



# PREPPING FOR COP27

*Egypt is a microcosm for the impacts of climate change being felt across the MENA region, with water loss at the very top. It should likewise be high on the agenda when Cairo hosts this year's UN climate summit*

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**T**he Middle East and North Africa (MENA) is the most water-scarce region in the world and is expected to be the most sensitive to ongoing climate change. This is especially true for Egypt, considered a global climate change hotspot that is on track to warm by as much as 4-8°C by 2100 (although predictions vary). This will be felt especially in the Western Desert, Upper Egypt, and the Red Sea coast. North Africa, including Egypt, is being squeezed from both north and south by encroaching salt water and desert, respectively, and freshwater loss. Additional freshwater loss driven by overuse and exacerbated by an unpredictable climate demands serious attention.

As the keystone of the Water-Energy-Food (WEF) Nexus, water management must be the focus of mitigation and adaptation strategies adopted by MENA societies to ensure their survival and a sustainable future. We focus here specifically on the impact of climate change on water, and its domestic and agricultural use, within the context of changing human demographics and the urban-rural disconnect that is rapidly developing in MENA. The WEF Nexus model is offered as a tool for policymakers to address the complex systems of human-environment relations more easily. Special emphasis has been placed on issues that require immediate attention, with a spotlight on Egypt. It is hoped that this information can serve as a partial roadmap for the COP27 meeting set to be held here in November 2022.

## **Shrinking Living Space**

Ninety percent of the population of North Africa is concentrated in less than 10 percent of the land area, crowding around Mediterranean coastal areas and both the valley and delta of the Nile River. In addition to the impacts of temperature and precipitation change, this occupied zone is being squeezed from north and south by two advancing fronts. From the north, progressive sea

◀ *The urban landscape around the Nile River in Cairo, March 10, 2020. Mohamed Abd El Ghany/Reuters*



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level rise along the Mediterranean coast is expected to promote shoreline retreat of 0.48-0.85 meters per year and major subsidence (the gradual sinking) of the Nile Delta by 2100. Natural dunes along part of the shoreline are likely to buffer the impacts of sea level rise, but engineered structures designed to protect coastal beaches and human occupancy are costly, hard to maintain, and unlikely to keep pace.

Although portions of the Nile Delta are under imminent flooding threat from sea level rise, most of the area is also in danger of sinking and erosion. Saltwater intrusion is reducing freshwater reserves of coastal dune and delta aquifers, but its rate and intensity are being pushed along by over-pumping of groundwater and the expansion of agriculture into lands of marginal suitability. There is an urgent need for mitigation and adaptive management plans to meet the challenge of sea level rise. These plans should emphasize nature-based solutions that can be rapidly implemented.

Expansion of the Sahara Desert from the south also poses a major threat to the sustainability of North African populations and agriculture. The Sahara has expanded southward significantly (8-10 percent) since the mid-19<sup>th</sup> century. Most emphasis has been placed on the 100-km movement southward of the desert boundary, while movement of the northern boundary has received less attention. Rather than an advancing front, northern expansion occurs throughout the southern occupied region and is associated with loss of natural vegetation and unsustainable agriculture practices, including over-extraction of groundwater from aquifers without active recharge.

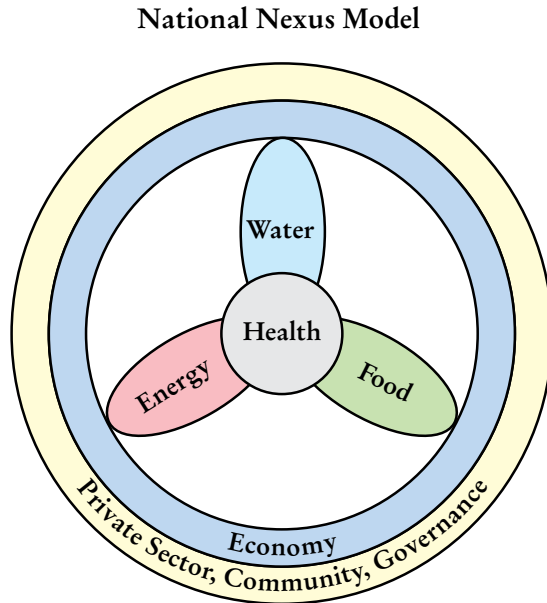
With these forces pushing in from north and south, preserving water resources in the region is obviously critical to the survival of communities here. Moreover, it is the key to the maintenance of the entire WEF Nexus.

