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WATER CHALLENGES AND COOPERATIVE RESPONSE IN THE MIDDLE EAST AND NORTH AFRICA

WORKING GROUP DISCUSSION PAPER

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This draft is intended to serve as a discussion paper for the Water Challenges working group at the 2012 U.S.-Islamic World Forum. The final paper will be completed shortly after the Forum, and will include a summary of the working group's discussions and a set of policy recommendations. Please visit http://www.brookings.edu/about/projects/islamic-world/us-islamic-world-forums for draft and final versions of all four 2012 Forum papers.

DRAFT

Water Security in the Middle East and North Africa

CONVENERS

Syed Iqbal Hasnain, David Michel, and Amit Pandya

Convened with support from the Stimson Center, this interdisciplinary working group will comprise experts in water science, policy, and related disciplines. The group will seek to improve understanding of water issues in the Middle East and North Africa, build stronger cooperative relationships, and identify intellectual and technical resources (such as data, modeling and remote sensing tools, best practices, policy approaches, and institutional insights) that could be adapted, applied, or shared across the region.

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Water Challenges and Cooperative Response in the Middle East and North Africa

Introduction

Societies across the Middle East and North Africa (MENA)—stretching eastward from Morocco across northern Africa to the Persian Gulf, and from Turkey in the north to Yemen and Oman in the south—have long balanced the competing water demands of households, industry, and agriculture. Careful management of water resources has been an absolute necessity, particularly in the Arab world, where annual renewable water supplies average about 219 billion cubic meters (BCM), compared to Africa's 4,180 BCM, Asia's 10,485 BCM, and the world total of 40,670 BCM.

Recent developments that have posed substantial stress on societies and challenged policymakers, scientists, engineers, and planners alike include population growth, migration, industrialization, urbanization, pollution, and climate and other environmental change. Today, rapid depletion of water resources, deterioration in water quality, increased water demand, and changes in water endowments affect environmental quality, food security, municipal infrastructure, and economic development in most societies of the MENA region. These stresses pose serious challenges to social order and political stability. It is no exaggeration to say that water policy and water security are as central a determinant of the future well-being of the region as is governance or ideology.

The region has 6 percent of the world's population, but hosts less than 2 percent of the world's renewable water supply. Yet some parts of the region (namely the more prosperous members of the Gulf Cooperation Council) have some of the highest *per capita* water consumption rates in the world. How quickly and in what manner nonrenewable resources are drawn down—and the manner in which renewable resources are used—are critical policy issues within and between countries. Changes in the types and pace of water usage also have significant impacts on local water endowments.

Within societies, issues of water scarcity and water use affect agriculture (crop choice, growing seasons, and pests), fisheries, forestry (corporate and artisanal), and livestock (pastures and pests). These factors have a significant effect on livelihoods and food security. Meanwhile, water infrastructure affects industrial processes and municipal water quality and sanitation. Industrial processes are critical to livelihoods and the longer-term economic development strategies of states and elites, while water quality and sanitation are of critical importance to public health. All these elements are crucial to maintaining social and political stability. To date, various mitigation or management

strategies have been adopted by societies in the region. Some supply-side strategies—such as desalinization and dam construction—have side-effects that pose additional environmental, economic, and social stresses. Other strategies, such as integrated water resource management (IWRM), have been lauded as models of prudent stewardship.

The MENA region's water resources include rivers, wetlands, and aquifers. The uses of transboundary rivers and aquifers between countries can lead to competition, conflict, or cooperation. These dynamics affect not only relationships among Arab countries, but also between these countries and non-Arab states. Sixty-seven percent of the Arab world's population depends on water supplies originating in non-Arab states. For instance, 84 BCM of the Nile's annual renewable water supply originates in eastern Africa, and 28 BCM of the Euphrates's supply and 38 BCM of the Tigris's supply originate in Turkey.[1] A partial listing of such shared water resources—among them the Nubian Sandstone Aquifer beneath Egypt, Libya, Chad, and Sudan; the Nile basin; the Jordan basin; and the Tigris-Euphrates basin—suffices to convey the challenge and the opportunity embodied by transboundary waters.

Today, factors such as rapid urban and population growth, increased water withdrawals for irrigation, and the proliferation of energy-intensive lifestyles are placing an unprecedented strain on the MENA region's limited water resources. Already, a few countries are facing serious water stress and none more so than Yemen, where the country's twenty-four million people are sitting on top of land that has essentially gone dry both above and below the surface. Complicating the picture in little-understood yet potentially profound ways are the impacts of climate change. According to a 2007 assessment from the Intergovernmental Panel on Climate Change (IPCC), much of the MENA region will likely face hotter and drier weather over the coming decades. Many global climate models also project a grim outlook for most of the MENA region, in terms of major precipitation reductions, increases in evaporation, and subsequent reductions in both runoff and soil moisture.

Further, projections reveal stark differences in how changing climates will affect the region. For instance, runoff levels in northern Africa and the eastern Mediterranean are projected to drop by nearly 50 percent, encompassing an area that includes the headwater regions of the Euphrates and Tigris river systems. Meanwhile, eastern Africa and the southern Arabian Peninsula are projected to experience heightened runoff levels up to 50 percent greater than current levels. The area affected by this change includes the headwaters of the Nile basin. Put another way, if such models hold, climate change will

[1] Musa N. Nimah, "Water Resources," in *Arab Environment Future Challenges*, Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2008), p.66

reduce water availability in the northern and western parts of the MENA region, while increasing availability in Egypt and the southern fringe of the MENA. The effects of climate change will push countries into uncharted territory, as far as water usage and water sharing are concerned. It will therefore be critical to manage that transition with as few bumps as possible to ensure that water does not aggravate other elements of the region's delicate political balance.

Countries and territories in the MENA region can be largely divided into two groups: (1) those that have low levels of renewable water resources, such as flowing rivers, and must rely on groundwater and desalination for most of their supply, and (2) those that get much of their water from river systems they share with other countries. The former group includes, among others, the Gaza Strip, Kuwait, Oman, Saudi Arabia, Qatar, the United Arab Emirates (UAE), and Yemen, while the latter group consists of Egypt, Iraq, Jordan, Lebanon, the West Bank, and Syria.

