impacts of COVID-19 on water & wastewater utilities are mostly from an economic standpoint. Measures to contain the virus from spreading have affected the revenue of water utilities. Water utilities are expected to see revenue reductions by 15% as a result of the pandemic (IFC, 2020). This is simply because the pandemic negatively affected the income of many people who, in turn, could not afford to pay the water bill. In Bahrain, for instance, the government covered the electricity and water bills of residents and businesses to counter the effects of the coronavirus (Time Out Bahrain, 2020),which also protected the utility companies from any potential revenue shortfall. Globally, three measures have generally been adopted to solve the issue (IFC, 2020): (a) exemptions from utility bill payments for vulnerable groups, (b) moratoriums on cutting off the water supply (justified by the importance of hygiene in reducing the spread of the virus), and (c) suspensions of meter reading and invoicing.

PART 2

CHALLENGES AND SECTORAL LINKAGES

Chapter 4

Climate Change Impacts on Water Sector

Climate change is one of the biggest challenges in the 21st century, and today's actions will determine the state of the future world we are going to live in. The Stern Review (Stern, 2007) suggested that developing countries would most likely suffer most from the impacts of climate change. The OIC member states, constituting a substantial part of the developing world, should be aware of this coming threat. Climate change has caused growing unprecedented extreme weather conditions and natural hazards. There was an increase in occurrences of natural hazards of about 7 times during 1960-2000 globally, while, in the same period, OIC countries witnessed an increase of about 9 times.[13] In OIC countries, the number of incidences increased from 134 in the 1970s to 1,178 in the 2000s. The major drivers of natural disaster incidents in OIC countries were floods, epidemics, earthquake, storms, wet mass earth movements, droughts, and extreme temperatures, most of which are categorized as climate-driven disasters. These disasters not only caused causalities in human lives but also gave a huge blow to the economy. During 1970-2011, total costs of natural hazards in OIC countries exceeded $140 billion.

Without any interventions, the average global temperature is expected to increase more than 2°C above pre-industrial levels by the end of this century (UNEP, 2019). OIC is one of the most vulnerable regions due to its high exposure and low adaptive capacity. According to modelling results (IPCC, 2014a), some of the highest increases in temperature are estimated to occur in arid and semi-arid regions, particularly in Sub Saharan Africa, Middle East, and Central Asia, where many OIC countries are located.

The same regions will also have to bear the negative impact of climate change on renewable water resources, as global climate change is projected to increase the frequency of extreme events (such as heatwaves, drought, and flood) and climate variability (IPCC, 2014b). Moreover, changes in water quantity and quality due to climate change are expected to give further pressure on food security and access to clean water and sanitation and disturb the operation of water infrastructure (e.g. irrigation systems, hydropower, etc.), thus threatening the well-being of the society.

4.1. Impacts on Water Resources

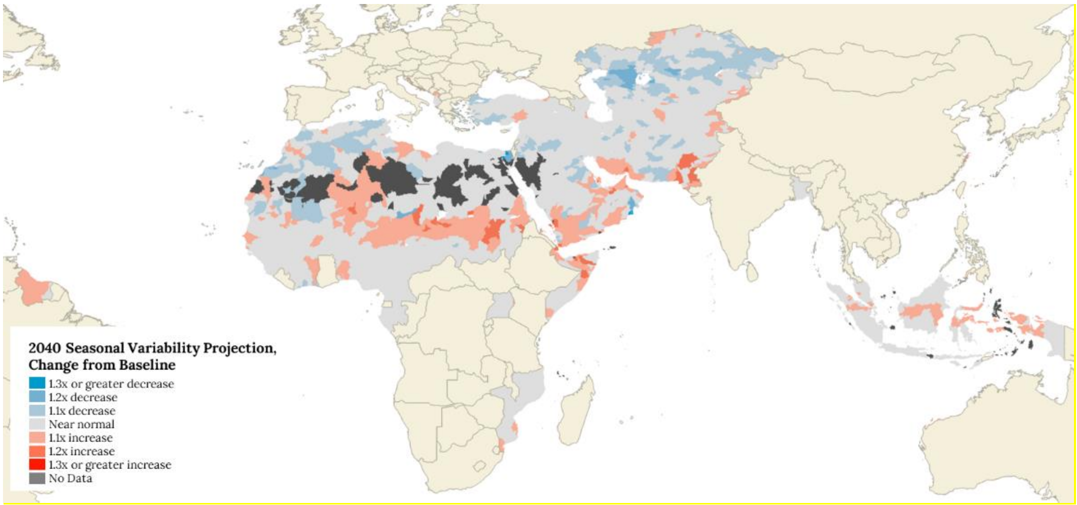
Water resources have a direct relationship with the climatic conditions since the resources are replenished through the natural climate cycle. Steady and regular climatic

[13] See SESRIC (2012a) and (2012b) for further information on the natural disasters in OIC member countries.

conditions are more desirable than a climate with high variability. The variability makes water availability less predictable, thereby constraining the effectiveness of water planning and management.

Variability of water supply in some areas in OIC is already high as discussed above in Chapter 1. The future supply of water is predicted to be more erratic and uncertain due to increasing water supply variability. Figure 4.1 shows that some areas in SSA, MENA, and ESALA are expected to have an increase in seasonal variability of at least 1.1 times relative to the baseline level. The areas that have high supply variability coincide with the ones that already have high water stress, implying that climate change will put more stress on these areas.

Figure 4.1 Projected Change in Seasonal Water Supply Variability by 2040



Source: SESRIC Staff Generated Map Based on WRI (2019).

Climate change manifests itself in the increasing trend of climate hazards such as intense frequency and magnitude of heatwaves, unprecedented rainfalls, thunderstorms and storm surge. Furthermore, higher water temperatures from rising global temperature would negatively affect water quality, as dissolved oxygen is reduced, and so is the capacity of self-purification of water bodies. A higher risk of contamination might also persist due to pollution from floods or by intensifying pollutants during drought. Ecosystems that depend on the water system are also affected, especially wetlands and forests. Biodiversity loss is threatened, as well as other water-related ecosystem services such as carbon capture and storage, water purification, and natural flood protection.

Climate-related disturbance on water systems is already being felt in various OIC regions. For instance, degradation of quality and quantity of water resources is recorded in OIC countries in North Africa (Hamed et al., 2018), while an important basin in SSA such as Lake Chad is already experiencing significant decrease in its surface area

(Mahmood et al., 2019). A further change in climate, as a result, will potentially deteriorate the water resources in OIC even further.

4.2. Risks, Vulnerabilities, and Readiness

Climate change impacts on the water sector in OIC countries vary between regions, countries, as well as local regions. Therefore, understanding water-related climate change risks and vulnerabilities is very crucial for planning and implementing adaptation actions at various levels.

Climate change impacts on water systems create underlying risks to society whether directly or indirectly. These risks have emerged through interactions between climate-related hazards and vulnerabilities in the population. IPCC (2014a) provided key risks of climate change, some of which are related to water systems (see ANNEX III). Increasing climate hazards such as drought, flooding, and precipitation variability and extremes will disturb water resources and ultimately increase the risk of food insecurity, particularly for a vulnerable and disadvantaged population. Moreover, the risk of further deterioration of rural livelihoods and income loss would also increase due to insufficient access to drinking and irrigation water, which in turn reduces agricultural productivity.

The degree of regions' risks from climate change is related to their underlying level of vulnerability and readiness. Understanding both dimensions could help stakeholders to allocate resources and deal with climate change challenges more efficiently. Based on the ND-GAIN index[14], in 2018, the water sector of OIC countries has an average vulnerability level of 0.39, slightly more vulnerable than the world average (0.35). In terms of the readiness for climate change, OIC has a lower readiness level at 0.34 compared to the world average of 0.42. In other words, the water sector in OIC is highly vulnerable and not quite ready to deal with climate change challenges. This will result in higher risks posed by the impacts of climate change through the water sector.

Water sector vulnerability and readiness differ between OIC regions as well as within OIC countries. Regional vulnerability analysis shows that all OIC regions, except ECA, are more vulnerable than the world average level. SSA is the most vulnerable region with the index level of 0.43, followed by ESALA, MENA, and ECA with an index level of 0.39, 0.37 and 0.35, respectively.

To look at the issues in more detail, Figure 4.2 presents a comparison of OIC sub-regions with the world average for each component of the vulnerability index and the readiness index. In terms of vulnerability, almost all components in all OIC regions are more vulnerable than the benchmark world level. In terms of **exposure** to climate change, ECA and MENA performed better than the world average.

In terms of **sensitivity** to climate change, ESALA and SSA, both scoring near the global average, perform better than the other OIC sub-regions. For the **adaptive capacity** of the water sector to adapt to the impacts, ECA is significantly better than the world and the

[14] See BOX 1 for descriptions of the ND-GAIN index.

other OIC sub-regions. ECA countries, in general, can reduce potential damage from the negative consequences of climate events.

In general, compared to the global averages, MENA is highly vulnerable in terms of sensitivity and adaptive capacity, ECA is lacking mostly in sensitivity, SSA in exposure and adaptive capacity, while ESALA is vulnerable partially in exposure and adaptive capacity. Therefore, efforts to decrease the vulnerability of the water sector to climate impacts should be focused on the specific dimensions where the region is lacking most.

BOX 1: The Notre Dame Global Adaptation Initiative (ND-GAIN) Composite Index

The Notre Dame Global Adaptation Initiative (ND-GAIN) composite index outlines countries' vulnerability to climate change together with their readiness to improve resilience. Within the index, vulnerability is defined as "*propensity or predisposition of human societies to be negatively impacted by climate hazards*" (Chen et al., 2015, p.3) through the interactions of three dimensions: **the exposure** to climate-related hazards; **the sensitivity** to the impacts of the hazard; and **the adaptive capacity** to cope with these impacts.

- **The exposure** dimension of the index measures the extent to which human society and its supporting sectors are stressed by the future changing climate conditions. Less exposure means future climate would not change the water resources so significantly.
- **The sensitivity** dimension of the index tells the degree to which society is affected by climate-related impacts on the water sector.
- **The adaptive capacity** dimension tells the ability of society and its supporting sectors to adjust to reduce potential damage and to respond to the negative consequences of climate events.

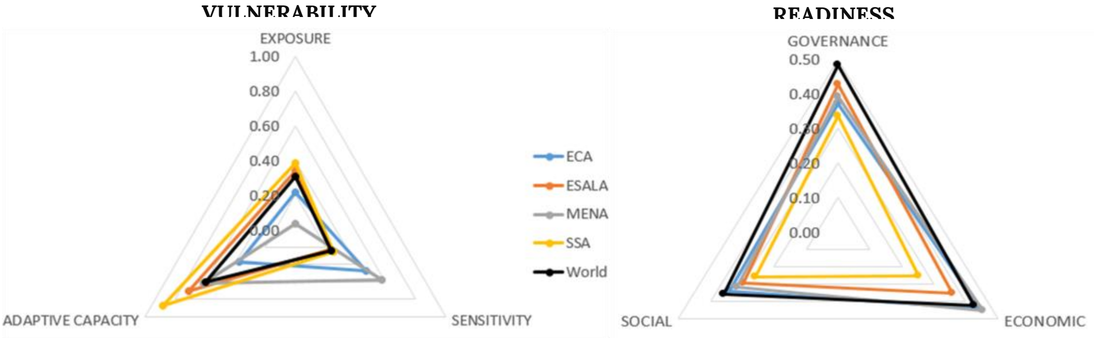
On the other end, the readiness index meant to measures the country's ability to leverage investments to adaptation actions. Three main components of the readiness index are **economic readiness, governance readiness, and social readiness**.

- **Economic readiness** measures the investment climate that facilitates mobilizing capital from the private sector.
- **The Governance readiness** tells about the stability of the institutional arrangements that contribute to the investment risks.
- Finally, **Social readiness** evaluate the social conditions that encourage the efficient use of investment.

Source: Chen et al., 2015

In terms of readiness level, all OIC sub-regions are mostly catching up with the world level in all readiness components. ECA has relatively the same level as the world average, while ESALA and SSA are still lacking the readiness in all three components. On the bright side, MENA has more readiness than the world, especially in terms of economic readiness.

Figure 4.2 Regional Comparison of Water Sector Vulnerability (Left) and Readiness (Right) to Climate Change Impacts



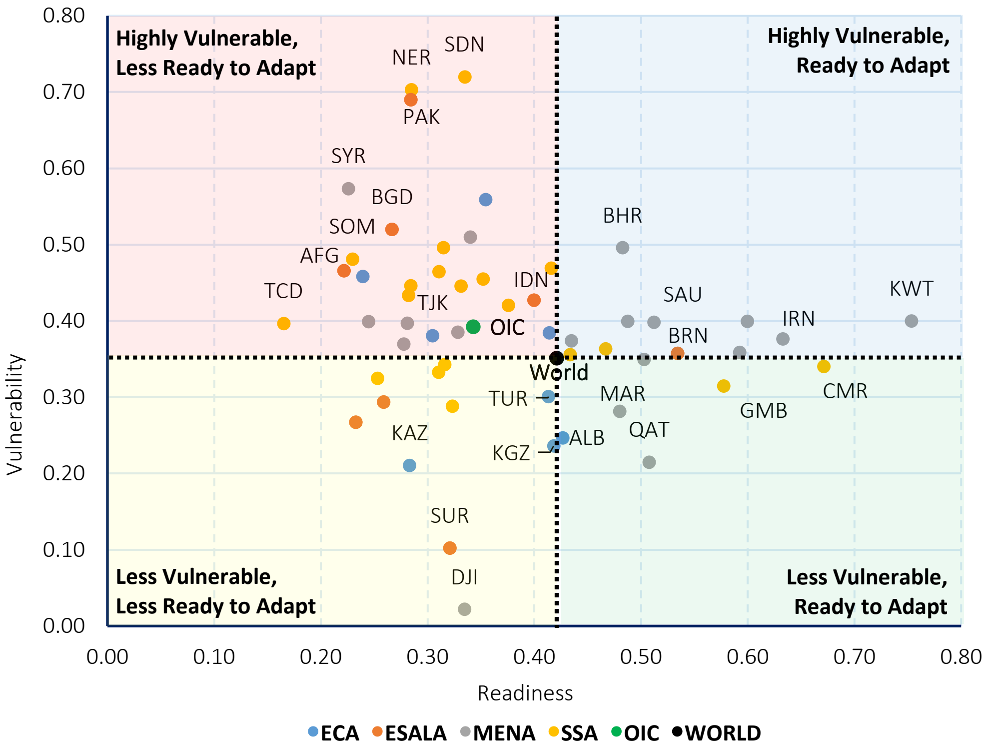
Source: SESRIC staff calculations based on ND-Gain Index.

To quickly compare OIC countries' state of vulnerability and readiness to climate change, a scatter plot matrix is presented in Figure 4.3. The countries are coloured depending on their regions to see the regional distribution on the plot. There are four quadrants on the plot, delineated by the world average level of vulnerability and readiness. Figure 4.3 shows the positioning of individual countries and a general overview of the OIC regions more clearly.

It is observed that, at the individual country level, almost 70% of OIC countries have vulnerability levels above the world average. While 75% of OIC countries have readiness levels below the world average. Furthermore, several points can be drawn: *First*, the most vulnerable countries are Sudan, Niger, and Pakistan, while countries with the least readiness to climate change are Chad, Afghanistan, and Somalia. *Second*, the top left box (red zone), which indicates highly vulnerable and less ready countries, comprises mostly SSA countries (almost half of total red zone). This is equivalent to 60% of SSA OIC countries. *Third*, most of MENA countries are in the top right box (blue zone), indicating countries that are highly vulnerable but have enough capacity to adapt. *Fourth*, Most ESALA countries are lying in the red zone and yellow zone (bottom left: less vulnerable and not ready to adapt). *Fifth*, ECA countries, with the exception of Albania, are distributed in red and yellow zones. *Lastly*, only six countries are in the safest zone –the bottom right zone (green zone) which indicates less vulnerable and highly adaptable. These countries are Albania, Morocco, Oman, Qatar, Gambia, and Cameroon.

The countries in the red zone are the ones needing special attention since the risks of getting climate change impacts are largest. Countries in the yellow zone, despite their low level of vulnerability, need to improve their economic, social, and governance readiness to be more ready to adapt to climate change. As for the blue zone, despite high vulnerability, the fact that the countries have enough resources to adapt is beneficial for reducing future risks. Finally, the green zone has the lowest risks of climate change impacts as they are less vulnerable and have sufficient capacity to adapt.

Figure 4.3 Water Sector Vulnerability and Readiness to Climate Change Impacts, 2018



Source: SESRIC staff generated figure based on ND-Gain Index.
Note: Refer to ANNEX I for country codes.

4.3. Water Sector Responses to Climate Change

The water resources are highly variable over time and space and this variability could pose a constraint on socio-economic development. As already discussed above, the impacts of climate change will intensify the already water-stressed regions, and potentially affect economic, environmental as well as political dimensions. There is a need to formulate policies and strategies which integrate water and related sectors (such as energy and agriculture) and disaster risk reduction, with a calculated risk toward climate change impacts, thereby providing a resilient and sustainable development (IPCC, 2014b).