### **The Value of a WEF Nexus Approach**

The WEF Nexus is a robust approach for quantifying the three main sustainability controls of water, energy, and food. Human society is interlinked with the Nexus, which responds to external forces of climate change, disasters, and human demographics as well as being an important tool to develop and implement sustainability policy. Recognizing the importance of human interactions, water specialists and ecologists Raul Muñoz Castillo and Thomas Crisman envisioned the Nexus as three spokes of a wheel (water, energy, and food) with health as the hub and economics as the rim. Subsequent work in Puerto Rico and ten Small Island Developing States (SIDS) found that natural resources and human communities are extremely resilient in the face of disasters

and long-term change, while infrastructure and governance sectors are woefully inadequate to adjust rapidly to change. The current WEF Nexus concept incorporates the private sector, governance, and economics as the ultimate controlling factors for sustainability.

Water is the critical factor controlling both agriculture and energy as well as all linkages within the WEF Nexus. With the exception of Egypt, the MENA region overall has relatively low dependence on freshwater for power generation, but relies heavily on energy to extract groundwater and desalinate seawater. Current and projected deficiencies in both water and food in the MENA region and their compounded interactions pose a vexing problem: how will the region increase agricultural sustainability without deteriorating the environment and water reserves?



In the face of decreasing water availability, mitigation and adaptation to short- and long-term conditions are the only means by which MENA countries can hope to meet the seventeen Sustainable Development Goals of the United Nations. Failure in any component of the WEF Nexus will affect human health and security.

### Chasing Water

Predicting rainfall in the MENA region is even more difficult than predicting temperature (and models vary), but climate change will certainly have an impact. Although significant reductions are predicted for most of the region, precipitation north of the 25 degree latitude is expected to decline significantly by 2050, while areas to the south should experience significantly higher values associated with monsoon seasons. Models for coastal areas, however, show the greatest disparity. Some studies forecast significantly reduced precipitation for Mediterranean coastal areas by 2050, while others suggest significantly elevated values.

Evapotranspiration—the evaporation of water from surfaces and plant leaves—will increase with higher temperatures, leading to lower water availability overall.

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Most MENA countries lack surface freshwater and have traditionally relied on rainfall and groundwater to meet their needs. MENA governments have allocated most funding to large-scale water projects (desalination, dams, inter-basin transfer, extraction of fossil groundwater, importing virtual water) with little attention to water conservation and adaptation to changing conditions. Freshwater springs, the only surface water in Saudi Arabia, have declined from forty-six to fifteen in the past thirty years, largely associated with the over-extraction of fossil groundwater for irrigation (predominantly of wheat). As is happening rapidly in coastal MENA countries, Saudi Arabia is abandoning diminishing groundwater resources in favor of more energy intensive desalination.

Overall, the region lost 66 percent of its water reserves between 1960 and 2009 and is projected to lose an additional 50 percent by 2050—a trend attributed more to changing human demands than supply. The inverse relationship between population and water resources in Egypt has resulted in a progressive decline in per capita water availability. By itself this would eventually lead to total water insecurity, but the timing accelerates greatly when climate change and human use factors are considered.

### *Urban-Rural Disconnect*

People are concentrating in urban areas as agricultural output becomes more unpredictable, and this has disrupted supply chains of food to urban areas. This urban-rural disconnect is further exacerbated by a loss of farmland to urban sprawl and an overall decreased availability of water for domestic use from groundwater sources, (70 percent of which are disproportionately allocated for irrigation, leaving 20 percent for industry and only 10 percent for urban populations). Aging urban infrastructure is unable to meet the demand for services, often leading to social insecurity and associated political upheaval. As these problems evolve, policies to address them must stress nature-based solutions over artificially engineered structures, which have tended to fail.

### *Nature-Based Solutions for Water Treatment and Wastewater Management*

Green infrastructure—especially constructed wetlands—is a cost effective, quick to implement, and efficient alternative to engineered options for treating both drinking water and wastewater globally. Egypt has constructed wetlands for waste treatment with sites serving as public parks and treated water used for agriculture. Mechanisms for disseminating this experience broadly throughout

the region are critically needed to meet demands from rapidly expanding urban populations.

### *Water Reuse*

The time of assuming that water is a free commodity is over. The distance between rural water sources and urban consumers is widening to a point that urban areas must be considered a separate biome that recycles its own resources to maximize multiple sector services. Egypt is spearheading the separation of gray water (bathing, laundry, kitchen uses) from black water (toilets) at residential units and using the former for vertical and rooftop gardens, public parks, and urban agriculture. This should be expanded.

### *Human Health and Water Borne Diseases*

The hub of the WEF Nexus is health, and the increased incidence of Neglected Tropical Diseases or NTDs has been linked to climate change in the MENA region. Schistosomiasis and Dengue are of particular concern given their water associated vectors. Humans will be forced to rely on water sources of poor-quality during times of drought and climate change, thus exposing them to these diseases. The situation is especially dire in Egypt and Yemen as water sources are reduced to small, often contaminated pools.