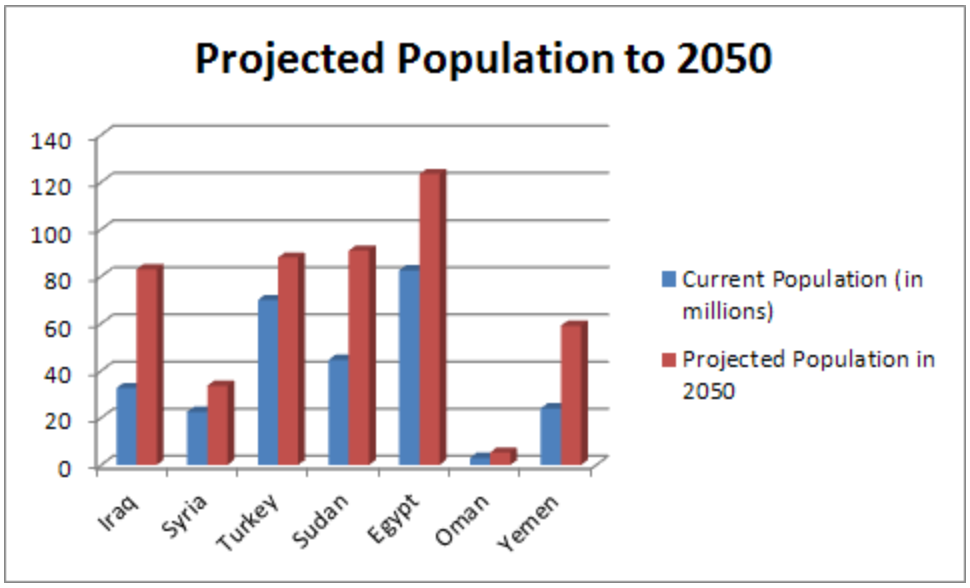
Key Trends

Demographically, the MENA region is enveloped in a period of fairly sweeping changes, all of which will have major implications for water governance. The highly contentious Tigris-Euphrates basin, shared by upper riparian Turkey and downstream states Syria and Iraq, is one example. By 2050, Iraq's population—and projected water needs—will soar, as the country grows to 2.6 times its current size, its population increasing from 32.6 million to more than 83 million. Syria, which also depends on the Euphrates as an important economic lifeline, will see its population by mid-century grow to 1.5 times its current size, from 22.5 million to 33.6 million.[2] Combined, this population growth in Syria and Iraq will increase water demand for irrigation, industrial development, and domestic usage, placing pressure on Turkey to ensure an ample flow of water downstream throughout the year. As the effects of climate change lengthen droughts and alter the timing of snowmelt and precipitation, tensions could easily flare throughout the basin, as they have in the past. For instance, abnormally low precipitation levels in the basin's Turkish headwaters might cause Ankara to withhold water behind Turkish dams to generate hydroelectricity, to the detriment of downstream water users that rely on the same water to grow food and drive economic activity.

Even MENA river basins that have fared fairly well in terms of cross-border cooperation in stewarding shared waters are not immune to the effects of demographic change. The Nile basin, for instance, where water management has been guided largely effectively by the Nile Basin Initiative (NBI), will need to support a far larger population

[2] Population Reference Bureau, 2011.

over the next forty years than it ever has before. The two lowest riparians—Sudan and Egypt—will see their current populations grow by 2.0 and 1.5 times, respectively. Sudan's population by mid-century will jump from the current 44.6 million to 90.9 million, while Egypt's will grow from 82.6 million to 123.4 million by 2050.[3] There are major human security implications for this sort of growth, due to the increase in water demand that will accompany this rate of demographic change. Population growth throughout the Nile basin is leading to speculation that transboundary agreements governing water use in the Nile and its tributaries may need to be renegotiated to take into account both current and future demographic realities.



Source: Population Reference Bureau, 2011.

Despite the warning signs that the region is facing daunting and relatively immediate security challenges stemming from water availability, two countries at the southern end of the Arabian Peninsula offer insights into how water might be sustainably and efficiently managed over the coming decades. Compared to increasingly water-scarce Yemen, Oman has a fraction of Yemen's population—just under three million people, compared to Yemen's twenty-four million—and a fraction of Yemen's political troubles. Oman's population is projected to grow by a factor of 1.8, increasing its population to 5.3 million in 2050, while Yemen's population is expected to increase 2.5 times, bringing the country's population to over 59 million by mid-century.[4] (Short of massive investments in desalination, Yemen's population growth will place significant strain on domestic water supplies—especially given the state of the country's nearly nonexistent surface water and severely depleted underground water supplies.) Yet an examination of best water practices

[3] *Ibid.*

[4] Population Reference Bureau, 2011.

in the two countries offers the possibility that improved water management might mitigate potential water crises to some degree. Indeed, for Oman and Yemen, the solution to managing limited water resources in the face of continued population growth has been IWRM.

Water systems and resources such as aquifers and wetlands are often overlooked, particularly in generalist discussions, or discussions on MENA water resources policy among analysts outside the region. While aquifers and wetlands are found only in some areas, these resources can be critical to the environmental futures of some countries, and can themselves become sources of conflict within and between countries. In particular, groundwater stocks will become increasingly important water sources as water scarcity grows in the MENA region. States will need to negotiate policies for extracting this water and address contentious issues such as sustainable management of underground water resources and equitable allocation of water from shared aquifers. The key role that underground water resources—and in particular fossil water reserves—will play in the security of the region over the next fifty years remains largely unrecognized by the rest of the world.

To date, international and domestic responses to water-scarcity issues have largely focused on bolstering supply rather than reducing demand via measures that encourage or mandate greater water conservation. Augmenting supply allows governments to at least partially circumvent various political and ethnic tensions that often accompany water access. Focusing on conservation and greater water-use efficiency, meanwhile, has a much higher potential to trigger grievances, particularly among politically influential actors in the agricultural sector who may have become accustomed to unrestricted surface water and groundwater pumping for irrigation. In Oman, Yemen, and elsewhere, IWRM—because of its more balanced consideration of both supply and demand dynamics—has gained steam in recent years. Policymakers are increasingly viewing the approach as not only a better way to manage water, but also as a more effective means to spur cooperation between riparian states. IWRM is based on the philosophy that all uses of water are interdependent, and that water exists both as a social and economic good. For instance, agricultural runoff can pollute aquifers and rivers, leading to poor-quality drinking water and environmental degradation. Conversely, limiting agricultural water withdrawals for ecological reasons—such as sustaining fisheries—can result in disappointing crop yields. These issues have security ramifications when they create or add to intrastate or interstate instability.