One aspect that needs immediate attention is to design an adaptation strategy in the face of hydrological changes. In this regard, water-related risks are key components and need to be included as part of the decision making processes to climate change adaptation in the water sector. Generally, there are three steps for climate change adaptation (Goosen et al., 2014). *First*, climate change impact or vulnerability assessments. *Second*, the design and the selection of adaptation options. *Finally*, the evaluation of adaptation options. Table 4.1 illustrates various policy options that can be pursued for adaptation in the water sector.

Table 4.1 Climate Change Adaptation Policy Options

Policies	Net Benefits Independent of Climate Change	High Priority
General policies		
Incorporate climate change in long-term planning		X
Inventory existing practices		X
Tie disaster relief to hazard-reduction programs	X	X
Promote awareness	X	X
Water resources		
River basin planning and coordination	X	X
Contingency planning for drought	X	X
Marginal changes in construction of infrastructure		X
Use inter-basin transfers	X	
Options for new dam sites		X
Conserve water	X	
Use markets to allocate supplies	X	
Control pollution	X	
Sea-level rise		
Plan urban growth	X	X
Decrease subsidies to sensitive lands	X	X
Set-backs		X
Discourage permanent shoreline stabilization		X
Marginal increases in the height of coastal infrastructure		X
Preserve vulnerable wetlands	X	X
Forests		
Forest seed banks	X	X
Diverse management practices		X
Flexible criteria for intervention	X	X
Reduce habitat fragmentation; develop migration corridors	X	X
Ecosystems		
Integrated ecosystem planning and management	X	X
Migration corridors or buffer zones	X	X
Protect biodiversity off-site		X
Agriculture		
New crops and seed banks	X	X
Plant a variety of heat- and drought-resistant crops	X	
Avoid production subsidies	X	
Increase irrigation efficiency	X	
Conservation management	X	
Liberalize agricultural trade	X	
Drought management	X	

Source: Adapted from Smith & Lenhart (1996).

The adaptation measures also have to be a part of a larger sustainable water management framework, which measures not only the societal benefits but also environmental sustainability. Chapter 7 provides further details for discussions on such a framework.

Chapter 5
Water and Food Security Nexus

5.1. Overview

Food security is achieved when *"…all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy lifestyle"* (FAO, 1996). It is a basic human right whose fulfilment is dependent on a number of complex and intersectional factors that determine the availability, accessibility, stability, and utilization of food.[15] For instance, factors such as lack of adequate water and energy, physical attributes of agricultural land (soil fertility, irrigation), and quality of inputs (seeds and fertilizers) have an impact on the quantity and quality of food being produced. Similarly, socio-economic factors such as individual's purchasing power, household income, and access to markets can impact an individual's accessibility to food; economic downturn, conflicts, and natural disasters have a direct impact on the stability of food production and distribution; and consumption patterns, nutritional preferences, and access to basic water, sanitation, and hygiene services have an impact on the utilization of nutrition.

Amongst OIC member countries, the overall status of food security has improved in the past two decades. For instance, in terms of availability, there has been considerable growth in per capita food production and gross food production. There has also been an increase in accessibility to food resulting from a rise in GDP per capita in purchasing power parity and an improvement in food utilization indicated by a rise in average dietary energy supply adequacy.

However, the share of agriculture in the total GDP of OIC countries has gradually declined from 11.3% in 2000 to 9.8% in 2018 (SESRIC, 2020a). This is partly due to structural transformation, agricultural market instability, environmental stresses, and depletion/degradation of land and water resources. Similarly, the prevalence of hunger and malnourishment persists in low- and middle-income countries. In 2018, OIC member countries were home to 176 million undernourished people –out of the world total of 678.1 million– with the majority (83.7%) living in ESALA (47.3%) and SSA (36.4%) (SESRIC, 2020a). At the same time, there has also been a rise in the prevalence of obesity in adults and overweight in children in developed countries. To illustrate, over 17.5% of the population above the age of 18 in OIC member countries was obese in 2016 – with the majority living in MENA (29.1%) and ECA (20.1%) (SESRIC, 2019b).

[15] For a detailed discussion on the four dimensions of food security in OIC member countries, see SESRIC's technical background report on Agriculture and Food Security in OIC Member Countries (SESRIC, 2020a), available at https://www.sesric.org/publications-agriculture.php

More importantly, 32 OIC member countries are currently classified as 'low-income food deficit countries (LIFDC)', 'countries in crisis requiring external assistance', or both by FAO. Populations in OIC member countries also had the lowest recorded access to basic WASH services, as discussed in Chapter 2 of this report, which has serious implications for food utilization. Lastly, the variability of per capita food production and supply in OIC member countries was relatively volatile between 2015 and 2017. In the long-term, high variability and volatility, indicate instability and inconsistency in food production and supply.

5.2. Linkages between Water and Food Security

Food security is inextricably related to the use of water resources. As Figure 5.1 shows, there are direct and indirect consequences of inadequate access to water and water-related shocks on food security – especially in poor and low-income households. Access to basic WASH services, for example, determines the safety of the food being consumed and stored by households. Contamination of food due to unavailability of clean water, irregular hand-washing practices, lack of water to wash utensils and prepare food, etc. can facilitate the spread of infectious microorganisms that can cause diseases, which in turn can affect an individual's absorption of nutrients from food leading to food insecurity.

Similarly, as discussed in Chapter 2 of this report, the primary responsibility for the collection and management of water resources in a household often falls on women and girls – resulting in hours spent collecting, using, and storing water. The time women spend on collecting and managing water resources negatively affects their ability to generate income, which limits their ability to purchase and consume nutritious food, thus, significantly affecting the feeding practices and food security of a household.

Food security is intrinsically dependent on the quantity, quality, and management of water resources in a country. This is because the agriculture sector is one of the largest consumers of water resources in the world; thus, any instabilities in the availability and quality of water resources have a deep impact on the agriculture sector.

Yet, even though interventions pertaining to water resource management in the agriculture sector have grown in scope and number in recent years, achieving food security in the near future can prove to be a challenge to OIC member countries for the following reasons:

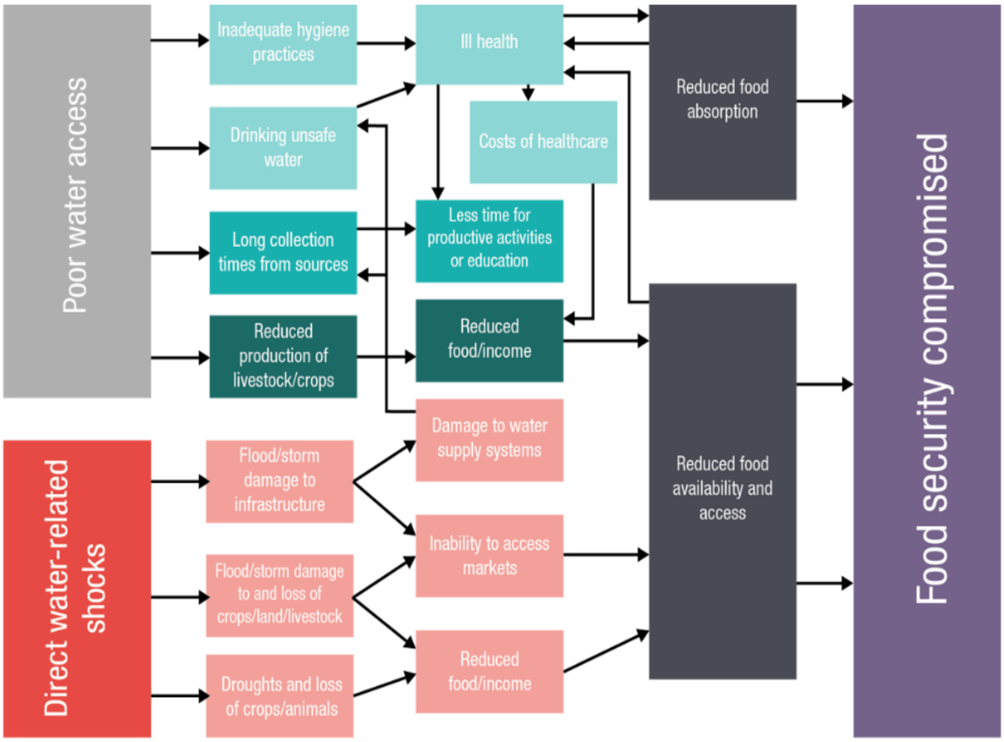
i. UN DESA's estimates show that the total population in the OIC region is expected to grow from 1.88 billion in 2020 to 2.8 billion in 2050; while the global population is expected to exceed 9 billion by 2050. This rapid increase in population is likely to increase the pressure on the food and water sectors resulting from a demand to produce more food. FAO estimates that, by 2050, the world will need to produce 60% extra food to meet global demand. The situation will be particularly dire for agriculture sectors in arid and semi-arid countries facing water scarcity.

ii. A scarcity of inputs required to produce food is likely to set off competition over insufficient resources such as irrigated agricultural land, fuel, seeds, and energy that can influence the production, distribution, and accessibility of food. Increased competition in the production of food may also result in farmers resorting to unsustainable means of production that can cause irreparable damage to eco-systems in the long-run.

iii. In addition to demographic stress on food and water resources, natural disasters ranging from droughts to floods, artificial disasters such as conflicts and economic recessions, and lack of interventions to adapt to or mitigate climate change in the OIC region are also likely to have direct and severe impacts on food security in the short- and long-terms.

iv. As economies in the OIC region grow, an increase in individual wealth and purchasing power can result in increased food consumption and changes in food consumption patterns. This can mean that people who are food insecure may not necessarily suffer from hunger, but they may lack access to sustainable and nutritious food, exposing them to malnutrition.

Figure 5.1 Micro-Level Impacts of Poor Water Access and Direct Water-related Shocks on Food Security



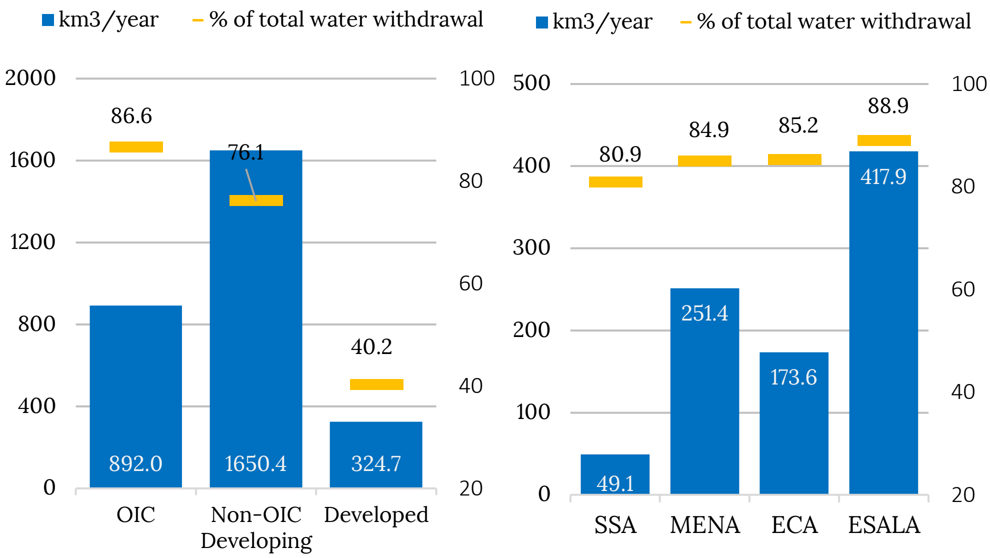
Source: Overseas Development Institute, 2017.

Meeting the demand for water in the agriculture sector is also likely to be a major cause for concern for OIC member countries in the coming years because OIC member countries have an arable land area of approximately 1.38 billion; accounting for more than one-fourth of the world's total agricultural land area. At the same time, the level of water security in the OIC region is alarming; indicated by a high level of water stress and water dependency in OIC member countries. Between 2000 and 2017, OIC region's water stress level was at 33%, which was 14 percentage points higher than the world average (SESRIC, 2020a). Similarly, water dependency ratios in OIC member countries were at 29.8% of the total water supply in 2017 – indicating their reliance on neighbouring countries for water.

5.3. Agricultural Water Productivity

A pressure to increase food production can also lead to increased water withdrawal, which is already at its highest in the agriculture sector. Globally, agricultural water withdrawal accounts for 71.5% of total water withdrawal. The remaining 28.5% are water withdrawals in the industrial and municipal sectors. The OIC region withdraws approximately 892 km^3 of water for agricultural use per year, which constitutes around 86.6% of its total water withdrawal – as shown in Figure 5.2 (left). In contrast, developed countries withdraw 324.7 km^3 of water per year for agricultural use – making up 40.2% of their total water withdrawal and non-OIC developing countries withdraw 1,650 km^3 per year – accounting for 76.1% of their total water withdrawals.

Figure 5.2 Agricultural Water Withdrawal around the World (left) and in OIC Sub-Regions (right), 2017

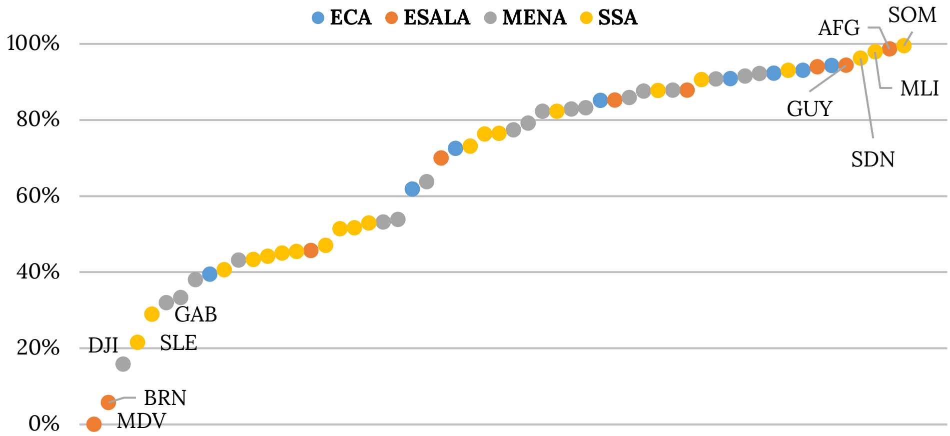


Source: SESRIC staff calculations based on FAO AQUASTAT. Data is from the latest year available between 2000 and 2017.

A breakdown of the total agricultural water withdrawal in OIC shows that the highest withdrawals were made by countries in ESALA region (418 km^3), followed by MENA (251 km³), ECA (174 km³) and SSA (49 km³). Furthermore, as Figure 5.2 (right) shows, in each of the OIC regions, agricultural water withdrawal accounted for more than 80% of their total water withdrawal, with the highest withdrawals in ESALA (88.9%) and lowest in SSA (80.9%).

At an individual country level, agricultural water withdrawal in OIC member countries was quite varied, as seen in Figure 5.3. The largest withdrawals were recorded in Somalia (99.5%), Afghanistan (98.6%), Mali (97.9%), Sudan (96.2%), and Guyana (94.3%), while the lowest withdrawals were recorded in Maldives (0%), Brunei Darussalam (5.8%), Djibouti (15.8%), Sierra Leone (21.5%), and Gabon (29%).

Figure 5.3 Agricultural Water Withdrawal in OIC Countries (% of total water withdrawal), 2017



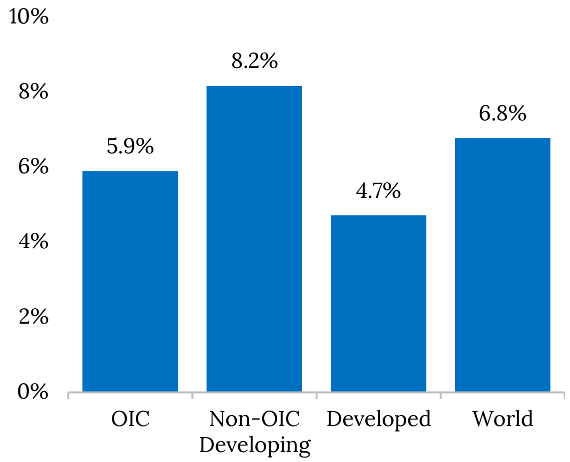
Source: FAO AQUASTAT. Data is from the latest year available between 2000 and 2017.
Note: Refer to ANNEX I for country codes.

It is important to note that the distribution of water resources in the OIC region is quite diverse. While some countries have an abundance of water, others face extreme scarcity. Additionally, in countries where water resources are abundant, not all resources are easily accessible, near agricultural or arable land areas, efficiently regulated for consumption, or affordable to explore and develop. This demonstrates that water scarcity is not limited to a physical lack of water resources, but also infrastructural obstacles, and institutional shortcomings.

In many cases, water scarcity and its impact on the agriculture sector can be mitigated through interventions such as artificial irrigation. Irrigation is a crucial method by which countries can increase food production, while also ensuring sustainability. However, rain-fed and irrigated agricultural lands are heavily reliant on precipitation and while some countries are able to rely primarily on rain-fed irrigation for food production (e.g. Gabon, Gambia, Sierra Leone, and Uganda), others need irrigation, with some developing sophisticated infrastructure such as Algeria, Egypt, Libya, Syria, and UAE (OIC, 2012). Yet, as discussed in Chapter 4, OIC member countries, especially some areas in SSA, MENA, and ESALA, are prone to the impacts of climate change, which may intensify water supply variability.