### *New MENA Cities*

The development of new cities is in vogue throughout the region. Rawabi, Palestine has progressed slowly, in part due to limited access to freshwater. The Al-Madina Al-Zarqa project in Oman ended before completion, but China is building Duqm for that country as an industrial city. The greatest attention, however, is on the New Administrative Capital (NAC) in Egypt and on Neom, Saudi Arabia. As with the projects in Palestine and Oman, whether these cities will develop into urban biomes with a sustainable WEF Nexus is not clear. The NAC is located in the desert east of Cairo, which lengthens its distance to water, energy, and food. Much of the infrastructure is based on advanced engineering, but use of treated wastewater to create a green river through the city is touted as green infrastructure. This feature will lose water to the atmosphere that could be used for urban agriculture and nature-based solutions to climate change. Neom is also being built in the desert but is striving for net zero energy via rooftop solar units and solar-powered desalination plants. More data on the WEF Nexus is critically needed for a proper assessment of the sustainability of these new cities.

### *Transboundary Issues and Dams*

Rivers in the Middle East are rare, and most cross international borders. The

oldest hydropower dams are located far from urban populations (Mosul, Aswan) and become relatively shallow and inefficient over time due to reservoir infilling. The recently completed Grand Ethiopian Renaissance Dam in the Ethiopian highlands is deep with a large volume of water retained, which leads to concerns about flow impacts downstream in Sudan and especially Egypt. In addition, the efficiency of its power transmission to population centers in Egypt should this happen in the future is likely reduced by distance and issues with infrastructure maintenance. Elsewhere in MENA, Turkey controls both water and electric energy resources for Syria and Iraq, Israel and Jordan are negotiating trading energy for water, while both resources in Palestine are totally controlled by Israel. These are each areas that are likely to grow more contentious as resources dwindle, and must be addressed.

As a dependent of water, and a determinant of the region's food security, agriculture faces a number of its own challenges which should also be addressed at this year's UN climate summit.

### **Rescuing Agriculture**

Agriculture is the largest employer in many MENA nations, but its dependency on rainfall (70 percent) accentuates its fragility in the face of climate change. Historically, Yemen was the breadbasket of the region due to its highly efficient rainwater capture through elaborate terraced agriculture. Sadly, a shift to inefficient irrigation using groundwater in the latter half of the 20<sup>th</sup> century resulted in Yemen becoming a major food importer rather than exporter. Also dependent on groundwater irrigation in the last twenty years, Saudi Arabia has gone from the sixth largest wheat exporter globally to an importer to support its needs, as irreplaceable aquifers became totally depleted. A similar situation is apparent in Jordan. Wheat production is threatened throughout the Middle East because of depleted water reserves. Accelerating water and food gaps exacerbate each other in vicious cycles with economic, social, and political ramifications. Moving forward, these will be the critical issues to consider:

#### *Loss of Farmland*

In addition to desertification—as well as sea level loss and subsidence of the Nile Delta in the case of Egypt—urban sprawl has reduced farmland significantly in both Egypt and Jordan. To meet local food demands, agriculture is expanding into marginally productive lands with poor soils and undependable water resources.

#### *Saline Agriculture*

Decreasing water availability and increasing salinity has made wheat unsuitable for most of the MENA. It is time to adapt agriculture to current and projected changes in water resources by introducing new crops and growing techniques.

Egypt has successfully introduced quinoa as a commercial crop for high salinity soils in the Nile Delta, and the UAE is investigating four forage grass cultivars that can be irrigated with saline water. Salicornia, a halophyte growing in coastal wetlands, also shows great promise as an export and bioenergy crop.

### *Water Conservation and Community Economic Development*

The High Atlas Foundation of Morocco (High Atlas Foundation | For sustainable prosperity in Morocco) has an extremely successful program of planting trees throughout the kingdom to promote water conservation, carbon sequestration, and community empowerment through project ownership and economic development. Geoengineering of the Sahara and Sahel can have significant positive effects on regional climate by strengthening the vegetation component in the land-atmosphere feedback. There is a critical need to support community-based programs similar to HAF throughout MENA. The key to a sustainable WEF Nexus is at the community level.

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### **Fostering Nexus Resilience**

As studies in the Caribbean have demonstrated, even with relatively abundant water resources, failures in infrastructure, governance, and the private sector can prevent otherwise resilient communities from reaching WEF Nexus sustainability. The basis of policies that take a WEF Nexus approach must be data rich, multi-disciplinary, and recognize that one model does not fit all nations. Most importantly, there must be close linkages among science, policy, and all stakeholders (community and private sector) to develop and implement policy. According to Mohamed ElFetyany of the National Water Research Center in Egypt, not linking Egyptian policy decisions to trade priorities and water security is hindering water management and suggested that water footprints be considered as a means to bridge this gap.

Finally, Nexus resilience—the ability of the environment to adjust to human use, climate change, and disasters—will depend upon: improving resilience in WEF across scales, sectors, and disciplines; developing tools and indicators to measure that resilience; bridging the implementation gap associated with governance complexity; and integrating resilience and Nexus thinking into policy. Following this approach should support adaptive management and be the key to Nexus sustainability. 