Another potential approach to achieving greater water conservation calls for a more significant role to be played by the private sector. The public water-management sectors in many MENA countries suffer from poor management and/or inadequate investment in the

water sector. Private participation in the sector now seems inevitable, and could represent an important means of improving performance in water management and public sanitation and achieving significant gains in productivity and efficiency. Every government in the region, in conjunction with its advisors and investors, could choose the public-private mix that is best tailored to local needs, capacities, and circumstances. One particular challenge is that MENA governments would have to demonstrate the political will to raise water tariffs to cover costs and develop the regulatory arrangements that would give private sector firms confidence that they can generate a fair rate of return on their investments. Even relatively low-risk contracts, such as leases to provide management services, would require governments to establish their credibility as good partners of the private sector. While many governments are currently contemplating reforms that would make private participation in water and sewerage possible, only a few countries in the MENA region have succeeded to date in actually achieving private sector participation.

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The belief that water management has social, economic, environmental, and security ramifications began to gain mainstream attention in the 1990s. At the 1992 International Conference on Water and the Environment (ICWE) in Dublin, participants proposed guiding principles for an integrated, more holistic approach to water stewardship. Known as the Dublin Principles, these steps highlighted the following subject areas:

- Water management requires a holistic approach that links social and economic development with ecosystem protection. Water management policies should also consider land use in the vicinity of the water source.
- A participatory approach to water management is needed, which includes raising awareness among both policymakers and the general public, as well as involving water stakeholders at all levels.
- As primary providers and users of water domestically, women need to play a pivotal role in water management.
- Water is an economic good, and as such should be managed efficiently and equitably, with special attention to conserving and protecting water resources.

These principles were presented at the United Nations Conference on Environment and Development (UNCED) later that year, and echoed at the first and second World Water Forums in 1997 and 2000, respectively. At the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, targets were set to develop national integrated water resource management and water efficiency plans by 2005. At the fourth World Water Forum in Mexico in 2006, Yemen, Palestine, Jordan, and Egypt were recognized as

the most successful MENA countries and territories to formally incorporate IWRM into their national water policies. Kuwait, Iraq, and Oman, meanwhile, were judged to be the least successful.

The primary challenge for most states in the MENA region has been accepting water as something more than just a resource to be exploited for purposes of development and modernization. Part of this process has involved moving toward recognition that water resources are limited, and that water management must focus not only on finding new sources and exploiting current ones, but also on educating water users regarding conservation techniques (demand management). Additionally, before being able to effectively implement IWRM policies, many MENA countries had to contend with highly fragmented control over water management, characterized by overlapping responsibilities among different institutions and water-using sectors. Further complicating matters, many countries in the region had to overcome the sort of rigid, overcentralized control of water resources that had become the norm over the past fifty years, a period of rapid economic development and large water infrastructure projects.

To overcome these hurdles, countries were forced to make difficult decisions and restructure institutions involved in water governance. To encourage better management and conservation, it became necessary to situate water management responsibilities in one national-level ministry, while engaging water stakeholders at the municipal and community levels. (To its credit, Egypt has been particularly successful in adopting such changes.)

Today, several regional institutions are dedicated to encouraging IWRM cooperation in the region. One is the Arab Integrated Water Resources Management Network (AWARENET), which seeks to foster regional communication on how to best incorporate IWRM into national policies. The Arab Water Council, established in 2004, is also concerned with supporting IWRM in the region. The council focuses on developing a multidisciplinary approach to water management and increasing the sharing of scientific information, such as hydrological data, within and between countries. Bilateral agreements in the MENA region are also beginning to reflect a greater acceptance of IWRM. IWRM-based agreements provide states that share water resources with many potential benefits, including the following:

- *Cooperation.* Cooperation between fellow riparians can improve stewardship of shared surface waters, increase agricultural production and energy generation, and facilitate preparedness for disasters, such as floods and droughts.
- *Reduced costs.* Costs for water management can be shared between the two countries, thus reducing cross-border tensions and lowering conflict potential.

- *Security*. Cooperation in the management of water resources can lead to improved political and economic relations between the two countries.

More broadly, IWRM can play an important role in fostering scientific diplomacy, sharing lessons learned, and building domestic and cross-border institutional infrastructure that might help anchor regional stability—as far as environmental security is concerned—in the coming decades.

Urbanization and economic modernization are also altering traditional patterns of water consumption across the MENA region. The increasing competition for water resources in the face of significant population growth means that the potential for conflict over water is also elevated—among old adversaries and new water-using actors alike. But despite grim (and controversial) warnings about looming water wars in the MENA region and elsewhere, growing water scarcity also provides intriguing pathways toward intrastate and interstate cooperation. With so many governments in flux across the MENA region given the impacts of the Arab Spring protests, cooperation on environmental security concerns—water access chief among them—could be an entryway to cooperation between countries in transformation. Science diplomacy does not necessarily carry the divisive political, religious, and cultural baggage that can accompany other forms of state-to-state interaction. Greater scientific exchanges across the region would fulfill many objectives by bolstering understanding and preparedness of current and future climate change impacts, and by establishing cooperative frameworks for jointly responding to changes in water availability.

The collection and dissemination of comprehensive, accurate hydro-meteorological and water-use data are essential for sustainable water-resource management in general, and for transboundary river basins in particular. At the moment, however, water data acquisition in the MENA region faces many challenges, including: inadequate coverage and poor maintenance of hydro-meteorological networks due to insufficient funding; low human-resource capacity (at the professional as well as technical levels) within national hydrological services; incompatible water data and information systems among riparian states; and distrust of data monitoring and theft of monitoring equipment. To promote and facilitate the establishment and maintenance of sustainable hydro-meteorological data and information systems, policy interventions could be implemented that develop public awareness programs regarding the importance of data sharing, strengthen national-level hydro-meteorological institutions, build scientific expertise at the professional and technical levels, and support the development of data dissemination systems across the MENA region.

If achieved, greater cooperation in the realm of data sharing could spill over to increase transparency and exchange in other areas of bilateral relations. Further, identifying knowledge gaps and bolstering communication about key water resources in the region—particularly transboundary sources such as the Nubian Sandstone Aquifer and the Nile and Tigris-Euphrates basins—could serve as important and relatively attainable confidence-building measures in the years ahead.