The merits of irrigation for increasing agricultural yield are well-documented (FAO, 2011). However, as Figure 5.4 shows, merely 5.9% of the total agricultural area in OIC member countries is equipped for irrigation, which is comparatively lower than non-OIC developing countries (8.2%) and the world (6.8%). This is partly because irrigation is often expensive for small-scale farmers and can lead to water-logging and salinization, which reduces the overall agricultural yield of irrigated land. However, both of these issues can be resolved with effective management as evidence by the use of improved inputs (fertilizers, seeds, etc.) and newer technologies such as pressurized irrigation (FAO, 2011).

Figure 5.4 Area Equipped for Irrigation (% of agricultural land), 2017

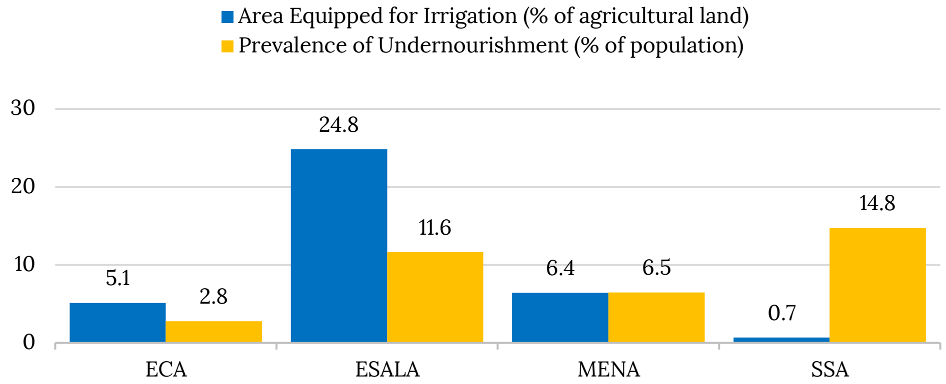


Source: SESRIC staff calculations based on FAO Online Databases. Data for Share of area equipped for irrigation is from latest year available between 1987 and 2017.

According to FAO (2011), people who have better access to water are likely to have lower levels of undernourishment – especially in countries where the dependence on local agriculture is high. Nevertheless, when it comes to the link between irrigated agricultural lands and food security, there is a clear disparity between various OIC regions as shown in Figure 5.5. In OIC regions, undernourishment was highest in SSA (14.8%) and member countries in this region had the lowest area equipped for irrigation as a percentage of agricultural land in 2017. On the other hand, the largest area equipped for irrigation was in ESALA (24.8%), where the prevalence of undernourishment was at 11.6%. The lowest disparity between undernourishment and area equipped for irrigation was in the MENA region. It is highly probable that a lack of water resources and irrigation is one of the main factors resulting in insufficient food production in SSA. Consequently, a deficit of food is one of the leading causes of the high prevalence of undernourishment in the region.

OIC member countries utilize various techniques of irrigation. The most common technique is 'surface irrigation', which consumes the most volume of water. While most widely used in the world, it is a wasteful technique because a large quantity of water diverted for surface irrigation ends up being wasted via deep percolation or surface runoff (SESRIC, 2020a). In 2017, 74.4% of the total area equipped for irrigation in OIC member countries used surface irrigation as compared to 79% in non-OIC developing countries, 36.1% in developed countries, and 71.3% in the world (Figure 5.6). Further breakdown of individual OIC member countries shows that, in 24 member countries, surface irrigation was used to irrigate more than 50% of the area equipped for irrigation. Of these 24 countries, 6 relied solely on surface irrigation to meet their needs.

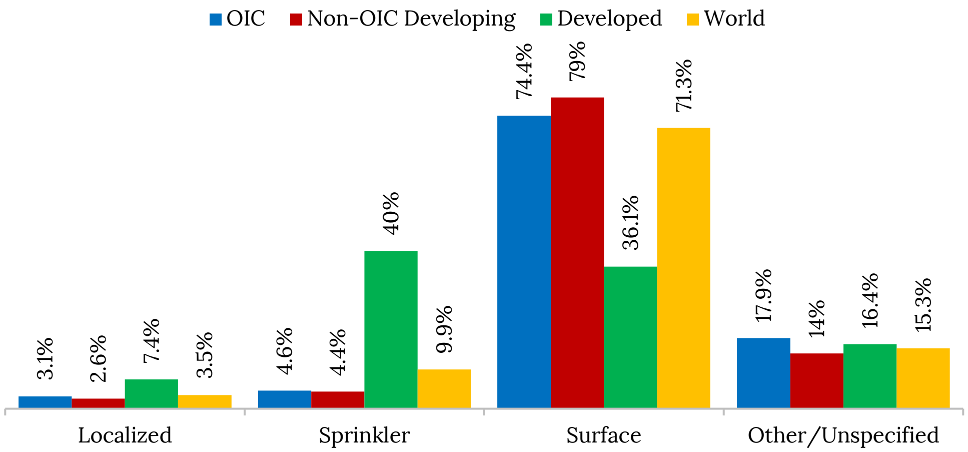
Figure 5.5 Irrigation and Undernourishment in OIC Sub-Regions, 2017



Source: SESRIC staff calculations based on FAO Online Databases.

In developed countries, 40% of the area equipped for irrigation used ‘sprinkler irrigation’, which saves more water than surface irrigation. However, the use of sprinkler irrigation was significantly lower in both OIC member countries (4.6%) and non-OIC developing countries (4.4%) – as shown in Figure 5.6. It also varied largely among OIC member countries. On one hand, sprinkler irrigation was used to irrigate more than 30% of agricultural land equipped for irrigation in Saudi Arabia (44%), Azerbaijan (42%), Algeria (31%), and Lebanon (31%). On the other hand, in 23 OIC countries, the share of area equipped for irrigation using the sprinkler technique was less than 0.1%.

Figure 5.6 Irrigation Techniques used around the World (% of total area equipped for irrigation), 2017

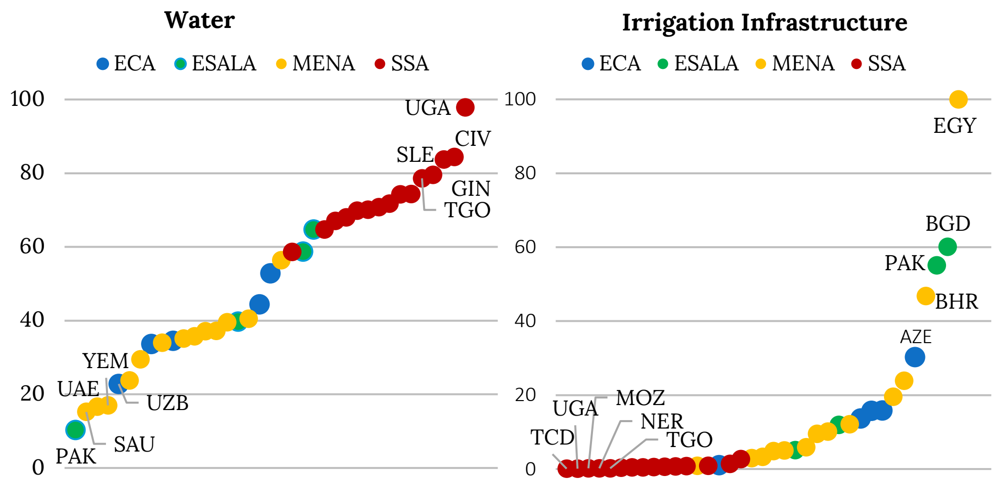


Source: SESRIC staff calculations based on FAOSTAT Online Databases. Data is from the latest year available between 2000 and 2017.

Similarly, localized irrigation – which saves the most amount of water – was only used to irrigate 3.1% of the area equipped for irrigation in OIC member countries, 2.6% in non-OIC developing countries, and 7.4% in developed countries. Nevertheless, the use of localized irrigation technique was notably high in several OIC member countries, such as Palestine (83%), UAE (77%), and Jordan (60%). In Tunisia (32%), Lebanon (32%), Oman (24%), and Algeria (23%), localized irrigation was used to irrigate more than 20% of the area equipped for irrigation. However, in 26 OIC member countries, less than 0.1% of the area equipped for irrigation utilized localized irrigation techniques. Overall trends from OIC member countries show that sprinkler and localized irrigation techniques are more popular in countries in arid regions (SESRIC, 2020a).

Of specific relevance to this chapter are two sub-indicators of the Global Food Security Index (2019): 'water' and 'irrigation infrastructure'. The sub-indicator of water measures the health of fresh-water resources and how depletion might impact agriculture. It includes both quantity and quality aspects of agricultural water risk. Quantity assesses the ratio of total annual water withdrawals to total available annual renewable supply while quality assesses the risk that water might be polluted. As shown in Figure 5.7 (left), OIC member countries in the SSA region had the highest scores – Uganda (98), Cote d'Ivoire (84), Sierra Leone (84), Guinea (80), and Togo (79) leading the ranks. On the other hand, Pakistan (10), Saudi Arabia (15), UAE (17), Yemen (17), and Uzbekistan (23) had the lowest scores.

Figure 5.7 Global Food Security Index (GFSI) Scores for Water Resources in OIC Countries, 2019

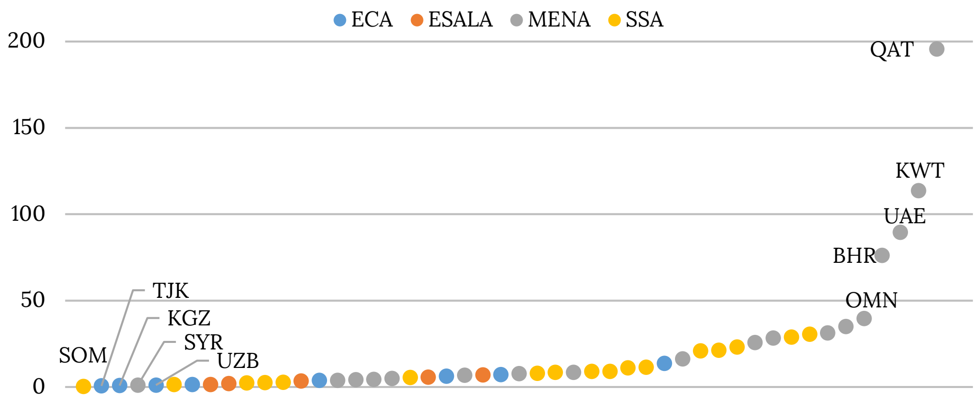


Source: Economic Intelligence Unit's GFSI 2019.
Note: Scores for water (4.2) are extracted from the GFSI's Natural Resources and Resilience indicator. Irrigation infrastructure (2.3.6) scores are extracted from GFSI's Availability indicator. Score are 0-100, where 100 = best. Refer to ANNEX I for country codes.

The sub-indicator of irrigation infrastructure assesses the percentage of cultivated agricultural area that is equipped for irrigation. Irrigation infrastructure can support the ability of farmers to provide a consistent water supply for crops. Egypt received a score of 100 for this indicator, placing it far above any other OIC member country in this category, followed by Bangladesh (60), Pakistan (55), Bahrain (47), and Azerbaijan (30), as shown in Figure 5.7 (right). At the other side of the spectrum, Chad, Uganda, Mozambique, Niger, Togo, Cameroon, Cote d'Ivoire, and Nigeria received a score of 0.

Lastly, when it comes to the water-use efficiency (WUE), this indicator measures the value-added in US dollars per volume of water withdrawn by various economic sectors in a country, including agriculture, industry, and municipal water withdrawal. However, since the agriculture sector is responsible for 71.5% of total water withdrawal in the world, its impact on WUE is particularly relevant. According to FAO's estimates, WUE is approximately 15 USD per cubic meter around the world (FAO, 2018). As shown in Figure 5.8, 15 out of 48 OIC member countries with available data have WUE values above the world average, particularly Qatar (195.7), Kuwait (113.6), UAE (89.5), and Bahrain (76.1). Of the other 33 OIC member countries – with WUE values below the world average – Somalia, Tajikistan, and Kyrgyzstan have values even less than 1 USD per cubic meter. Generally, countries with a technologically advanced agriculture sector have higher water use efficiencies (FAO, 2018). Overall, there is room for considerable improvement within OIC member countries.

Figure 5.8 Water Use Efficiency in OIC Countries (USD per cubic meter), 2017



Source: SDG Indicators Database (Indicator 6.4.1). Data is from the latest year available between 2010 and 2017. Note: Higher values indicate more efficiency. Refer to ANNEX I for country codes.

To effectively address the challenges associated with the role of water in food security, it is imperative for OIC member countries to not only develop infrastructure, but also improve their policy frameworks. The need for cohesive management of land and water resources is as vital as investing in newer, more sustainable technologies. It is also important to understand the diversity of resource-related challenges faced by various OIC regions and develop frameworks, policies, and programs that are tailored to region-specific needs. More importantly, it is necessary to improve the resilience of member countries against future pressures that are unavoidable and can be mitigated using timely interventions.

Chapter 6
Energy and Water Nexus

Water and energy systems are intertwined. Secure and sustainable access to both resources is critical to basic survival and socio-economic development everywhere around the world. Water is an important input in energy production, and vice versa, energy is needed in the whole water supply chain. Changes in one system will, directly and indirectly, affect another. Therefore, this connection carries significant implications for managing water and energy security challenges.

6.1. Energy System Overview

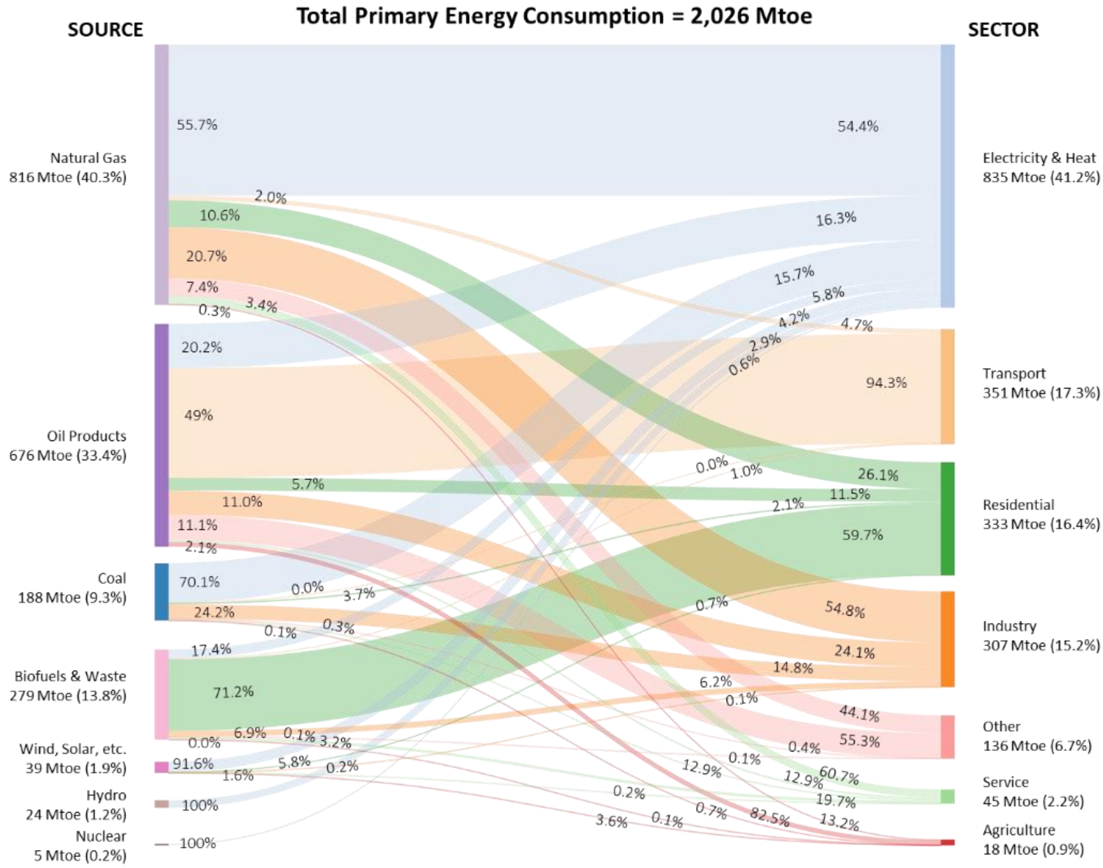
The static representation of the energy system of OIC can be seen through the energy balance table (see ANNEX IV). Figure 6.1 shows a simple representation of the energy balance table, where primary energy consumption by source and its respective consuming sectors can be identified. In 2018, the total primary energy consumption (TPEC) of OIC countries was 2,026 Million tonnes of oil equivalent (Mtoe). By comparison, TPEC of the world was 14,281 Mtoe, which means the OIC accounted for 14% of the global primary energy consumption. Fossil fuels (natural gas, coal, and oil) and nuclear constitute most of the primary energy consumption, accounting for 83.1% of the total. In the sectoral basis, electricity & heat sector is the most energy-intensive sector with a total share of 41.2%.

Besides presenting the relative and the absolute quantity of the primary energy consumption by source and sector, Figure 6.1 also shows the relationship between sources and sectors. In other words, it enables to identify the sources used by each sector and, conversely, the consuming sectors for each energy source. For example, regarding the energy sources of the electricity & heat sector, the figure shows that more than half of OIC's electricity & heat is supplied through natural gas (54.4%), followed by oil products (16.3%) and coal (15.7%). Similarly, as regards the sectoral distribution of the energy consumption from natural gas, the figure indicates that most of the energy sourced from natural gas is consumed by the electricity & heat sector (55.7%), industry (20.7%), and residential sector (10.6%).