This paper considers three case studies to illuminate some of the water-governance policy options in the region: the Tigris-Euphrates basin, the Nile basin, and a side-by-side examination of water stewardship in Yemen and Oman. Across these case studies, a number of potential policy options and interventions might be considered:

- *Prioritizing conservation, rather than bolstering supply, especially in the agricultural sector.* Agriculture remains the dominant sector for water use, accounting for 80–90 percent of total fresh water usage in many countries across the MENA region. Agriculture has an impact on water quality as well as quantity, since pesticide and fertilizer runoff can contaminate surface water supplies and groundwater stocks. In order to meet the needs of the MENA region's growing populations over the past fifty years, countries planned and developed large-scale infrastructure projects to source, control, and deliver water. These projects—such as dams, desalination plants, and river diversions—focused almost entirely on the supply side of water management. While these large supply-oriented projects were meant to alleviate conflicting demands domestically, they often triggered conflict between states that share transboundary waters.
- *Mitigating unchecked groundwater pumping.* As is the case in Yemen and Syria, water-stressed countries sometimes try to pump their way out of periods of water scarcity. Governments are often complicit in the act, as they tend not to charge agricultural and industrial users for water withdrawals, nor do they encourage conservation. These practices have led to abuse of the resource, highly inefficient usage, and unsustainable withdrawal rates that have placed many pockets of the MENA region on the brink of serious water shortages.
- *Recognizing the impact of ongoing urbanization on water-use patterns and implementing water-management policies accordingly.* Like much of the world, the MENA region is rapidly urbanizing, changing the way water resources are utilized by public and private interests. For example, according to the United Nations, Saudi Arabian cities experienced a 28-fold increase in population from 1950 to 2005, while the country's rural population didn't even double in the same time frame. During the same period in Egypt, rural populations grew by 185 percent, while urban populations swelled by 354 percent. In Syria, meanwhile, rural populations grew by 287 percent, while urban populations expanded by 800 percent.

- *Noting the prevalence of increasingly water-intensive lifestyles.* Public attitudes toward water change with increasing prosperity. Many people in developed societies would view a daily shower and water to keep their lawns green as basic needs. In the MENA region, the thriving Gulf states have some of the highest per capita water consumption rates in the world—between 300 and 750 liters per person per day.[5] (By comparison, the World Water Council reports that the average per capita daily use in the United States is 350 liters, 200 liters in Europe, and 10-20 liters in sub-Saharan Africa.) By 2050, it is estimated that all countries in the MENA region except for Iraq will have water scarcity problems. The intersection of growing populations, changing and growing demand for water, and the looming threat of water scarcity across the Arab world has the potential to create conflict within the region.
- *Recognizing that desalination is not a cure-all.* Desalination can help mitigate water scarcity issues, but the technology will never represent a silver bullet. For the lucky few—namely deep-pocketed energy producers like the United Arab Emirates that can afford desalination to meet domestic water-use needs—the technology is hugely important. Other countries across the MENA region are not so lucky. While desalination can help mitigate domestic and industrial water-supply issues in coastal population centers, cost and energy requirements make using desalinated water for large-scale irrigation prohibitively expensive.

Case Study #1

Dividing Conflict Zones New and Old: The Tigris-Euphrates Basin

Turkey controls the headwaters of both the Tigris and the Euphrates, which flow through Syria (or in the case of the Tigris, along the border) and into Iraq, later emptying into the Persian Gulf. As early as the 1950s, Turkish leaders had discussed harnessing the waters of both rivers to drive national economic development and bolster domestic energy production. The resulting project, GAP—from its Turkish name *Güneydogˇu Anadolu Projesi*, or the Southeastern Anatolia Project—was launched in the 1980s, with plans for twenty-two dams and nineteen hydroelectric power plants. Upon completion, this massive infrastructure project is expected to eventually divert enough water to irrigate 1.7 million hectares of land and provide 27 billion kilowatt-hours (kWh) of electricity. The project enables the continued economic development of the politically restless Kurdish southeast

[5] Mostafa K. Tolba et al, "Executive Summary" in *Arab Environment Future Challenges*, Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2008), p.10

corner of the country where unemployment remains high and which, given the sentiments of separatist Kurds, Ankara is eager to bring closer under its wing.[6]

For Syria and Iraq, GAP heightens water insecurity and their perception of Turkey as a threat. Turkey's hydroelectric infrastructure means the country could likely cut off water flow to downstream neighbors in the event of a serious conflict. It's not without precedent—in 1990, Turkey cut off the entire flow of the Euphrates for three weeks, an event that looms large even today. Syrian towns dependent on Euphrates hydroelectric power went dark as a result.

Regional tensions between Syria and Turkey have flared up before, revealing possible fault lines in any potential water-related conflict. In the 1980s, Syria surreptitiously supported the Kurdistan Workers Party in its campaign against the Turkish government as a way of sabotaging the GAP project. The two countries eventually inked an agreement in 1987, whereby Turkey agreed to maintain a minimum flow of 500 cubic meters per second (m/s) from its dams on the Euphrates in exchange for Syrian cooperation regarding Kurdish separatists.[7] But Turkish leaders' attitudes toward the basin's water resources in the ensuing years remained fairly aggressive. In July 1992, future Turkish President Suleyman Demirel marked the opening of the Ataturk Dam by offering this analogy:

> "Neither Syria nor Iraq can lay claim to Turkey's rivers any more than Ankara could claim their oil. This is a matter of sovereignty. We have a right to do anything we like. The water resources are Turkey's, the oil resources are theirs. We don't say we share their oil resources, and they cannot say they share our water resources."[8]

Iraq and Syria have also clashed over the waters of the Tigris and Euphrates. In the early 1970s, the Tabqa Dam began blocking water flow on the Euphrates to fill Lake Assad behind the dam. Syria's filling of the reservoir significantly reduced flow into Iraq, leading Iraq to complain to the Arab League that Syria was abusing its role as an upper riparian. Syria abandoned negotiations and closed its airspace to Iraq in May 1975. Soon, the two neighbors were amassing troops at their borders in preparation for conflict,