There is a huge gap in the development of renewable energy (Hydro, Biofuels & Waste, Wind, Solar, etc.), both for the electricity & heat generations and for direct-use in other sectors. The renewable energy utilization in OIC is still very low, accounting for only 342 Mtoe or 16.9% of total primary energy consumption. Out of that amount, the electricity and heat sectors use 31.7% of total renewable energy, while the rest is utilized for direct-use in industry, buildings, transport, and other sectors. Biofuels and waste have the highest share in terms of renewable energy sources mix, supplying energy that amounts to around 279 Mtoe or 13.8% of total primary energy consumption.

The residential sector consumes most of the energy coming from biofuels & waste, the majority of which is in the form of traditional use of fuelwood and animal dung for heating and cooking. This is due to the fact that many populations in OIC still lack access to modern energy services. Although the resource is renewable, it has a significant drawback. The use of traditional energy services is constraining productivity, well-being, and socio-economic development (Fathurrahman, 2016).

Figure 6.1 Total Primary Energy Consumption by Source and Sector in OIC Countries, 2018



Source: SESRIC staff calculations based on IEA Energy Balance Database.

Low utilization of renewable energy can be an opportunity to increase the share of the resources. Wind, solar and others, for example, currently account for only 1.9% of TPES. Considering the OIC's regional advantages in terms of solar energy potential resources, this type of energy will be important for the future development of the energy system in OIC.

6.2. Interactions between Energy and Water

Both water and energy resources are important for human well-being as having access to them is a prerequisite for socio-economic development. Both resources are also interrelated across their production-consumption processes. Energy production requires water for nearly all production and conversion processes, including fuel extraction and electricity generation. On the other hand, energy is needed for extracting, treatment, and distribution of water to be used in many activities. Therefore, securing safe and reliable access to both resources are very crucial for human well-being and socio-economic development. The link between both resources is commonly known as water-energy nexus.

Water for Energy

Water is an important input for energy production. The use of water for energy production can be distinguished into fuel production and electricity production.[16] The water-use for energy production can be estimated through energy production data and water-use factors. Water-use factors tell us how much water is used per unit of energy produced. they can be utilized to compare the intensity of water usage from different types of energy production and technology. Considerable amounts of studies have estimated water use factors based on different energy type and technology being used. The water use factors are compiled in ANNEX V.

As the demand for energy increases, the burden of required water resources to support energy productions will depend on the mix of technologies that it deployed to satisfy the demand. International Energy Agency (IEA, 2016) estimates that, in 2040, global water withdrawal for energy will increase by less than 2%, but consumption will rise by almost 60%.[17]

The water use for energy production in the OIC is estimated by multiplying energy consumption with water use factors. Accordingly, as of 2018, OIC withdraws 68.8 km^3 of water, and 16% of it (10.8 km^3) is consumed during production (Figure 6.2). Similarly, like the global pattern (IEA, 2016), electricity production in OIC is by far the largest source of water withdrawals in the OIC although, in terms of consumption, fuel production is larger. The high amount of withdrawal in electricity production[18] is due to the need for cooling in thermal power plants, which account for more than 80% of total electricity

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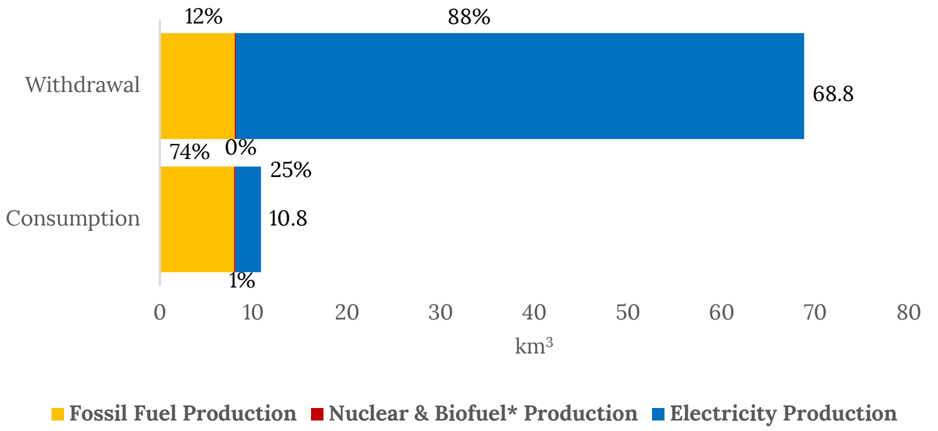
[16] Water-use is distinguished into two types: water withdrawal and water consumption. Water withdrawal is defined as *"the amount of water removed from the ground or diverted from a water source for use"* (Maupin et al., 2014, p.51). Water consumption is a subset of the withdrawal category and refers to the amount of *"water withdrawn that is evaporated, transpired, incorporated into products or crops, or otherwise removed from the immediate water environment"* (Maupin et al., 2014, p.49).
[17] The estimate was based on New Policies Scenario, which projects future trends on the basis of existing legislation as well as the commitment of governments and regional economic organisations to transform their energy policies in the period up to 2040. See IEA (2016) for further details.
[18] Hydropower water-use is not considered in the analysis. Hydropower relies on water passing through turbines to generate electricity, a majority of which is returned to the river. The amount of water used is very site-specific and currently there is no agreeable measurement method (IEA, 2016).

output in the OIC. However, most of the amount withdrawn is released back to the environment while the rest is 'consumed' as evaporation during the cooling process.

Figure 6.2 Water Withdrawal and Consumption for Energy Production, 2018



*Value based on Spang et al. (2014)
Source: SESRIC staff own calculations.

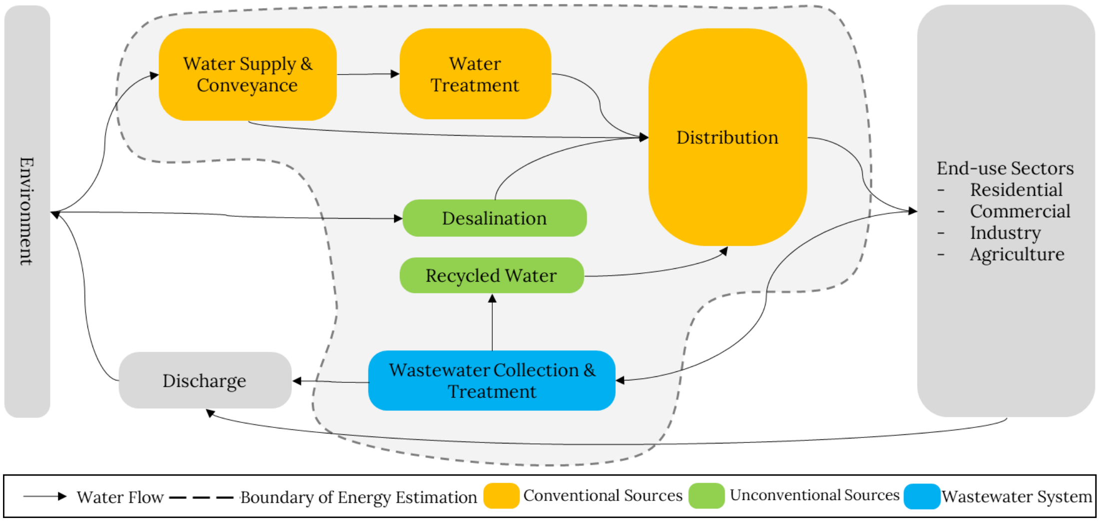
OIC countries consumed 10.8 km^3 of water for energy production in 2018, up from 2008's level of 8.6 km^3 (Spang et al., 2014). Fuel production account for 75% of total water consumption in energy production, almost all of which is used for fossil fuel production (Figure 6.2). This is quite explicable by the fact that the OIC is one of the largest producers of fossil fuel and, therefore, the majority of water consumption is dedicated to fossil fuel production. In 2018, OIC accounted for almost 30% of the global production of coal, crude oil, and natural gas.

It is worth mentioning the role of biofuel in energy production. Biofuel production is a water-intensive process. In the case of non-rainwater fed agriculture, there is a need to withdraw and consume water for irrigating the land. However, different crops require different amounts of water, ranging from almost zero water for palm oil to around 1,000 m^3 of water per toe biofuels from sugarcane (Spang et al., 2014). The production of biofuel in the OIC is still very low. Most of the biofuel is produced from palm oil by the global leaders of palm oil production, Indonesia and Malaysia. While the future importance of biofuel could be significant –especially to complement/substitute the use of oil– the development of this renewable resource should also consider water availability and food security in the region. Studies put concern over the competition of biofuel crops that could harm food security (Rulli et al., 2016).

Energy for Water

Energy is an essential input in all water production processes, which are illustrated in Figure 6.3. Conventional sources of water (i.e. surface and groundwater) will need pumping to extract the resources. While unconventional sources (such as desalination and recycled water) will require energy for the treatment process. Depending on the water quality and usage, water treatment is needed before the water is distributed to the end-users. Finally, wastewater from end-use sectors is collected and treated in the wastewater treatment, while some of them directly discharged to the environment without any treatment. Some of the treated water is reused for various purposes but the majority is still discharged back to the environment.

Figure 6.3 Simplified Flow of Processes in Water Sector



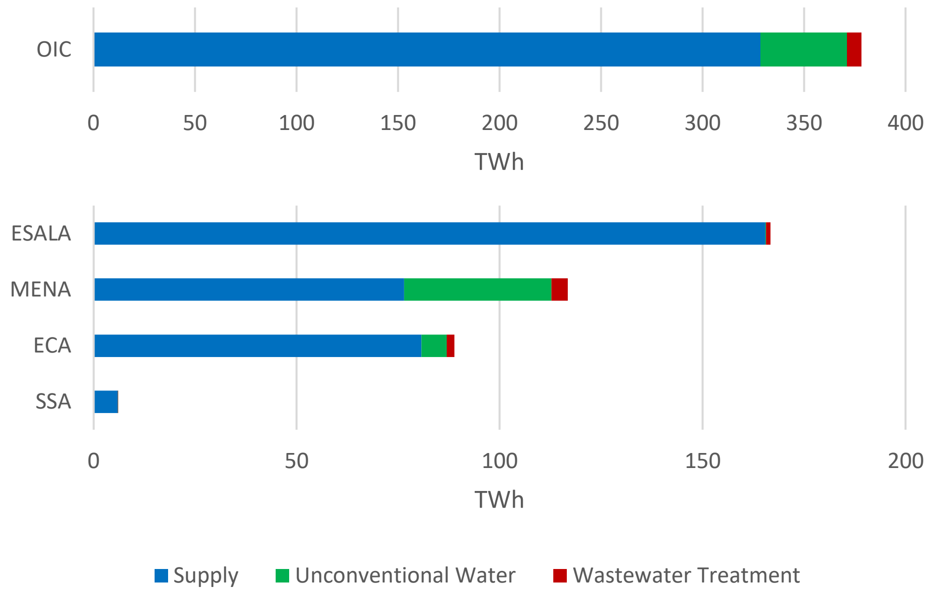
Source: Adapted from Plappally & Lienhard V (2012).

The energy intensity of various water processes can be seen in ANNEX VI. There are many uncertainties around energy intensity for water processes, thus the estimation result has to be used with caution. The energy consumption in the water sector is site and technology-specific. The averaged energy intensity estimates might overestimate/underestimate the use of energy in a certain location. For example, energy intensity for surface water extraction can be lower or higher depending on the distance of pumping and complexity of piping network (IEA, 2016). Furthermore, the energy demand for water treatment will depend on the quality of water resources and, in turn, the technology being used. Therefore, the minimum and maximum values of energy intensity are also presented.

Under the boundary of energy estimation, as seen in Figure 6.3, and based on estimated energy intensity values in ANNEX VI, the OIC's energy consumption in the water sector is estimated at 378.4 TWh. This is equivalent to around 13% of the OIC's total electricity production. Out of this amount, more than 80% goes for the supply of water, which includes the water supply & conveyance, water treatment, and distribution. Unconventional water supply (i.e. desalination and recycled water) uses around 42.8 TWh or 11.3% of the total energy for water processes, while wastewater treatment makes up for around 7 TWh (1.9% of total). The demand for wastewater treatment currently plays a lesser role since the share of wastewater collected and treated in OIC countries is very low. However, future improvement of the wastewater system will increase the energy demand for this process.

The energy consumption for the water sector in the OIC and its sub-regions is presented in Figure 6.4. The energy use is parallel with the degree of water withdrawal. ESALA, the region with the largest water withdrawal, is also the largest in terms of energy consumption in the water sector. The energy usage in ESALA is estimated at 166.7 TWh, followed by MENA (116 TWh), ECA (88.9 TWh), and SSA (5.9 TWh).

Figure 6.4 Energy Consumption in Water Sector by Region and Processes



Source: SESRIC staff own calculations.

While the water supply sector holds the largest share in all regions, unconventional water (most of which is through desalination) is also taking its toll. MENA is the region with the highest share of energy use for unconventional water supply at 36.3 TWh or 31% of its total energy use in the water sector. By comparison, desalination accounts for only 5% at the global level (IEA, 2016).

The reason for such a high share is that desalination is a very energy-intensive process and the MENA region is heavily dependent on desalinated water due to the scarcity of freshwater resources. While significant progress has been made in terms of lowering down the energy consumption for desalination, a further decrease is limited by the laws of thermodynamics (Plappally & Lienhard V, 2012). Thus, future development in desalination technology should also consider the alternative supply of energy. Coupling renewable energy and desalination technology is favourable and could be a very important technology in the near future.

6.3. Underlying Risks

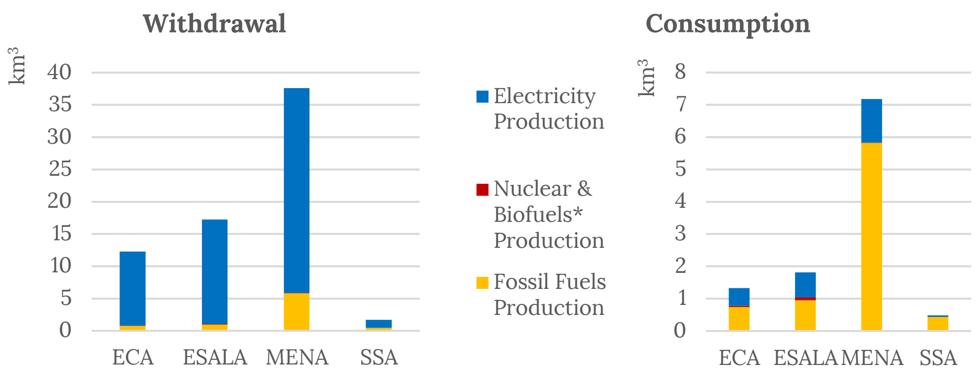
Disturbance on water and energy security would threaten the productivity of both sectors. This part of the report discusses the potential risks of both sectors due to various potential disruptions.

Water-Related Energy Risks

Globally and particularly in the OIC, the challenge of water security lies upon growing population, socio-economic development, and climate change. Declining supply and degradation in water quality will have both direct and indirect impacts on the energy sector. IEA projected that, under the New Policies Scenario, future energy supply will be more water-intensive. There will be a 20% increase in 2040 water consumption-intensity – that is, total water consumed per unit of energy produced, showing the relative consumption-intensity of the energy portfolio as a whole – for energy production relative to the 2014 level. This means that dependency on the energy sector towards a safe and stable supply of water will be stronger.

Many OIC countries are already at the level of water stress. Future population growth and socio-economic development amplified by climate change would make the competition for water more intense. The energy sector currently has a mix of technology that requires a significant amount of water. Not only most of the thermal power plants rely on fossil fuel, but it also depends on a continuous supply of water. Besides, a declining supply of water will also have direct consequences on hydropower production. Therefore, disturbance in the quantity of water would directly affect electricity production.

Figure 6.5 Water Use for Energy by Region and Energy Processes



Source: SESRIC staff own calculations.

The second risks involve the declining quality of water. As discussed in Chapter 1, the OIC group experiences declining water quality in terms of pathogen pollution, increasing level of nutrients and salinity. Furthermore, a future increase in the average weather temperature would also increase the water temperature that has a direct impact on the thermal power plant's efficiency. For instance, a 1°C increase in cooling water temperature would decrease the power output and thermal efficiency of a nuclear power plant by 0.4% and 0.2%, respectively (Attia, 2015).

The water-related risks in the energy sector vary on a country or regional level, given the differences in the energy mix, geography, and water security level. MENA is perhaps the most vulnerable region in the OIC in terms of water use for energy production. This region not only is already a water stress region but also has the highest water-use among the OIC sub-regions, as can be seen in Figure 6.5. The risks in the region will lie in every aspect of energy productions. As a region that economically relies heavily on fossil fuel production, increasing water stress would mean a disturbance in production that, in turn, will heavily influence the economy. On the other end, as the electricity-mix is mainly sourced from thermal power plants, there is a pressing need to keep water flowing to the power plant. IEA (2016) estimates that, compared to 2014, the water withdrawal for electricity in the MENA region will increase by a quarter by 2040.