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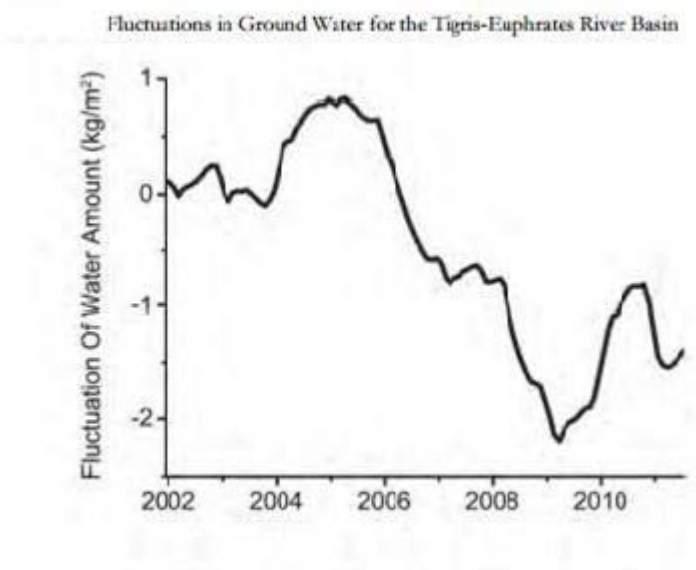
[6] International Energy Agency, *Energy Policies of IEA Countries: Turkey 2005 Review* (Paris: OECD/IEA, 2005), pp.118, 120; Republic of Turkey, *Southeastern Anatolia Project Action Plan 2008-2012* (Southeastern Anatolia Project Regional Development Administration, May 2008), p.5.

[7] *Ibid.*

[8] Christopher Reed. "Paradise Lost?" Harvard Magazine, Jan-Feb 2005. http://harvardmagazine.com/2005/01/paradise-lost.html.

averted only when Saudi Arabia brokered a pact in which Damascus agreed to guarantee that 60 percent of the flow of the Euphrates would make it to Iraq.[9]



Relative changes in the amount of Ground water for the Tigris-Euphrates river basin for the period between April 2002 to December 2010.

Human-induced changes to the basin's landscape and the ongoing effects of climate change combine to make the three primary basin countries vulnerable to heightened water tensions. Low flow levels on the Tigris and Euphrates have been recorded at less than one-third of average annual flow volume, with such variability an indicator that low flows combined with high seasonal demand could be a recipe for political and social unrest. Further, the basin's long-term ecological integrity remains threatened by huge canals and earthworks constructed to reroute the Tigris's and Euphrates's waters around the marshes they once nourished, and channel these rivers' waters directly into the Gulf instead. The end result was catastrophic from an environmental standpoint, with 93 percent of the lower basin's original marshlands wiped out by 2002.[10] Marsh Arabs' traditional livelihoods and ways of life were also marginalized to the point of non-existence, fulfilling Baghdad's intention to consolidate government influence in the region. (The UN imposed strict sanctions as a result, requiring Baghdad to pay compensation for war damages and environmental damage. These sanctions, however, restricted Iraq's ability to restore key social services and infrastructure. At the Al-Rustamiyah wastewater treatment plant in Baghdad, for instance, it proved impossible to import spare parts to rehabilitate the plant,

[9] Kevin Freeman, "Water Wars? Inequalities in the Tigris-Euphrates River Basin," *Geopolitics* 6, no.2 (2001); Marwa Daoudy, "Asymetric Power: Negotiating Water in the Euphrates and Tigris," *International Negotiation* 14, no.2 (2009); Frenken.

[10] *Ibid*.

resulting in the discharge of 300,000 cubic meters per day of untreated sewage into the Tigris.[11])

Today, Iraq's water infrastructure and usage patterns leave little room for optimism. Baghdad's water supply and sewage systems have fallen into disrepair from years of neglect and lack of maintenance, suffering damage from war, looting, and power cuts. The country's production capacity is approximately 2.1 million cubic meters per day, far below the country's basic demand of approximately 3.4 million cubic meters per day. The situation is made worse by the fact that water loss rates hover between 50 percent and 60 percent, owing to leaky water-distribution networks and pipe ruptures.[12] Meanwhile, newly developed areas in city suburbs are not served with any potable water; instead, the population depends entirely on raw, low-quality water provided by private vendors.

The economic stability of Iraq and Syria depends fundamentally on Ankara's water management policies. At present, Turkey uses a limited portion of Euphrates waters (35 percent) and a small fraction of Tigris waters. Even so, were it to increase the volume of water it withdraws from those rivers, Turkey would be in a favorable position to defend itself. With Syria experiencing significant internal unrest and Iraq recovering from two decades of sanctions and war, neither country would pose any sort of threat to Turkey's powerful military. Nevertheless, water-induced human insecurity in downstream states could have an impact on Turkey in other ways, such as the possibility of increased migration from water-scarce areas. Turkey must also tread carefully in its water-rich southeastern region. Without sufficient consultation or involvement of the region's Kurdish leadership, hydroelectric developments in the region could end up agitating Kurdish separatist factions.

A comprehensive agreement on the Tigris-Euphrates basin remains elusive, despite several decades of promising technical cooperation and bilateral agreements among the three riparian countries. The prevailing Syrian and Iraqi views are that the basin's waters are a common good, to be shared equally and fairly. Turkey views the headwaters as its sovereign domain, with the freedom to utilize those water resources as it sees fit. Commanding the literal and figurative high ground has allowed Turkey great influence over the basin's hydrology. Yet Ankara has also signaled its intention to improve water-sharing relations on the river, declaring its willingness to work with downstream riparians to ease tensions over basin disputes. Still, climate change will complicate water-sharing relationships between the three countries, unless new frameworks are devised to take into

[11] Hassan Partow, "Environmental Impact of Wars and Conflicts," in *Arab Environment Future Challenges,* Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2008), p.164.
[12] Jeannie Sowers et al, "Climate change, water resources, and the politics of adaptation in the Middle East and North Africa," in *Climatic Change*, J. Sowers et al (Springer Science + Business Media, 2010), p.606.

account the heightened water-supply variability that may become increasingly commonplace.

Case Study #2

Successes and Failures: The Nile Basin Initiative

Countries in eastern and northeastern Africa have a mixed track record when it comes to management of transboundary water resources. This case study will focus on the two lower riparians of the Nile basin, Egypt and Sudan. The two countries have enjoyed success in water diplomacy over the past twenty years, including the signing of a 1992 agreement detailing water-sharing in the Nubian Sandstone Aquifer. Not yet under significant stress, this aquifer will play an important role in fortifying each country's water security. Water access in the Nile basin may prove much more complicated, however, given a host of issues that do not affect underground supplies, such as hydroelectric development and evaporation. Indeed, population growth in the Nile basin and the attendant need for greater food production has placed the Nile and its many tributaries under mounting pressure in recent decades. While conflict over access to the Nile's waters has been held in check by the Nile Basin Initiative, new demographic and political variables (e.g., the emergence of South Sudan as an independent state) may change traditional water access dynamics.

The case of the Nile is somewhat different from that of the Tigris and Euphrates. Unlike the Tigris-Euphrates basin—where upstream Turkey is the dominant geopolitical power—in the Nile basin, it is downstream riparians Egypt and Sudan that feel they have dominant claim to the river's waters (despite the fact that the river passes through ten countries, and 85 percent of the Nile's waters originate in the highlands of Ethiopia[13]). Egypt and Sudan typically receive less rainfall than riparians in the higher reaches of the Nile basin. Consequently, both countries rely heavily on the Nile for irrigation. Given this need, it has largely been Egypt and Sudan that have determined who has priority over the river. Together, the two countries use about 94 percent of the river's water.[14] Egyptian and Sudanese water rights are outlined in the original treaty governing allocation of Nile waters. To ensure sufficient allotment in the face of demographic change through the basin, the ten Nile basin riparians have negotiated the Nile River Basin Cooperation Framework Agreement through the Nile Basin Initiative. Upon conclusion of these negotiations,

[13] Ashok Swain, "Mission Not Yet Accomplished: Managing Water Resources in the Nile River Basin," *Journal of International Affairs* 61, no. 2 (2008), p. 202.
[14] *Ibid*.

disagreements have persisted among the states; in particular, Egypt has voiced continuing concern about sufficient water access.

Egypt's water availability and demand (*c.f.* Mason, 2004)

	1999 $km^3\ year^{-1}$	planned by 2017 $km^3\ year^{-1}$
Nile water, according to the 1959 agreement between Sudan and Egypt	55.5	55.5
Fossil groundwater	0.5 - 0.9	1.2 - 3.3
Rain	1.4	1.4
Desalinated water	0.03	0.5
Water lost to the sea	- 4 to - 1	- 0.3 to 0
Total available	53.4 - 58.3	58.3 - 60.7
Re-use / increase in efficiency:		
Recycling of drainage water	4.3	9
Recycling of sewage water	0.4	2.5
Nile-groundwater (reused Nile-water)	2.6 - 4.8	4.9 - 7.5
Improved irrigation system	0.5	3
Changed crop sorts and patterns		3.5 - 4.2
Total amount of water that can be used (=Total available + recycling / efficiency increase)	61.2 - 66.6	81.2 - 86.9
Use:		
Agriculture	56	66.6
Municipal	3	6.8
Industry	6	12.4
Total use	65	85.8

In Egypt, population growth, rising living standards, and the needs of industry and agriculture (particularly in reclaimed lands) are placing serious strain on water resources. Agriculture is the dominant sector for water use, accounting for approximately 70 percent of total withdrawals. Meanwhile, municipal and industrial water needs consume 3.5 percent and 1.5 percent of water supplies, respectively. The substantial balance—estimated at roughly 25 percent of overall water stocks—is lost either through evaporation (5 percent) or squandered due to drainage issues (20 percent of drainage water is discharged into the Mediterranean Sea and the desert fringes of the Nile system).[15]

Until the 1990s, the Egyptian government's priority was "balancing" water supply and demand through supply augmentation. Significant investments were made in water supply, drainage, and rehabilitation of irrigation infrastructure. Still, by the late 1990s, the need for a more integrated approach became apparent due to continued deterioration of water quality, a growing demand-supply gap, intensification of intersectoral and interregional water allocation problems, inadequate government funds to sustain new

[15] Jeannie Sowers et al, "Climate change, water resources, and the politics of adaptation in the Middle East and North Africa," in *Climatic Change*, J. Sowers et al (Springer Science + Business Media, 2010), p.609.

investments, and poor operational performance of water agencies. Over the past decade, government policy has shifted in the direction of integrated water quality and quantity management. As will be discussed in the subsequent section on water use in Oman, the IWRM approach seeks to address sectoral concerns through a mix of institutional reforms, changes in incentive structures, and technical innovations.

In January 2005, the Egyptian Ministry of Water Resources and Irrigation issued a National Water Resources Plan based on IWRM concepts. The first part of the plan aims to conserve current water resources, rather than tapping or creating new supplies. Sustainable use of existing water resources in Egypt has also involved (1) adjusting operational practices at the massive Lake Nasser reservoir to reduce evaporation, (2) mining fossil water in the Western Desert with an eye toward conserving the aquifers for future generations, (3) harvesting rainfall, and (4) deploying desalination technology.

On the demand side, Egypt's plans include provisions for improving irrigation techniques to minimize waste. Particularly in the West Delta area, Egypt has instituted a design, build, and lease (DBL) system for farmers involving the construction of three major channels to deliver irrigation water. The hope is that local stakeholders will be more likely to conserve water if they feel they have an ownership stake in the water-delivery mechanism.

Looking at the Nile basin more broadly, many riparian countries have experimented with IWRM policies with the view of promoting regional cooperation. Signatories to the 1999 Nile Basin Initiative—Uganda, Tanzania, Sudan, Rwanda, Kenya, Ethiopia, Egypt, the Democratic Republic of Congo, and Burundi—agreed that a pact could help "develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security."[16] NBI-sanctioned projects tend to include environmental protection, stakeholder education, and increased efficiency in agricultural water usage. Incorporating both the economic and the security ramifications of water management, the NBI reveals an impressive shift in regional thinking about water resources.

Egypt and Sudan will grow significantly over the next forty years. Given the two countries' history with one another vis-à-vis water sharing, these demographic changes could escalate tensions. The two countries have almost come to blows over access rights to the Nile waters before. When Sudan gained independence in 1956, the country's first prime minister immediately requested that all previous agreements between the two countries be revised, while objecting to Egypt's plan to build the Aswan High Dam. Egypt responded in kind, withdrawing its support for Sudan's reservoir project at Roseires on the Blue Nile. In

[16] The Nile Basin Initiative, "Water Resources Planning and Management Project." February 2, 2009.

a subsequent escalation, after Sudan's announcement that it would not adhere to any past agreements, Egypt amassed troops on the border. The two countries eventually signed the Agreement for the Full Utilization of the Nile Waters (Nile Waters Treaty) in 1959, but only after a military takeover in Sudan resulted in the installation of a government friendlier to Cairo.