Water supply is also a constraint in the development of biofuels, especially in ESALA and ECA. Depending on the type of crops to produce biofuels, biofuels production could be the most water-intensive energy production. Currently, the role of biofuel resources in the OIC is still minimal. Only a small number of countries in ESALA and ECA are active producers of biofuels, namely Indonesia, Malaysia, and Turkey. However, these renewable energy resources will have an important role soon, especially in diversifying the energy supply in the transportation sector. However, the development of these energy resources is also challenged by concerns over the competition with food crops and land usage. Therefore, there is a need to integrate policies between agriculture-energy-water sectors for sustainable development.

Energy-Related Water Risks

Water development depends on energy development. Most of the energy demand in the water sector is in the form of electricity. However, there is an apparent gap in energy development between developing and developed countries (Fathurrahman, 2016), which is also the case for OIC countries. Access to electricity in the OIC, especially in rural areas, is still a challenge. Energy development is a prerequisite for clean water and sanitation and an integral part of accomplishing SDG target 6.[19] The lack of access to electricity, therefore, constrains the development of clean water and sanitation (IEA, 2018). The penetration of electricity not only is vital as input in the water sector but also can improve the well-being of society. The supply of electricity to rural communities, in the short run, would promote incremental improvement in rural population, employment, and values of rural property, while in the long run lead to increase economic growth through socio-economic development (Lewis & Severnini, 2020).

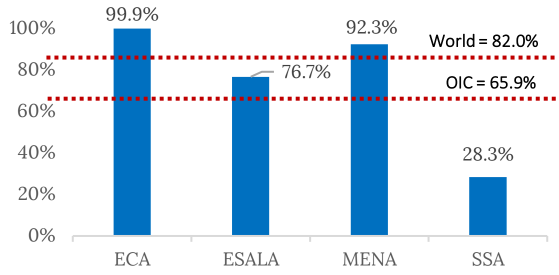
In 2018, on average, only 65.9% of the rural population in the OIC had access to electricity. This figure is lower than the global average of 82%. Moreover, looking at the

[19] SDG 6: Ensure availability and sustainable management of water and sanitation for all

OIC sub-regions, SSA seems to need particular attention. As shown in Figure 6.6, only 28.3% of the rural population in SSA have access to electricity, while at the same time, the other OIC regions have achieved significantly higher shares. It is necessary to pay paramount importance to foster the penetration of modern energy in order to improve not only the water sector but also socio-economic development in the region.

The challenge of providing modern energy is amplified due to the prospects for increasing energy intensity in the water sector. Similar to the increasing trend of water intensity in the energy sector, the water sector is expected to be more energy-intensive by 2040 (IEA, 2016). The main reasons are high growth in municipal and industrial water withdrawals, growing reliance on unconventional water resources, and wastewater system improvement.

Figure 6.6 **Rural Electricity Access in OIC Sub-regions**



Source: SESRIC staff calculations based on World Bank WDI Database.

The largest increase occurs in the MENA region, which is expected to see a significant increase in the energy intensity of water withdrawals (IEA, 2016). This is because energy-intensive unconventional water withdrawal would be required to satisfy the water demand of the society in the region. In other regions that are currently experiencing a lack of clean water and sanitation access, the improvement in this sector would also increase the volume of treated wastewater and supply of clean water, which, in turn, will increase the demand for energy in the water sector.

There is also a water quality risk due to the intense production of energy. Energy productions, whether for fossil fuel or for electricity, put significant pressure on the quality of water. For instance, produced water[20] from oil and gas production can affect the quality of surface and groundwater. Furthermore, the water discharged from thermal power plants can also degrade water quality since it contains harmful pollutants, while water from the cooling tower can give thermal pollution to water bodies.

Another risk and vulnerability relate to fulfilling energy needs for water supply in urban areas. With the high level of urbanization, cities in many developing countries are expected to be a major source of increasing energy demand for the water sector (WWAP, 2014). OIC countries are not exceptional. Their annual average urbanization rate of 3% is among the fastest globally. It is expected that, in 2050, 68.2% (1.7 billion) of the OIC's population will live in urban areas (SESRIC, 2019a). The increasing demand for water in urban areas will require a significant improvement in terms of energy efficiency in water supply and wastewater treatment.

[20] Produced water is water that is produced as a byproduct during the extraction of oil and natural gas.

PART 3

THE WAY FORWARD

Chapter 7
Towards Sustainable Water Management

Over the development of human civilization, socio-economic and technological advancement are the product of intensive use of critical resources, including water. However, this is not without a cost. Developments have caused environmental disasters such as loss of biodiversity, deteriorating environmental quality and changing weather patterns (UNEP, 2019).

The traditional approach of sole reliance on physical/engineering-based solutions in water management is regarded to be obsolete, as it remains unable to solve water-related societal problems. Basic water-needs of many populations are still unmet, while at the same time, extracting water from new sources is challenged by intense competition among different users. Furthermore, ecological values of the resources are often neglected, causing severe environmental problems such as the destruction of ecosystems, loss of species, and declining quantity and quality of resources (Gleick, 2000).

The current approaches to water management and planning are emphasizing the need to incorporate sustainable development concepts into the water sector through sectoral integration, broader stakeholder involvement, considering human dimensions of management, and wider recognition of the economic, ecological, and cultural values of water (Schoeman et al., 2014). Furthermore, the system should be adaptive enough to deal with future uncertainties including climate change.

This chapter will discuss the current approaches to water resources planning and management as well as the themes related to enabling sustainable water management in OIC countries such as exploiting supply from unconventional waters and water demand management.

7.1. Water Resources Management Approaches

The modern water paradigm emphasizes the need to have multi-sector integration, broader stakeholder involvement, and the importance of economic, social and ecological values of water (Schoeman et al., 2014). Good governance of water resources is important to reach the overall water objective of society. Providing equitable access to water resources, as mandated in the SDGs and the OIC Water Vision, can only be achieved through participatory and transparent management. Furthermore, there is also the need to integrate policies across various related sectors (such as energy and agriculture) to form a solid regulatory and institutional framework. In this process, the impacts and trade-off resulting from various policies must also be considered before deciding which path to pursue.

In the OIC, the governance of water is also closely related to safeguarding peace and security in the region. The previous OIC Water Report (SESRIC, 2018) stressed that many treaties regulating water resources in various OIC countries are either ineffective or non-functioning, therefore risking peace and stability. In this regard, there is a need to have an agreeable approach for OIC member countries to solve the governance of water within and between the borders.

Among others, three approaches are gaining global attention to solve water problems, namely, Integrated Water Resources Management (IWRM), Ecosystem-based Approaches (EBA), and Adaptive Management (AM).

Integrated Water Resources Management

Integrated Water Resources Management (IWRM) is perhaps globally the most popular concept of water resources management. The failure of traditional physical/extraction-based water planning encouraged international society to bring into the table a water management solution that incorporates ecological and societal values into water decision making. Theoretically, IWRM tries to bridge the gap between sustainable development and cross-sectoral planning (Jeffrey & Gearey, 2006).

The concept got international recognition when formally introduced at the 1977 United Nations Water Conference and further popularized by the Global Water Partnership (GWP) during the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992. The Conference drew attention to the Dublin Statement that was adopted earlier in January at the International Conference on Water and the Environment (ICWE) in Dublin, Ireland, and that set out recommendations for action based on four guiding principles –known as the Dublin Principles.[21] GWP later summarized these principles as follows: "*Integrated water resources management is based on the equitable and efficient management and sustainable use of water and recognises that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilisation.*" (GWP, 2011). Accordingly, the IWRM was defined by GWP as *a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*" (GWP, 2000, p.22).

The framework of IWRM can be seen in Figure 7.1. There are three pillars of IWRM:

[21]The principles are as follow: (1) Fresh water is a finite and vulnerable resource, essential to sustain life, development, and the environment. (2) Water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels. (3) Women play a central part in the provision, management and safeguarding of water. (4) Water is a public good and has a social and economic value in all its competing uses.

- **Enabling environment**: to form suitable policies, strategies and legislation for sustainable water resources development and management.
- **Institutional framework**: through which to put into practice the policies, strategies and legislation.
- **Management instruments**: required tools for the institutions to perform their duties.

The basis of the framework is that many different usages of water resources are interdependent. For example, intense use of water for agriculture might leave polluted water, which hinders the usage for other purposes (such as drinking water, industry, etc.). Municipal and industrial discharges often contain highly contaminated water that threatens the river ecosystem. On the other hand, leaving water purely for its ecological value will limit the use for other sectors. In practice, the application of IWRM consists of basin-scale management of water resources, establishing water rights, water pricing for allocation, and participatory decision making (Giordano & Shah, 2014).

Figure 7.1 General Framework of IWRM

Source: Adapted from GWP (2020)

UNEP (2012) reports that, since 1992, 80% of countries have started reform procedures to improve the enabling environment for water resources management based on the application of IWRM. Over the past decades of implementation, countries that have adopted integrated approaches have been reported to boost infrastructure development, provide diverse financing sources, and improve institutional frameworks, which has led to better water management practices and socio-economic benefits (UNEP, 2012). The economic benefits are suggested through efficiency improvement, mostly in water-use in the agriculture sector. Social and environmental benefits are also reported in terms of improved access to water and improved water quality through wastewater treatment.

However, there is a disparity in the impacts among countries, where countries with higher HDI[22] are reported to enjoy quite more benefits than those with lower HDI.

In the OIC, countries are also implementing IWRM. For instance, Kazakhstan, Kyrgyzstan, Azerbaijan, Tajikistan, and Turkmenistan have undergone IWRM implementation such as the transition to basin management approach, institutional setup, and regulatory reform since the 2000s (OECD & United Nations, 2014). Furthermore, many other OIC countries are also undergoing implementation with differing stages.[23]

While the IWRM concept is mostly acceptable by the international community, studies show that it also has its limitations. IWRM is cited to be a vague concept, constraining practical applications of the concept (Biswas, 2008). There is still important disagreement on what needs to be integrated, how to achieve, who will provide leadership, and who will pay (Schoeman et al., 2014).

Ecosystem-Based Approach

Various ecosystem-based approaches (EBA) are developed through preceding ideas on natural resources management, such as sustainable development, biodiversity, natural capital and ecosystem services. The concepts are then reflected in various international policy agreements such as the adoption of the Convention on Biological Diversity (CBD) and its Ecosystem Approach, the UN's Millennium Ecosystem Assessment and its activities including the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Schoeman et al., 2014).

Similarly to IWRM, EBA promotes an integrated approach that influences the management of natural resources and their use towards sustainable development and equity (Cook & Spray, 2012). EBA tries to balance nature conservation and human resources, and at the same time, aspire to maintain and restore the natural structure and functioning of ecosystems (Schoeman et al., 2014).

EBA also paved the way for global discourses on new natural resources management ideas, which resulted in the proliferation of new ecological-based concepts. One of them is Nature-based Solution (NbS). The concept has been positioned as an 'umbrella concept' for various ecosystem-based approaches and it is defined as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*" (Cohen-Shacham et al., 2016, p.4). Applications of the ideas vary to address issues such as water security, food security, human health, disasters risk reduction, and climate change adaptation.

The framework of NbS and its relation with EBS is illustrated in Figure 7.2, where NbS is depicted as an umbrella concept that covers ecosystem-related approaches –placed

[22] HDI refers to Human Development Index developed by UNDP. More information can be accessed at http://hdr.undp.org/en/content/human-development-index-hdi

[23] Case studies of IWRM implementation in OIC countries and globally can be seen in https://www.gwp.org/en/learn/KNOWLEDGE_RESOURCES/Case_Studies/

into five main categories– all of which address societal challenges. In this framework, NbS interventions need to be applied based on a set of general principles. According to Cohen-Shacham et al. (2016), Nature-based Solutions:

- embrace nature conservation norms (and principles);
- can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions);
- are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
- produce societal benefits fairly and equitably, in a manner that promotes transparency and broad participation;
- maintain biological and cultural diversity and the ability of ecosystems to evolve;
- are applied at a landscape scale;
- recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystem services;
- are an integral part of the overall design of policies and measures or actions, to address a specific challenge.

Figure 7.2 **Nature-based Solutions Framework**

Source: Adapted from Cohen-Shacham et al. (2016)

In terms of water resources management, NbS promote the direct connection in the adoption of SDG Target 6.6 ("*By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes*") to support the achievement of SDG 6 ("*Ensure availability and sustainable management of water and sanitation for all*"). In the World Water Development Report 2018 (WWAP, 2018), NbS became the main theme and was proposed as the solution for water management.

NbS combat water security problems by improving water quantity and quality while at the same time, reducing the risks and providing social, economic and environmental co-benefits (WWAP, 2018). Applying NbS means harnessing 'natural infrastructure' such as forests, wetlands, and floodplains to solve water-related problems, particularly for the future uncertain climate. For example, the application of NbS in water bodies for the agriculture sector can provide many benefits. Steady supply and quality of water would increase the productivity of the sector while at the same time reducing downstream pollution. In the context of water and sanitation, constructed wetlands for wastewater treatment are deemed cost-effective due to additional benefits such as reducing downstream pollution and reuse of effluent water for various purposes (e.g. non-potable use, energy production).

The NbS concept has been applied in some of the water-related projects in OIC countries. Egypt constructed wetlands to treat wastewater, which provide multiple benefits (WWAP, 2018). The resulted effluent from the wetland is at a secondary-level and used as irrigation to nearby farms. The construction and operation costs were also lower than conventional wastewater treatment plants. Therefore, the project has not only contributed to the conservation and preservation of water but also provided economic benefits. In Jordan, NbS approach is implemented to restore the unsustainable practice of land management in the Zarqa River basin. The project intends to let the land naturally regenerate itself. The project resulted in an increase in economic growth through the cultivation of indigenous plants and the conservation of natural resources in the Zarqa River Basin (Cohen-Shacham et al., 2016).

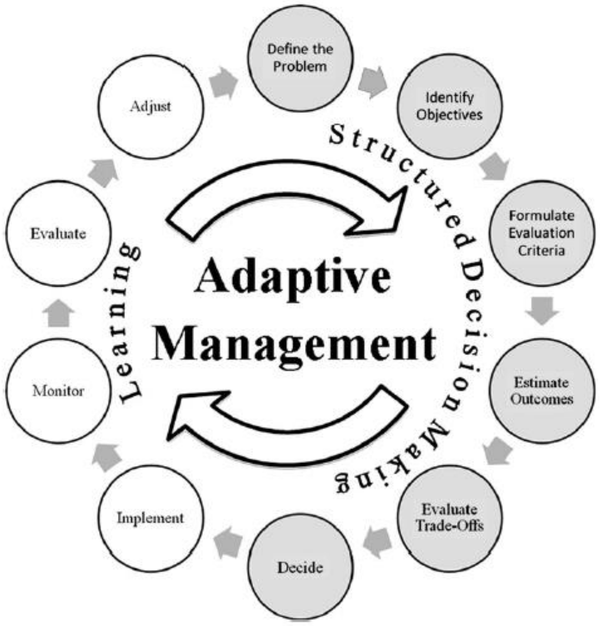
The EBA concept sounds appealing and provides fewer risks. However, this concept also has its limitation. Like IWRM, EBA also has ambiguity in its concept, plus, many 'branch' of similar concepts might be confusing for some (Schoeman et al., 2014). This results in a difficult implementation of the concept. Valuing ecosystem services, which is part of EBA, also incites debates. Implementation of the concept is also challenged by the status quo of a traditional water development approach that exists in civil engineering, market-based economic instruments, the expertise of service providers, and consequentially in the minds of policymakers and the general public (WWAP, 2018).

Adaptive Management

Adaptive management (AM) is a "*systematic approach for improving resource management by learning from management outcomes*" (Williams et al., 2009, p.1). This broad definition can be achieved through various methods depending on the study system. AM is deemed as an appropriate approach for managing natural resources with present uncertainty.

The AM process usually involves several steps as illustrated in Figure 7.3. *First*, the problem needs to be defined and further identification of objectives in collaboration with stakeholders is necessary. This process will result in the specification of multiple options that can be pursued to solve the problems. *Second*, the evaluation criteria of the system need to be determined together with the interpretation of how the system responds to the interventions. This stage usually involves the development of quantitative conceptual models. *Third*, the implementations of actions. *Fourth*, monitoring of the system typically requires regular basis monitoring. *Fifth*, based on the result of the monitoring, interventions to the system are adjusted. From here, the cycle goes on again to the first step until a desirable outcome is reached. AM is often characterized as a 'learning by doing' approach where formal iterative processes change over time depending on resulting impacts from the interventions. While there are many

Figure 7.3 Adaptive Management Project Cycle



Source: Adapted from Allen et al. (2011)

projects claimed to implement adaptive management, only a small number of them are following the AM cycle mentioned above (Williams et al., 2009). Applications of AM (either partially or fully) are also observed in OIC countries. Amudarya basin, which is shared by Afghanistan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, is an example of those applications. The water allocation system in the Amudarya basin applies AM principles that allow flexibility and adaptation to climate change. On the other hand, it also consists of legal instruments and joint-organizations to deal with water allocation, which follows IWRM principles. While there are still limitations, the management of the basin has ensured water allocation in Central Asian countries over the last decades (USAID, 2016).

While AM is highly promising to solve problems related to future uncertainty, there are some major issues to its implementations. Similar to those discussed for IWRM and EBA, there is ambiguity in the definition, complexity, institutional barriers, cost and underlying risks. These issues are amplified by cultural obstacles where institutions tend to do action rather than reflection, box-ticking rather than learning, and encouragement of competition rather than cooperation (Allen et al., 2011).

The Way Forward

Managing water is a complex task due to inherent multi-stakeholders, local-regional uniqueness, cultural dynamics, and political and regulatory complications. Amplified with uncertainty over future climate change, policymakers should find the most appropriate way to manage water resources for the benefit of society and the environment. All the above-mentioned approaches in water resources management still have constraints in their implementation. Therefore, a 'one-size-fits-all' approach should not be pursued but rather using a combination of approaches that suits the local/regional needs.

It is therefore important to consider the differences between the concepts and examine how one's strength may complement another's limitations to accomplish sustainable water management. For instance, IWRM and EBA aim for integration, which in theory, can be achieved through the AM approach (Schoeman et al., 2014). The feedback mechanisms in AM could further improve the IWRM or EBA framework by having a highly adaptive system.

7.2. Unconventional Water Resources

The role of unconventional water resources is becoming more important due to increasing water stress and the threat of climate change. Globally, 2/3 of the world population is expected to experience water stress by 2030. Unconventional resources might be crucial in the OIC to fulfil society's water needs and achieving the mandate of the SDGs and the OIC Water Vision.

Unconventional water resources can be produced through specialized processes such as desalination or need suitable pre-treatment and special technology to collect/access water. Some examples of unconventional water resources are (UN-Water, 2020b):

- Desalination of seawater and brackish groundwater;
- Icebergs;
- Ballast water;
- Rainwater harvesting;
- Cloud seeding or fog water collection;
- Recycle and reuse of treated wastewater, greywater, and storm water;
- Reuse of agricultural drainage water.

The most common sources of unconventional waters are desalinated water and reuse of wastewater and agricultural drainage water. OIC countries, particularly the ones lying in water-scarce regions, need to exploit the unconventional water resources for sustainable development. It is estimated that, yearly, around 2 km^3 or 0.2% of the total water demand in the OIC is fulfilled by unconventional water resources. The use of these resources can help close the water supply-demand gap.

Despite their benefits, the lack of information on the importance of such resources has made them under-explored. Furthermore, various technological, economic, and political barriers should be addressed through innovative financing, sustainable management, and support from policies and institutions. For example, the direct use of wastewater in the OIC is limited due to the fact that, in many cases, many countries were unable to develop sewer systems fast enough to meet the needs of their growing urban populations. As a result, the collection and treatment of wastewater became ineffective.

There are growing examples of using unconventional water resources or developing new technologies to boost water supplies, both low and high costs, to address water scarcity in OIC countries and around the world. However, there is no coordinated initiative to date for cooperation across countries to build and share a global vision to harness the potential of unconventional water resources. There is an urgent need in OIC countries to have coordinated efforts to foster the development of unconventional water resources and technologies, mainly due to increasing water stress in various regions. These efforts will also align with the objectives of the OIC Water Vision and protect the security of water supply for present and future generation.

BOX 2: Key Actions to Foster the Development of Unconventional Water Resources

There is a need to consider strategies for implementing sustainable water resources management by harnessing the potential of unconventional water resources. Some of the important elements of such a strategy would require the following actions:

(1) Assess the potential of augmenting current water supplies with unconventional water resources in water-scarce areas;
(2) Revisit and make country- and area-specific unconventional water resource(s) a priority in political agendas, policies, and management of water resources in water-scarce countries and river basins, and enable their use through supportive action plans;
(3) Guide institutional strengthening and collaboration to avoid fragmented approaches and clarify the roles and responsibilities of water professionals and institutions;
(4) Understand and analyse the economics of action and inaction to overcome the perception of high costs by undertaking comprehensive analyses of innovative financing mechanisms, the cost of alternate options (such as tankers or water transportation from wells from far distances), and economic and social costs;
(5) Build capacity of skilled human resources to address the complexity of assessing and utilizing some unconventional water resources along with their environmental, ecosystem, and economic trade-offs;
(6) Encourage private sector investment in projects utilizing unconventional water resources;
(7) Engage communities to enhance local interventions with context-specific knowledge and integrate gender mainstreaming objectives and processes in community-based projects
(8) Support increased scientific funding to understand and tap the potential unconventional water resources in water-scarce regions.

Source: Adapted from UN-Water (2020b)

7.3. Demand Management

To achieve sustainable water resources management, demand-side management of water needs to be addressed. Water demand management for sustainable development will require improvement of water-use efficiency through wise use and other water-use reduction measures.

The benefits of implementing water demand management in OIC countries are numerous (Freie Universitat, n.d.). *First*, managing demand eases pressure on scarce resources. *Second*, it is more productive to encourage or adopt measures for efficient use of water than to invest in additional sources of supply. *Third*, it would be possible to estimate the present and future sectoral water use, which is important for water planning and allocation. *Lastly*, demand management promotes the sustainability of the resource by eliminating water loss.

Agriculture Water Demand Management

Agriculture is one of the most important sectors in OIC countries. The future demand for food will require an increase in agriculture yields by improving its resource use efficiency, and therefore water plays a central role. The most general approach to improve water use efficiency in the agriculture sector is by practising conservation and reuse of water. Water conservation is recognized as a basis to implement 'sustainable ecological intensification' of food production (Freie Universitat, n.d.). Conservation works by enhancing ecosystem services in agricultural landscapes through improved soil and vegetation management. The idea is to keep water basin pristine enough from any disturbance, therefore, maintaining the quantity and quality of water for the end-use sector. In terms of reuse of water, technologies to collect and treat drainage agriculture water can be used such that the treated water can be applied again to the crops. This will minimize the use of water from surface or groundwater.

BOX 3: Options to Improve Water Efficiency at Farm Level

In addition to general water conservation and reuse practices, three possible options can be exercised to save water at the farm level. These options are:

(1) Increasing crop productivity per unit of water. This option considers alternatives that include planting drought-tolerant crops or reducing inputs such as fertilizers or water to decrease vegetative vigour.
(2) Improving management capacity of growers. This can be realized by increasing grower ability to optimize irrigation amounts in time and space utilizing site-specific irrigation techniques, enhanced water delivery systems, decision support tools, and other advanced methodologies.
(3) Spatially optimizing water applications and use. This can be applied through various scientific irrigation scheduling scenarios including deficit irrigation, geographically relocating specific crops to areas of maximum adaptation and productivity, and fully or partially retiring lands from irrigation so water can be moved to more productive areas or uses.

Source: Adapted from Evans & Sadler (2008)

Urban Water Supply & Use

Addressing water use in the urban setting is important given the continuous growth in urban population and, therefore, the increase in urban water demand. Flörke et al. (2018) estimated that, by 2050, 233 million of the urban population in various cities around the world would have water demands that exceed surface-water availability, in short, experiencing a surface-water deficit.

Cities are where a mix of infrastructure and sectoral administrative and governance systems interact with each other, forming a complex dynamic system. Therefore, urban water use efficiency is not solely a matter of efficient water consumption; it should also consider efficiencies in water supply sources and demand management. Cities of the future should be 'water sensitive cities', that is, cities that could integrate the values of environmental sustainability, supply security, flood control, public health, amenity, liveability and economic sustainability, amongst others (Brown et al., 2009).

The source of water supply in cities has to consider its fit-of-purpose. For instance, the use of water for city landscape would be different from the use of drinking water. Since cities are also posed as water supply catchments, various unconventional water sources can be harnessed. For instance, diversifying supply of water can be achieved through seeking alternative sources such as rainwater, storm water, recycled wastewater, and desalinated water. In terms of infrastructure, combining grey infrastructure with green infrastructure could address water supply availability in urban settlements. Green infrastructure, such as green buildings, could improve water security by posing as a catchment for water and recharging aquifer in urban areas.

Demand management is the other important part of building a sustainable and resilient water system for cities. Behavioural change of the society in consuming water is needed so that no drop of water is wasted. Therefore, raising awareness and literacy of water in the society is fundamental in improving the efficiency of water use. Technological advancement can also be harnessed for this purpose. Water-efficient appliances, along with a proper labelling, can be a key step in providing a water-efficient lifestyle. Furthermore, smart metering and big data analysis can be a useful tool for public communication and building the social capacity for the effectiveness of urban water demand management.

Chapter 8

Concluding Remarks and Policy Recommendations

8.1. Concluding Remarks

Present and Future are not Favorable

Water is one of the most important resources responsible for sustaining life and prosperity. The 57 member countries of the OIC are diverse in terms of water resources, availability, infrastructure, and resources management. Over the last decade, the OIC has worked to address major issues of environmental and social concern such as clean water availability and access to sanitation. In response to a direct request from the OIC Water Ministers, the OIC General Secretariat began the process of developing a common vision to address water issues up to the year 2025. Following deliberations at meetings of an Advisory Panel of Experts in Dubai in May 2010 and Astana in June 2011, the OIC developed a draft vision for presenting to wider communities for adoption. During the 2nd Islamic Conference of Ministers Responsible for Water, held in Istanbul in March 2012, the OIC Water Vision (OIC, 2012) of *"working together for a water-secure future"* was adopted. The Vision calls for knowledge sharing and collaborative activities in research, policy, and management support amongst OIC knowledge centres on water.

Despite the considerable progress in political agenda and various activities within the scope of the OIC Water Vision, the present situation shows that the water sector in OIC countries still far from reaching its intended vision. OIC countries are experiencing increasing water scarcity, facing high water-related risk and stress, and lacking drinking water and sanitation services. Furthermore, the COVID-19 pandemic has threatened the continuous supply of water mainly due to increasing domestic demand and pressure on water utility companies. Low income and least developed OIC countries are suffering the most; having more constraints on socio-economic development, poverty alleviation, and famine eradication efforts.

The future of water security is also unfavorable unless significant changes take place. The water-secure future in OIC countries faces challenges in the form of intensifying pressure on water due to population growth, rapid urbanization, socio-economic development, change of consumption patterns, and climate change.

Climate Change Impacts

OIC countries, mainly in SSA and ESALA, already have 'high' to 'extremely high' level of variability, which infers the degree of fluctuation of water supply between months of the year. Climate change, in this regard, can exacerbate the variability further. Some regions in the OIC can witness an increase in variability by at least 10% by the year 2040. Global climate change also projects an increase in the frequency of water-related extreme events (such as heatwaves, drought, and flood). This pressure on water resources will give further pressure on food security and access to clean water and sanitation, disturb the operation of water infrastructure (e.g. irrigation systems, hydropower, etc.), and, thereby, threaten the well-being of the society.

Knowledge about future risks and vulnerabilities of climate change in the water sector is essential in forming water policies. Water-sector related risks from climate change relate to hazards (drought, extreme precipitation, rising temperature, etc.) associated with it. For example, increasing water variability may increase the risks of insufficient water supply, loss of agricultural productivity and/or income of rural people, and destruction of livelihoods, particularly for those depending on water-intensive agriculture.

The water sector in OIC countries is very vulnerable to the impacts of climate change. This is because OIC countries are sensitive and highly exposed to climate change and in the same time lacking the adaptive capacity to cope with the impacts. Furthermore, there is a need to improve the readiness of the society by improving the area of governance and socio-economic development.

OIC member countries need to pursue various mitigation and adaptation efforts to face this challenge. These efforts will not only contribute to reducing stress on the environment but also provide various economic and social benefits by increasing food production and resilience towards the future changing climate. It may also have co-benefits (improved efficiency, reduced cost, environmental co-benefits) which could give positive spill over effects to other sectors in the economy. Furthermore, there is an important need to analyse the implications of climate change at local levels and share experiences within OIC member countries in terms of coping policies, management, and use of technology.

Water-Energy-Food Security Nexus

Linkages between the water sector and energy and food security are important to consider since the sectors are strongly interrelated. Water is one of the most essential inputs for food and energy production. Pressure on water sector will directly affect the production of food and energy, which is also essential in safeguarding the livelihood of society.

Food security challenges faced by OIC member countries are further compounded by the fact that, in the near future, the OIC region is expected to experience a rapid population growth and urbanization. UN DESA estimates show that, by 2050, the OIC's total population will exceed 2.8 billion. When combined with the occurrence of natural and artificial disasters due to climate change and conflicts, the existing pressure on food and water systems in OIC member countries will intensify. At the same time, economic growth in the OIC region will also result in an increase in individual wealth and purchasing power, which will not only increase consumption, but also transform consumption patterns. Naturally, a combination of these factors will result in a demand for increased food production, which is likely to set off a competition over scarce resources – particularly water, agricultural land, irrigated land, energy, seeds, etc.

The largest withdrawal of water in energy production relates to electricity production in thermal power plants. Given that the overall electricity in the OIC is generated through thermal plants, the continuous supply of water is becoming crucial. Furthermore, some countries can expect to increase their electrification rate in response to an increased demand. Consumption of water, on the other hand, is the largest for fossil fuel production. The OIC region, as one of the biggest global producers of fossil fuels, therefore, requires water to keep its production going. Failing to comply may hamper the fossil fuel production, which, in turn, could harm the economy and societal well-being.

There is also a need for energy in the entire water supply chain, from the extraction of the resources to treatment, distribution, wastewater treatment, and discharge. Most of the energy used in the water sector is for supplying water, where pumping water needs electricity. The OIC can expect an increase in the demand for energy from the water sector, especially due to rapid urbanization rate, which requires the expansion of water and wastewater utilities.

8.2. Policy Implications

Sustainable Water Management as a Solution

Water governance is a complex task due to the involvement of multiple stakeholders across various sectors and requires region-sensitive policies and approaches, cultural diversities, and political and regulatory mechanisms. There is a need to form an appropriate water management framework that is 'sustainable', meaning that the distribution of water resources and services is equitable for the economy and society, while also pursuing the goal of environmental protection and conservation. In this regard, OIC countries can make use of the emerging trend of water management framework in global discourses such as integrated water resources management, ecological based approach, and adaptive management. Furthermore, practices such as exploiting unconventional water resources and efficiency in demand management need to be addressed as part of the big sustainable water management framework.

Sectoral integration is one of the more important points, as the water sector is highly linked with other sectors (especially food and energy). Both IWRM and EBA try to solve water issues through sectoral integration, multi-stakeholder involvement, and valuing natural/ecosystem services, with an equal market-based allocation of resources. Furthermore, AM provides an important tool to safeguard achieving sustainable management through a continuous iterative cycle of 'learning' processes.

However, all above-mentioned approaches in water resources management still have constraints in their implementation. Instead of pursuing a 'one-size-fits-all' approach, OIC countries should rather use a combination of approaches that suits the local/regional needs. It is, therefore, important to consider the differences between the approaches and analyze how one's strength may complement another's limitations to accomplish sustainable water management. For instance, IWRM and EBA aim for integration, which, in theory, can be achieved through the AM approach (Schoeman et al., 2014). The feedback mechanisms in AM could further improve the IWRM or EBA framework by having a highly adaptive system.

Policy interventions focusing on the use of water in WASH sector need to consider three critical factors: accessibility, availability, and quality of services. Merely increasing the number of WASH facilities is not enough to bridge the gap in coverage of WASH services. The facilities also need to be safe to use – especially in disadvantaged or underprivileged communities; otherwise, unsafe WASH facilities can cause more harm. Similarly, in the domain of agriculture and food security, water plays an important role at multiple intersections. Therefore, interventions ensuring food security in member countries need to address not only the quantity of water being utilized in the agriculture sector, but also the quality of water.

Finally, policy makers in OIC member countries need to incorporate a social perspective in the regulation of water resources. For instance, low-cost and small-scale options for harvesting water, irrigation, and drainage, are necessary for rural communities that depend on manual labour. Rural communities can also benefit from subsidies and government support in adapting to sustainable farming methods. In order to do so, OIC member countries need to understand how low-income households depend on agriculture sector to combat poverty and food insecurity.

Unconventional Water Use

The role of unconventional water resources is important not only to safeguard water supply but also to protect the environment. Therefore, exploiting these resources is crucial to practice sustainable water management. OIC countries, in particular, need to increase the utilization of these resources due to inherent water scarcity and increasing pressure to water security. Unconventional water resources can help OIC countries to fulfil the mandate of the SDGs and the OIC Water Vision.

Current usage of these resources is constrained by the lack of information and technological, economic, and policy barriers. Such constraints should be addressed through innovative financing, sustainable management, and support from policies and institutions.

Demand Management

Demand-side management of water aims to use water as efficiently as possible. OIC countries, in general, do not use water in efficient ways. Water productivity in OIC countries is still low while at the same time some countries recorded a high level of water loss. Therefore, managing demand will require economic, technological and behavioral change across end-use sectors.

It is imperative for policy makers and practitioners to focus on interventions that increase the efficiency of water use in the agriculture sector, reduce agriculture sector's impact on freshwater resources, and improve its resilience to water risks. This can be achieved through conventional water conservation and reuse practices or involving technology to increase crop productivity with lower water use. In municipal water management, the use of water for urban population needs to be considered since the urban population in the OIC is growing quite rapidly. Behavioural change in water consumption can be pursued through education and awareness programs as well as encouraging the use of water-efficient appliances. Furthermore, the exploitation of unconventional water for cities (such as wastewater reuse and storm water) can be enhanced to reduce stress on water bodies.

Governments in OIC member countries should strengthen and enforce existing policies and regulations, create incentives for farmers to improve their water consumption and better manage the use of ecologically harmful inputs, and remove regulations that support excessive use of water and activities that can harm ecosystems.

OIC Policy Suggestions

The OIC Water Vision has been a great point of departure on the types of actions needed in the water sector. However, in this report, five specific actions need to be fostered to enhance the sustainability of water management in OIC countries.