Egypt has also clashed with other riparians over water rights. In 1970, it threatened war against Ethiopia over the proposed construction of a dam on Lake Tana on the Blue Nile. In 1979, Egyptian President Anwar Sadat made water access a top foreign policy priority, famously declaring that "the only matter that could take Egypt to war again is water." That sentiment was later echoed by Egyptian Foreign Minister Boutros Boutros-Ghali in 1988, when he predicted the next war in the Middle East would be over the waters of the Nile. Still, Egypt continued its saber-rattling regarding access to Nile waters, with Egyptian Defense Minister Lt. Gen. Mohammed Hussein stating in October 1991 that Egypt would not hesitate to go to war to defend its claim to the Nile River.

Egypt's water-resource development in the basin has contributed to significant environmental degradation to the lower Nile. The 1962 construction of the Aswan High Dam in southern Egypt, near the Sudanese border, entrapped large volumes of sediment in Lake Nasser, resulting in significant erosion to the Nile delta. Sediments that would typically replenish the delta also became diverted by dense irrigation networks and drainage channels. At present, only a small amount of the Nile sediments are carried seaward to replenish the Nile delta coast at its northern margin, yet even these modest sediment volumes are depleted by strong easterly sea currents. Indeed, analysis of Landsat (satellite) images reveals that between 1972 and 2003, the promontory of Rosetta in Egypt lost approximately 9.5 square kilometers in area, while its coastline retreated 3 kilometers inland . This signifies that this part of the delta is retreating at an alarming rate of about 100 meters per year. The delta is also highly vulnerable because of the potential sea level rise associated with climate change. Under one of the more extreme scenarios—a sea level rise of five meters—more than half (roughly 58 percent) of the densely populated Nile delta would be vulnerable to flooding, and at least ten major cities (among them Alexandria, Damanhur, Kafr-El-Sheikh, Damietta, Mansura, and Port-Said) would be threatened. Such an outcome could conceivably force about 14 percent of the country's entire population to relocate to the southern edge of the Nile delta, where physical and institutional infrastructure would be ill-equipped to cope with the massive population resettlement.[17]

[17] Eman Ghoneim, "A Remote Sensing Study of Some Impacts of Global Warming on the Arab Region," in *Arab Environment: Climate Change*, Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2009), p.40.

Looking forward, Ethiopia's demographic outlook could place it in greater competition with Sudan and Egypt for the basin's waters. Rapid population growth in Ethiopia in the coming decades could even shift the basin's geopolitical power balance southward. According to the UN, the country's population is expected to rise from 77 million to roughly 126 million by 2030, heightening local demand for water resources. Further, limited access to safe drinking water poses a serious threat to Ethiopia's internal security, with only 22 percent of the population having access to safe drinking supplies (compared to 98 percent in Egypt).

Case Study #3

Getting It Right, Getting It Wrong: Integrated Water Resources Management on the Arabian Peninsula

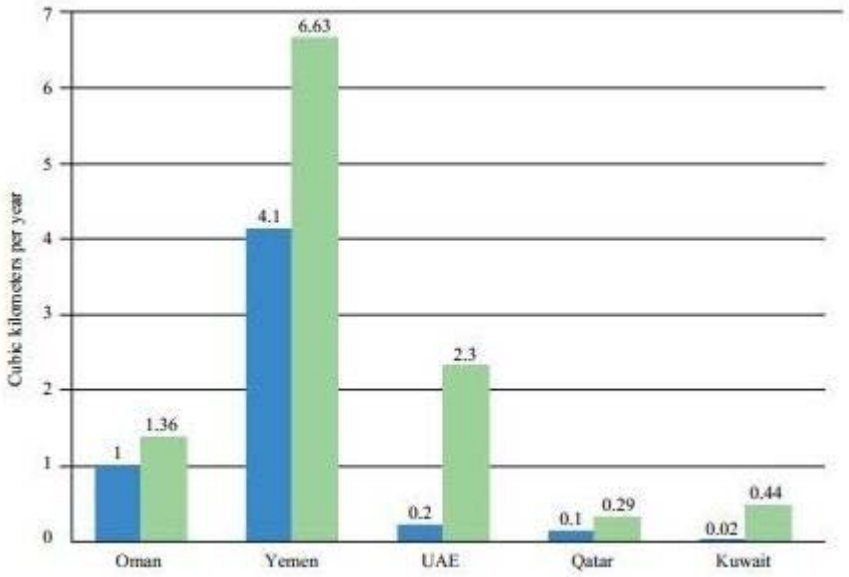
At the southern end of the Arabian Peninsula, neighbors Oman and Yemen offer an intriguing snapshot of two countries seeking to manage scarce water resources. Unlike other areas of the MENA region, Oman's and Yemen's water resources are largely self-contained, meaning there are no significant transboundary surface waters or groundwater stocks of note. While Oman is in a difficult position regarding water availability, it is well-off compared to Yemen—a state now considered one of the most water-stressed in the world, with no indications that the situation will improve substantially anytime soon.

Oman's and Yemen's experiences in the realm of water management speak to a larger reality across the MENA region: the region's water-scarce states might consider changes to how they manage and interact over water. The IWRM approach that the two countries have embraced focuses more on the human, ecological, and economic aspects of water management, whereas other approaches to water management tend to focus exclusively on bolstering water supply, regardless of the adverse side-effects it may have.

The conservation philosophy that IWRM embodies is perhaps most important for countries on the Arabian Peninsula, which draw most of their water from aquifers, reservoirs, treated wastewater, and desalination plants (Saudi Arabia has the largest desalination capacity in the world). These countries' biggest water challenge is that they are currently using significantly more water than they have. Saudi Arabia suffers the biggest gap between supply and demand: it has only 2.4 cubic kilometers per year of

renewable water resources, yet manages to use 17.33 cubic kilometers per year.[18] Illustrated below are resources-to-withdrawal ratios for the peninsula's other countries.