Integrating water governance with climate actions and food-energy policies. Water is one of the most directly impacted sectors from climate change. It also has strong linkages with two other life-essentials sectors, food and energy. The impacts of climate change, as discussed in Chapter 4, makes it important to integrate climate mitigation and adaptation efforts with water agenda. In the same way, as discussed in Chapter 5 and Chapter 6 on how water sector is strongly related to food and energy, policy integration in these sectors would be important. Therefore, solving water problems will require not only tangible interventions such as infrastructure upgrade but also intangible interventions through institutional reforms. Most importantly, a holistic framework for water resource management should ensure integration services in the use of water in such areas as WASH, energy, and irrigation. It should also adopt a multi-sectoral approach by bringing together experts on water, energy, agriculture, and public health when developing and implementing interventions. Integrating climate actions and food-energy policies with water governance would enable understanding and solving conflicting interests and provide coordinated solutions.

Reducing gender inequalities in access to WASH services. OIC member countries need to address gender inequalities in access to and the management of WASH services. The adoption of gender-responsive programming in WASH sector can have numerous benefits for OIC member countries, such as reducing inequalities in access to water, protecting women from the violence that results from unsafe sanitation services, and reducing mortality rates attributed to WASH. It can also reduce gender inequality and poverty in member countries because the hours that women spend on managing WASH services can instead be spent on education and/or income generation. More importantly, including women at the decision-making level is necessary to mainstream gender into WASH design and management at all levels.

Broaden funding opportunities. Project financing is one of the critical barriers that need to be tackled to foster the growth in sustainable water management, water supply, and sanitation services. Water managers and project managers have to think of innovative ways to generate finance for their projects. In the case where investment cannot be recovered through user-fees (for instance, in water supply and sanitation projects), revenue generation should be pursued from another channel. In this regard, public-private partnerships (PPPs) scheme can be a good alternative. The government can participate in the project through subsidies or equity stakes of the components where recovering revenue may be difficult. Furthermore, integrating actions of water with climate and food-energy sectors would allow countries to leverage additional resources and open larger funding options while also addressing issues of the overlapping sectors.

Knowledge sharing, collaborative activities in research, policy and management support. Under the tutelage of intra-OIC institutions and guided by the OIC Water Vision, OIC member countries need to build multi-sectoral capacities in line with their needs and requirements. This includes an awareness of the current state of agriculture and water resources in member countries, and knowledge of shocks and pressures that pose threats to the stability of these sectors, along with a will to better integrate water resource management in national development agendas.

Enhancing activities within OIC member states and with partner organizations in the domain of knowledge sharing, collaborative research, and policy and management support are important to increase the capacity of member countries to solve water issues. These kinds of activities are also part of the objectives mandated in the OIC Water Vision. Member countries are urged to take active actions to leverage various capacity building and training programs, such as those that SESRIC has long been providing.

Data collection and set up targets and key indicators to track progress. Given the future risks to water sectors in OIC member countries, policy makers need to focus on understanding, predicting, and responding to risks, threats, and emergencies. Predicting the impact of future risks should be undertaken in collaboration with local communities, which can help develop inclusive policies and tailor modalities to diverse circumstances and areas. Preparing for the future is also contingent upon data collection in the OIC region, which can better inform on emerging risks, determine the success rates of interventions, establish best practices, and facilitate the exchange of skills and knowledge.

The OIC Water Vision provides a good lead on shared water vision within OIC countries until the year 2025. There is a need to think about the continuity of this excellent initiative for the post-2025. More concrete actions and measurable progress can be a good option for the future agenda. OIC countries could prepare a strategic plan such as a 'Water

Action Plan', which include guidelines on data collection, standardized measurement framework, implementation and monitoring mechanisms. Key indicators and targets could be set to report on the most important priorities in the water sector in the OIC. In this regard, the SDGs-related targets can be a good point of departure, especially in aligning the efforts of the OIC with the efforts to meet the SDG targets.

REFERENCES

Allen, C. R., Fontaine, J. J., Pope, K. L., & Garmestani, A. S. (2011). Adaptive management for a turbulent future. Journal of Environmental Management, 92(5), 1339–1345. https://doi.org/10.1016/j.jenvman.2010.11.019

Attia, S. I. (2015). The influence of condenser cooling water temperature on the thermal efficiency of a nuclear power plant. Annals of Nuclear Energy, 80, 371–378. https://doi.org/10.1016/j.anucene.2015.02.023

Baldino, N., & Sauri, D. (2018). Characterizing the recent decline of water consumption in Italian cities. Investigaciones Geograficas, 69, 9–21. https://doi.org/10.14198/INGEO2018.69.01

Biswas, A. K. (2008). Integrated water resources management: Is it working? International Journal of Water Resources Development, 24(1), 5–22. https://doi.org/10.1080/07900620701871718

Brown, R. R., Keath, N., & Wong, T. H. F. (2009). Urban water management in cities: historical, current and future regimes. Water Science and Technology, 59(5), 847–855. https://doi.org/10.2166/wst.2009.029

Burek, P., Satoh, Y., Fischer, G., Kahil, M. T., Scherzer, A., Tramberend, S., Nava, L. F., Wada, Y., Eisner, S., Flörke, M., Hanasaki, N., Magnuszewski, P., Cosgrove, B., & Wiberg, D. (2016). Water Futures and Solution. International Institute for Applied Systems Analysis, May, 1–113.

Chen, C., Noble, I., Hellmann, J., Coffee, J., Murillo, M., & Chawla, N. (2015). University of Notre Dame Global Adaptation Index: Country Index. University of Notre Dame Global Adaptation Index Country:Country Index Technical Report, 46.

Cohen-Shacham, E., Walters, G., Janzen, C., & Magginis, S. (2016). What are Nature-based Solutions? In Nature-based solutions to address global societal challenges. https://doi.org/10.2305/IUCN.CH.2016.13.en

COHRE. (2008). Manual on the right to water and sanitation. Geneva: COHRE. Retrieved from https://issuu.com/cohre/docs/cohre_righttosanitationwatermanual_

Cook, B. R., & Spray, C. J. (2012). Ecosystem services and integrated water resource management: Different paths to the same end? In Journal of Environmental Management (Vol. 109, pp. 93–100). Academic Press. https://doi.org/10.1016/j.jenvman.2012.05.016

Cooley, H. (2020). How the Coronavirus Pandemic is Affecting Water Demand. Pacific Institute.

https://pacinst.org/how-the-coronavirus-pandemic-is-affecting-water-demand/

Daily Sabah. (2020). Expert warns of potential drought in Turkey due to increased water use amid COVID-19 outbreak. https://www.dailysabah.com/turkey/expert-warns-of-potential-drought-in-turkey-due-to-increased-water-use-amid-covid-19-outbreak/news

Economic Intelligence Unit. (2019). Global Food Security Index 2019. London: EIU.

Evans, R. G., & Sadler, E. J. (2008). Methods and technologies to improve efficiency of water use. Water Resources Research, 44(7), 1–15. https://doi.org/10.1029/2007WR006200

FAO (1996). Rome Declaration on World Food Security. Rome: FAO.

FAO. (2011). The state of the world's land and water resource for food and agriculture: Managing systems at risk. Rome and London: FAO and Earthscan.

FAO. (2018). Progress on water-use efficiency: Global baselines for SDG indicator 6.4.1. Rome: FAO/UN-Water.

Fathurrahman, F. (2016). Measuring the sustainability of energy development in emerging economies. International Journal of Global Environmental Issues, 15(4), 315–345. https://doi.org/10.1504/IJGENVI.2016.081059

Flörke, M., Schneider, C., & McDonald, R. I. (2018). Water competition between cities and agriculture driven by climate change and urban growth. Nature Sustainability, 1(1), 51–58. https://doi.org/10.1038/s41893-017-0006-8

Freie Universitat. (n.d.). *Water Demand Management*. Retrieved August 21, 2020, from https://www.geo.fu-berlin.de/en/v/iwm-network/learning_content/watershed-resources/ressource_water/water_demand/index.html

Giordano, M., & Shah, T. (2014). From IWRM back to integrated water resources management. International Journal of Water Resources Development, 30(3), 364–376. https://doi.org/10.1080/07900627.2013.851521

Gleick, P. H. (2000). A look at twenty-first century water resources development. Water International, 25(1), 127–138. https://doi.org/10.1080/02508060008686804

Goosen, H., de Groot-Reichwein, M. A. M., Masselink, L., Koekoek, A., Swart, R., Bessembinder, J., Witte, J. M. P., Stuyt, L., Blom-Zandstra, G., & Immerzeel, W. (2014). Climate Adaptation Services for the Netherlands: An operational approach to support spatial adaptation planning. Regional Environmental Change, 14(3), 1035–1048. https://doi.org/10.1007/s10113-013-0513-8

GWP. (2000). Integrated water resources management. In TAC

Background Papers (4). https://doi.org/10.1201/9781315153292

GWP. (2011). Dublin-Rio Principles. Water, 46(January 1992), 3–6.

GWP. (2020). The Need for an Integrated Approach. https://www.gwp.org/en/About/why/the-need-for-an-integrated-approach/

Hamed, Y., Hadji, R., Redhaounia, B., Zighmi, K., Bâali, F., & El Gayar, A. (2018). Climate impact on surface and groundwater in North Africa: a global synthesis of findings and recommendations. Euro-Mediterranean Journal for Environmental Integration, 3(1), 25. https://doi.org/10.1007/s41207-018-0067-8

Hofste, R. W., Kuzma, S., Walker, S., Sutanudjaja, E. H., Bierkens, M. F. P., Kuijper, M. J. M., Sanchez, M. F., Beek, R. V. A. N., Wada, Y., Galvis, S., & Reig, P. (2019). Technical Note Aqueduct 3 . 0 : Updated Decision-Relevant Global Water Risk Indicators. World Resources Institute, July, 1–53.

IEA. (2016). World Energy Outlook 2016. In World Energy Outlook. https://doi.org/10.1111/j.1468-0319.1987.tb00425.x

IFC. (2020). The Impact of COVID-19 on the Water and Sanitation Sector.

Irish Aid. (2009). Water, sanitation, and hygiene promotion: Policy brief. Ireland: Irish Aid.

IEA. (2016). World Energy Outlook 2016. In World Energy Outlook. https://doi.org/10.1111/j.1468-0319.1987.tb00425.x

IEA. (2018). Energy has a role to play in achieving universal access to clean water and sanitation. https://www.iea.org/commentaries/energy-has-a-role-to-play-in-achieving-universal-access-to-clean-water-and-sanitation

IPCC. (2014a). Climate Change 2014 Part A: Global and Sectoral Aspects. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://doi.org/10.1017/CBO9781107415379

IPCC. (2014b). Climate change 2014 Part B: Regional Aspects. In Climate Change 2014: Impacts, Adaptation and Vulnerability: Part B: Regional Aspects: Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://doi.org/10.1017/CBO9781107415386

Jeffrey, P., & Gearey, M. (2006). Integrated water resources management: Lost on the road from ambition to realisation? Water Science and Technology, 53(1), 1–8. https://doi.org/10.2166/wst.2006.001

Lewis, J., & Severnini, E. (2020). Short- and long-run impacts of rural electrification: Evidence from the historical rollout of the U.S. power grid. Journal of Development Economics, 143, 102412. https://doi.org/10.1016/j.jdeveco.2019.102412

Mahmood, R., Jia, S., & Zhu, W. (2019). Analysis of climate variability, trends, and prediction in the most active parts of the Lake Chad basin, Africa. Scientific Reports, 9(1), 1–18. https://doi.org/10.1038/s41598-019-42811-9

Masgon, M. A. & Gensch, R. (2019). Water, sanitation, and gender. SSWM. Retrieved from https://sswm.info/arctic-wash/module-1-introduction/further-resources-sustainability-relation-water-sanitation/water%2C-sanitation-and-gender

Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. (2014). Estimated Use of Water in the United States in 2010: U.S. Geological Survey Circular 1405. In US Geological Survey. (Vol. 1405, Issue November). http://dx.doi.org/10.3133/cir1405

Meldrum, J., Nettles-Anderson, S., Heath, G., & Macknick, J. (2013). Life cycle water use for electricity generation: A review and harmonization of literature estimates. Environmental Research Letters, 8(1). https://doi.org/10.1088/1748-9326/8/1/015031

OECD & United Nations. (2014). Integrated Water Resources Management in Eastern Europe, the Caucasus and Central Asia. Printed at United Nations.

OIC. (2012). OIC Water Vision. Jeddah: OIC.

Overseas Development Institute. (2017). Water for food security: Lessons learned from a review of water-related interventions. London: ODI.

PBL Netherlands Environmental Assessment Agency. (2018). The Geography of Future Water Challenges.

Plappally, A. K., & Lienhard V, J. H. (2012). Energy requirements for water production, treatment, end use, reclamation, and disposal. Renewable and Sustainable Energy Reviews, 16(7), 4818–4848. https://doi.org/10.1016/j.rser.2012.05.022

Poljanšek, K., Marin-Ferrer, M., Vernaccini, L., & Messina, L. (2020). Incorporating epidemics risk in the INFORM Global Risk Index: INFORM COVID-19 Risk Index. Luxembourg: Publications Office of the European Union.

Rulli, M. C., Bellomi, D., Cazzoli, A., De Carolis, G., & D'Odorico, P. (2016). The water-land-food nexus of first-generation biofuels. Scientific Reports, 6(1), 1–10. https://doi.org/10.1038/srep22521

Schoeman, J., Allan, C., & Finlayson, C. M. (2014). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. International Journal of Water Resources Development, 30(3), 377–390.

https://doi.org/10.1080/07900627.2014.907087

SESRIC. (2018). OIC Water Report 2018: Transforming Risk into Dialog and Cooperation. Ankara: SESRIC.

SESRIC. (2019a). Urban Development in OIC Countries. Ankara: SESRIC.

SESRIC. (2019b). OIC Health Report 2019. Ankara: SESRIC.

SESRIC. (2020a). Agriculture and Food Security in OIC Member Countries 2020. Ankara: SESRIC.

SESRIC. (2020b). Socio-Economic Impacts of Covid-19 Pandemic in OIC Member Countries: Prospects and Challenges. Ankara: SESRIC.

SESRIC. (2020c). Population Growth Rate. Did You Know. https://www.sesric.org/DidYouKnow/doc/DYK_POPULATION GROWTH RATE_20200323.pdf

Shiklomanov, I. A. (1998). World Water Resources: New Appraisal and Assessment for the 21st Century. In International Hydrological Programme. https://doi.org/10.4324/9781849772402

SIDA. (2015). Women, water, sanitation, and hygiene. Gender Tool Box Brief. Available at https://www.sida.se/contentassets/1d733a7ede3c42ad802b452b70f7ef28/women-water-sanitation-and-hygiene.pdf

Sivakumar, B. (2020). COVID-19 and water. Stochastic Environmental Research and Risk Assessment, 6, 10–13. https://doi.org/10.1007/s00477-020-01837-6

Smith, J. B., & Lenhart, S. S. (1996). Climate change adaptation policy options. Climate Research, 6(2), 193–201. https://doi.org/10.3354/cr006193

Stern, N. (2007). The economics of climate change: The stern review. The Economics of Climate Change: The Stern Review, 9780521877, 1–692. https://doi.org/10.1017/CBO9780511817434

Spang, E. S., Moomaw, W. R., Gallagher, K. S., Kirshen, P. H., & Marks, D. H. (2014). The water consumption of energy production: An international comparison. Environmental Research Letters, 9(10). https://doi.org/10.1088/1748-9326/9/10/105002

Time Out Bahrain. (2020). Government of Bahrain to pay residents' electricity and water bills for three months. News. https://www.timeoutbahrain.com/news/436963-government-of-bahrain-to-pay-residents-electricity-and-water-bills-for-three-months

Twisa, S., & Buchroithner, M. F. (2019). Seasonal and Annual Rainfall Variability and Their Impact on Rural Water Supply Services in the Wami River Basin, Tanzania. Water, 11(10), 2055. https://doi.org/10.3390/w11102055

UfM. (2020). Analysing the impacts of COVID-19 on the provision of drinking water and sanitation. https://ufmsecretariat.org/analysing-impacts-covid-19-provision-drinking-water-sanitation/

UN. (2018). Sustainable Development Goal 6: Synthesis Report on Water and Sanitation. In Synthesis Report. https://doi.org/10.1126/science.278.5339.827

UNESCO. (2020). The United Nations World Water Development Report 2020: Water and Climate Change. Paris: UNESCO. Retrieved from https://www.unwater.org/publications/world-water-development-report-2020/

UN-ESCWA. (2020). The Impact of COVID-19 on the Water-Scarce Arab Region.

UNICEF. (2017). Gender-responsive water, sanitation and hygiene: Key elements for effective WASH programming. New York: UNICEF.

UNICEF. (2018). Gender and Water, Sanitation and Hygiene. Retrieved from https://data.unicef.org/topic/gender/water-sanitation-and-hygiene-wash/#:~:text=In%20a%20WHO%2FUNICEF%20JMP,as%20boys%20to%20fetch%20water.

UN-Water, & FAO. (2018). Progress on Level of Water Stress. http://www.unwater.org/app/uploads/2018/08/642-progress-on-level-of-water-stress-2018.pdf

UN-Water. (2013). Water Security & the Global Analytical Brief.

UN-Water. (2020a). UN Water Annual Report 2019. Geneva: UN Water.

UN-Water. (2020b). UN-Water Analytical Brief on Unconventional Water Resources (Issue June). https://doi.org/10.13140/RG.2.2.11403.31526

UNEP. (2012). UN-Water Status Report on The Application of Integrated Approaches to Water Resources Management. In United Nations Environment Programme.

UNEP. (2019). Global Environmental Outlook 6: Healthy Planet, Healthy People. Cambridge University Press. https://doi.org/10.1017/9781108627146

USAID. (2016). Adaptability of the Water Allocation System in the Amudarya River Basin to Changing Conditions. October, 1990–1993.

WHO and UNICEF. (2017a). Safely managed drinking water - Thematic report on drinking water. Geneva: WHO.

WHO and UNICEF. (2017b). Progress on drinking water, sanitation, and hygiene: 2017 update and SDG baselines. Geneva: WHO and UNICEF.

WHO and UNICEF. (2019a). Progress on household drinking water, sanitation, and hygiene 2000-2017: Special focus on inequalities. New York: UNICEF and WHO.

WHO and UNICEF. (2020). Joint Monitoring Program (JMP) for Water Supply, Sanitation and Hygiene Global Database. Retrieved from https://washdata.org/data/household#!/

WHO. (2019). Safer water, better health. Geneva: WHO.

Williams, B. K., Szaro, R. C., & Shapiro, C. D. (2009). Adaptive management: The U.S. Department of the Interior technical guide (2009 Editi). http://pubs.er.usgs.gov/publication/70194537

WRI. (2019). Aqueduct Global Maps 3.0 Data. https://www.wri.org/resources/data-sets/aqueduct-global-maps-30-data

WWAP. (2014). The United Nations World Water Development Report 2014: Water and Energy. https://doi.org/10.1111/jdi.12037

WWAP. (2017). The United Nations World Water Development Report 2017: Wastewater the Untapped Resources. http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

WWAP. (2019). The United Nations World Water Development Report 2019: Leaving No One Behind.

WWAP. (2018). The United Nations World Water Development Report 2018: Nature-Based Solutions for Water. UNESCO.

ANNEXES

ANNEX I Country Classifications

OIC Member Countries (57):

AFG	Afghanistan	GAB	Gabon	MDV	Maldives	SDN	Sudan
ALB	Albania	GMB	Gambia	MLI	Mali	SUR	Suriname
DZA	Algeria	GIN	Guinea	MRT	Mauritania	SYR	Syria*
AZE	Azerbaijan	GNB	Guinea-Bissau	MAR	Morocco	TJK	Tajikistan
BHR	Bahrain	GUY	Guyana	MOZ	Mozambique	TGO	Togo
BGD	Bangladesh	IDN	Indonesia	NER	Niger	TUN	Tunisia
BEN	Benin	IRN	Iran	NGA	Nigeria	TUR	Turkey
BRN	Brunei Darussalam	IRQ	Iraq	OMN	Oman	TKM	Turkmenistan
BFA	Burkina Faso	JOR	Jordan	PAK	Pakistan	UGA	Uganda
CMR	Cameroon	KAZ	Kazakhstan	PSE	Palestine	ARE	United Arab Emirates
TCD	Chad	KWT	Kuwait	QAT	Qatar	UZB	Uzbekistan
COM	Comoros	KGZ	Kyrgyzstan	SAU	Saudi Arabia	YEM	Yemen
CIV	Cote d'Ivoire	LBN	Lebanon	SEN	Senegal		
DJI	Djibouti	LBY	Libya	SLE	Sierra Leone		
EGY	Egypt	MYS	Malaysia	SOM	Somalia		

* Syria is currently suspended from OIC membership.
Note: Country codes are based on ISO 3166-1 alpha-3 codes.

Non-OIC Developing Countries (98):

Angola	Dominica	Madagascar	São Tomé and Príncipe
Antigua and Barbuda	Dominican Republic	Malawi	Serbia
Argentina	Ecuador	Marshall Islands	Seychelles
Armenia	El Salvador	Mauritius	Solomon Islands
The Bahamas	Equatorial Guinea	Mexico	South Africa
Barbados	Eritrea	Micronesia	South Sudan
Belarus	Ethiopia	Moldova	Sri Lanka
Belize	Fiji	Mongolia	St. Kitts and Nevis
Bhutan	Georgia	Montenegro	St. Lucia
Bolivia	Ghana	Myanmar	St. Vincent and the Grenadines
Bosnia and Herzegovina	Grenada	Namibia	Swaziland
Botswana	Guatemala	Nauru	Tanzania
Brazil	Haiti	Nepal	Thailand
Bulgaria	Honduras	Nicaragua	Timor-Leste
Burundi	Hungary	Palau	Tonga
Cabo Verde	India	Papua New Guinea	Trinidad and Tobago
Cambodia	Jamaica	Paraguay	Tuvalu
Central African Republic	Kenya	Peru	Ukraine
Chile	Kiribati	Philippines	Uruguay
China	Kosovo	Poland	Vanuatu
Colombia	Lao P.D.R.	Romania	Venezuela
Democratic Republic of the Congo	Lesotho	Russia	Vietnam

Republic of Congo	Liberia	Rwanda	Zambia
Costa Rica	North Macedonia	Samoa	Zimbabwe
Croatia	Panama		

Developed Countries (39):**

Australia	Germany	Lithuania	Singapore
Austria	Greece	Luxembourg	Slovak Republic
Belgium	Hong Kong	Macao SAR	Slovenia
Canada	Iceland	Malta	Spain
Cyprus	Ireland	Netherlands	Sweden
Czech Republic	Israel	New Zealand	Switzerland
Denmark	Italy	Norway	Taiwan
Estonia	Japan	Portugal	United Kingdom
Finland	Korea, Rep.	Puerto Rico	United States
France	Latvia	San Marino	

** Based on the list of advanced countries classified by the IMF.

Geographical Classification of OIC Member Countries

Sub-Saharan Africa (21): OIC-SSA

Benin	Gambia	Nigeria
Burkina Faso	Guinea	Senegal
Cameroon	Guinea-Bissau	Sierra Leone
Chad	Mali	Somalia
Comoros	Mauritania	Sudan
Côte d'Ivoire	Mozambique	Togo
Gabon	Niger	Uganda

Middle East and North Africa (19): OIC-MENA

Algeria	Kuwait	Saudi Arabia
Bahrain	Lebanon	Syria*
Djibouti	Libya	Tunisia
Egypt	Morocco	United Arab Emirates
Iraq	Oman	Yemen
Iran	Palestine	
Jordan	Qatar	

*Syria is currently suspended from its OIC membership.

East and South Asia and Latin America (9): OIC-ESALA

Afghanistan	Guyana	Maldives
Bangladesh	Indonesia	Pakistan
Brunei Darussalam	Malaysia	Suriname

Europe and Central Asia (8): OIC-ECA

Albania	Kyrgyzstan	Turkmenistan
Azerbaijan	Tajikistan	Uzbekistan
Kazakhstan	Turkey	

ANNEX II Major Rivers in OIC Countries

River Name	Length (km)	Catchment area (km2)	Average discharge (m3/s)	Outflow	OIC countries in the drainage basin
Amazon	6,575	7,050,000	209,000	Atlantic Ocean	Guyana
Congo	4,700	3,680,000	41,800	Atlantic Ocean	Cameroon
Nile	6,650	3,254,555	2,800	Mediterranean	Sudan, Uganda, Egypt
Ob	5,410	2,990,000	12,475	Gulf of Ob	Kazakhstan
Niger	4,200	2,090,000	5,589	Gulf of Guinea	Nigeria, Mali, Niger, Algeria, Guinea, Cameroon, Burkina Faso, Côte d'Ivoire, Benin, Chad
Orinoco	2,101	1,380,000	33,000	Atlantic Ocean	Guyana
Zambezi	2,693	1,330,000	4,880	Mozambique Channel	Mozambique
Indus	3,610	960,000	7,160	Arabian Sea	Pakistan
Ganges	2,620	907,000	12,037	Bay of Bengal	Bangladesh
Euphrates	3,596	884,000	856	Persian Gulf	Iraq, Turkey, Syria
Brahmaputra	3,848	712,035	19,800	Ganges	Bangladesh
Amu Darya	2,620	534,739	1,400	Aral Sea	Uzbekistan, Turkmenistan, Tajikistan, Afghanistan
Senegal	1,641	419,659	650	Atlantic Ocean	Guinea, Senegal, Mali, Maur itania
Limpopo	1,800	413,000	170	Indian Ocean	Mozambique
Blue Nile	1,600	326,400	2,349	Nile	Sudan
Ural	2,428	237,000	475	Caspian Sea	Kazakhstan
Ogooué	1,200	223,856	4,706	Atlantic Ocean	Gabon
Syr Darya	3,078	219,000	703	Aral Sea	Kazakhstan, Kyrgyzstan, Uz bekistan, Tajikistan
Kura	1,515	188,400	575	Caspian Sea	Turkey, Azerbaijan
Ishim	2,450	177,000	56	Irtysh	Kazakhstan
Kızılırmak	1,182	115,000	400	Black Sea	Turkey
Aras	1,072	102,000	285	Kura	Turkey, Azerbaijan, Iran

ANNEX III Water-related Climate Risks and Vulnerabilities

Hazard	Key Vulnerabilities	Key Risks	Emergent Risks
Sea level rise, coastal flooding including storm surges	High exposure of people, economic activity, and infrastructure in low-lying coastal zones, Small Island Developing States (SIDS), and other small islands	Death, injury, and disruption to livelihoods, food supplies, and drinking water	Interaction of rapid urbanization, sea level rise, increasing economic activity, disappearance of natural resources, and limits of insurance; burden of risk management shifted from the state to those at risk, leading to greater inequality
	Urban population unprotected due to substandard housing and inadequate insurance. Marginalized rural population with multidimensional poverty and limited alternative livelihoods	Loss of common-pool resources, sense of place and identity, especially among indigenous populations in rural coastal zones	
	Insufficient local governmental attention to disaster risk reduction		
Extreme precipitation and inland flooding	Large numbers of people exposed in urban areas to flood events, particularly in low-income informal settlements	Death, injury, and disruption of human security, especially among children, elderly, and disabled persons	Interaction of increasing frequency of intense precipitation, urbanization, and limits of insurance; burden of risk management shifted from the state to those at risk, leading to greater inequality, eroded assets due to infrastructure damage, abandonment of urban districts, and the creation of high-risk / high-poverty spatial traps
	Overwhelmed, aging, poorly maintained, and inadequate urban drainage infrastructure and limited ability to cope and adapt due to marginalization, high poverty, and culturally imposed gender roles		
	inadequate governmental attention to disaster risk reduction		
Novel hazards yielding systemic risks	Populations and infrastructure exposed and lacking historical experience with these hazards	Failure of systems coupled to electric power system, e.g., drainage systems reliant on electric pumps or emergency services reliant on telecommunications. Collapse of health and emergency services in extreme events	Interactions due to dependence on coupled systems lead to magnification of impacts of extreme events. Reduced social cohesion due to loss of faith in management institutions undermines preparation and capacity for response.
	Overly hazard-specific management planning and infrastructure design, and/or low forecasting capability		

Warming, drought, and precipitation variability	Poorer populations in urban and rural settings are susceptible to resulting food insecurity; includes particularly farmers who are net food buyers and people in low-income, agriculturally dependent economies that are net food importers. Limited ability to cope among the elderly and female-headed households	Risk of harm and loss of life due to reversal of progress in reducing malnutrition	Interactions of climate changes, population growth, reduced productivity, biofuel crop cultivation, and food prices with persistent inequality and ongoing food insecurity for the poor increase malnutrition, giving rise to larger burden of disease. Exhaustion of social networks reduces coping capacity.
Drought	Urban populations with inadequate water services. Existing water shortages (and irregular supplies), and constraints on increasing supplies	Insufficient water supply for people and industry, yielding severe harm and economic impacts	Interaction of urbanization, infrastructure insufficiency, groundwater depletion
	Lack of capacity and resilience in water management regimes including rural–urban linkages		
	Poorly endowed farmers in drylands or pastoralists with insufficient access to drinking and irrigation water	Loss of agricultural productivity and/or income of rural people. Destruction of livelihoods, particularly for those depending on water-intensive agriculture. Risk of food insecurity	Interactions across human vulnerabilities: deteriorating livelihoods, poverty traps, heightened food insecurity, decreased land productivity, rural outmigration, and increase in new urban poor in low- and middle-income countries. Potential tipping point in rain-fed farming system and/or pastoralism
	Limited ability to compensate for losses in water dependent farming and pastoral systems, and conflict over natural resources		
	Lack of capacity and resilience in water management regimes, inappropriate land policy, and misperception and undermining of pastoral livelihoods		
Rising land temperatures, changes in precipitation patterns, and frequency and intensity of extreme heat	Susceptibility of societies to loss of provisioning, regulation, and cultural services from terrestrial ecosystems	Reduction of biodiversity and potential losses of important ecosystem services. Risk of loss of endemic species, mixing of ecosystem types, and increased dominance of invasive organisms	Interaction of social-ecological systems with loss of ecosystem services upon which they depend
	Susceptibility of human systems, agro-ecosystems, and natural ecosystems to (1) loss of regulation of pests and diseases, fire, landslide, erosion, flooding, avalanche, water quality, and local climate; (2) loss of provision of food, livestock, fiber, bioenergy; (3) loss of recreation, tourism, aesthetic and heritage values, and biodiversity		

Source: Adapted from IPCC (2014a)

ANNEX IV OIC Energy Balance Table (in Mtoe), 2018

	Coal	Crude oil	Oil products	Gas	Nuclear	Hydro	Wind,solar,geothermal,etc.	Biofuels and waste	Elec. & Heat	Total
Production	369	2013	0	1075	5	24	39	281	0	3806
Imports	75	100	271	105	0	0	0	0	6	557
Exports	-257	-1343	-318	-366	0	0	0	-2	-4	-2290
bunker + stock change	1	9	-56	1	0	0	0	0	0	-46
TPEC	**188**	**779**	**-103**	**816**	**5**	**24**	**39**	**279**	**2**	**2028**
Transfers	0	-111	121	0	0	0	0	0	0	10
Stat. Diff.	-4	10	8	-4	0	0	0	0	-2	9
Elec. + Heat	-121	-28	-71	-355	-5	-24	-35	-8	262	-385
Transformation	-4	-640	624	-10	0	0	0	-41	0	-73
Own use + Losses	-2	-7	-22	-86	0	0	0	0	-46	-163
Final Cons.	**56**	**3**	**556**	**361**	**0**	**0**	**3**	**231**	**216**	**1426**
Industry	45	1	68	168	0	0	0	19	68	370
Transport	0	0	353	16	0	0	0	4	1	374
Residential	7	0	40	87	0	0	2	199	77	411
Services	3	0	5	27	0	0	0	9	52	96
Agriculture	0	0	13	2	0	0	1	0	11	27
Other	1	2	78	60	0	0	0	0	8	148

Source: SESRIC staff calculations based on IEA Energy Balance Database.

ANNEX V Water Use Factors by Energy Production and Fuel Type (in m^3/toe)

Type	Fuel	Consumption			Withdrawal			Source
		Estimate	Min	Max	Estimate	Min	Max	
Fuel Production	**Coal**[a]	1.72	0.26	10.13	1.74	0.26	10.13	[1]
	Conventional Oil[b]	3.39	1.51	5.86	3.39	1.51	5.86	[2]
	Oil refining[b]	1.67	1.09	2.01	1.67	1.09	2.01	[2]
	Conventional Gas	0.18	0.04	1.14	0.22	0.18	1.50	[1]
	Nuclear[c]	3.15	0.57	14.53	4.31	0.57	18.05	[1]
	Biofuel[d]	516.08	1.30	15,570.99	516.08	1.30	155,70.99	[2]
Electricity	**Coal**[c]	20.22	0.18	57.23	399.12	7.04	2,509.39	[1]
	Nuclear[c]	25.39	4.40	39.18	722.00	22.01	2,641.46	[1]
	Gas/oil/biomass[c]	11.12	0.18	48.43	262.50	6.60	1,628.90	[1]
	Geothermal[c]	13.99	0.22	31.70	14.07	0.48	31.70	[1]
	Solar[c]	2.71	0.26	12.68	3.26	0.09	73.87	[1]
	Wind	0.00	0.00	0.04	0.00	0.00	0.04	[2]

[1] Meldrum et al., (2013) [2] Spang et al. (2014)
[a] *Average estimates from all technologies. Min and max are min and max value from all technologies*
[b] *Assume withdrawal equal to consumption*
[c] *Average estimates from all technologies. Min and max are min and max value from all technologies*
[d] *Averaged Sum of processing and cultivation from all biofuels. Min max are min max value from all biofuels. Withdrawal and consumption assumed to be the same*

ANNEX VI Energy Intensity of Various Water Process, in kWh/m^3

Water Process	Energy Intensity*		
	Min	Max	Estimates
Surface Water Supply and Conveyance	0.0002	2.4	0.37
Ground Water Pumping	0.14	1.44	0.48
Water Treatment	0.027	4.67	0.1
Water Distribution	0.1	0.32	0.22
Waste Water Treatment	0.1	1.2	0.395
Desalination	2.4	8.5	4.95
Water Reuse and Recycling	0.11	0.85	0.32

*The values presented on the table are based on the average value of each water process from various studies that are compiled in Plappally & Lienhard V (2012).