Water Resources and Withdrawal Levels in Select Arabian Peninsula Countries



Domestic water resources and withdrawal levels across selected countries of the Arabian Peninsula. Despite having comparatively large resource endowment, Yemen's water stresses are among the region's most severe. Neighboring Oman, meanwhile, enjoys the lowest proportion of water withdrawal compared to domestic resources. Source: Compiled from Peter H. Gleick (Ed.) sources in The World's Water 2006-2007 *(Washington, DC: Island Press, 2006)*

Although Yemen's water outlook remains grim, the country has over the past decade attempted to incorporate IWRM into its national water policy. In 2003, the newly created Yemeni Ministry of Water and Environment issued the IWRM-based National Water Sector Strategy and Investment Program, 2005–2009 (NWSSIP). Plans included involving farmers in water management by introducing cost-sharing investments in new irrigation techniques that conserve water, while simultaneously reducing government subsidies for the diesel fuel traditionally used to power groundwater pumps. To further encourage conservation, Yemen's Sanaa University began offering a master's of science degree in IWRM in 2004, with classes on the environment, the gender dynamics of water management, and the economics of water resources. (Of all IWRM objectives, recognizing the primary role of women in the use and allocation of water at the local level has received

[18] Musa N. Nimah, "Water Resources," in *Arab Environment Future Challenges*, Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2008), p.65.

the least attention, and it is significant that gender considerations were incorporated into the university's master's degree coursework.)

On the other end of the spectrum sits Oman, which has fared comparatively poorly in terms of incorporating IWRM policies into its national water plan. However, a careful examination of Omani water policies reveals the limitations of IWRM as the international standard of water management. Oman also highlights a virtually ignored aspect of water policy—the importance of cultural and religious values in water management.

Oman relies on precipitation for most of its renewable water resources. Rainfall replenishes reservoirs and shallow aquifers, providing 65 percent of Oman's water needs. The country depends on desalination to provide the rest. Most rain in Oman falls during mid- and late-winter, ranging from 20 to 100 millimeters a year on the coast and interior plains, and up to 700 millimeters a year in Oman's mountainous north.[19] Although some of the mountain rainfall seeps into aquifers that supply irrigation water for the plains, much of it runs down *wadis* (gullies that are usually dry) in the form of seasonal floods. Some of this water is caught in surface reservoirs, but these bodies of water have a high evaporation rate.

According to the Omani Ministry of Regional Municipalities, Environment, and Water Resources, water demand in Oman typically exceeds water supply by 25 percent while *The World's Water 2006–2007* estimates that demand exceeds supply by 36 percent. Desalination, as mentioned earlier, cannot be relied on to fill that gap because of the expense involved—energy usage accounts for up to 50 percent of desalination's total costs and Oman, unlike Saudi Arabia, is not a large fossil-fuel producer. (Raw materials for building desalination plants, such as steel, are expensive as well.) Desalination plants also have a significant impact on the local environment—including the discharge of brine that contains decaying organisms caught during in-flow, and chemicals and heavy metals introduced during the desalination process. These effects have potentially significant financial costs, and cleanup campaigns and construction of more environmentally friendly plants are likely to make desalination even more expensive.

The star of Oman's water management system has been, and to some extent remains, its *aflaj* system. Aflaj are water channels that take advantage of the earth's gravity and topography to deliver water from underground sources. With a history spanning thousands of years in the region, they currently deliver one-third of renewable water resources for irrigation, while wells supply the rest. Shares of aflaj water can be either

[19] Musa N. Nimah, "Water Resources," in *Arab Environment Future Challenges*, Mostafa K. Tolba et al. eds. (Arab Forum for Environment and Development, 2008), p.67.

owned or rented, and they are traditionally measured by complex calculations based on seasonal variations in the length of the day and night and the position of the stars.

Conserving its aflaj has been a key part of Oman's modern water policies. In 1997, the Sultanate established the National Aflaj Inventory Project, which counted 4,112 aflaj in the country, of which about 74 percent were then in operation.[20] The Sultanate takes responsibility for the maintenance of both aflaj and wells—a parallel Well Inventory Project was initiated in 1992—and continues to fund research on desalination and other water-sourcing technologies, such as fog collection.

Oman is an absolute monarchy governed by Sultan Qaboos bin Said Al Said, who has a great deal of influence over policymaking in the country. To his credit, Sultan Qaboos has been far-sighted in his management of the country's water resources. In 1984, he created the Ministry of Regional Municipalities, Environment, and Water Resources, which placed responsibility for water and environment issues at the municipal-government level, and made Oman the first Arab state to have a ministry dedicated to environmental issues. In 1986, he strengthened these links by consolidating the councils responsible for environmental resources and water resources into the Council for the Conservation of the Environment and Water Resources. The Sultan's implementation of these steps showed foresight—recognizing the relationship between local governance, environmental stewardship, and water management. These steps also reflect an understanding of the importance of maintaining a strong national authority that is not fragmented among various ministries and of decentralizing water management to better involve stakeholders at the local levels. These were concepts that would only enter the international discourse some years later, at the Dublin Conference in 1992 and then again in 2002 in Johannesburg, South Africa.

The objectives of the water resources sector of the Ministry of Regional Municipalities, Environment, and Water Resources include many of the same targets as plans formally incorporating IWRM, including a focus on sustainable use, demand management, environmental protection, and public outreach through educational initiatives. The primary objectives are (1) supplying sources of potable water and creating a balance between water utilization and renewable resources, (2) enhancing water resources and protecting them against depletion and pollution, (3) rationing water consumption, (4) establishing principles of water preservation, and (5) increasing awareness of the importance of conserving water resources.

[20] Jackson Morill et al, "Comparative Analysis of Water Laws in MNA Countries," in *Water in the Arab World: Management Perspectives and Innovations*, N. Vijay Jagannathan et al. eds. (World Bank, 2009), p.329.

Still, viewed in a broader context, Oman lags behind other countries in the region in adopting IWRM. Oman, unlike other countries in the region, has not developed a national plan that incorporates IWRM concepts and terminology, like the one Egypt issued in 2005. Instead, Oman has incorporated IWRM-like policies into its water management for decades. This case illustrates that international standards and targets—while useful in encouraging cooperation—can stand in the way of accurately understanding a country's water situation, particularly when only those international standards and targets are used as measurements. The Sultan's twenty-first National Day speech in November 1991 perhaps best indicates his integrated view of water management, including its importance to both regional and global security:

> "Of all the gifts with which God has blessed us, water is the greatest…. If extravagance is forbidden by Islam, it is even more applicable to water. Indeed, Islam emphasizes in its teaching that it is our duty to conserve it. We cannot stress too strongly the need to observe the conservation measures laid down by Government in this respect. The use of this vital resource throughout the world can have a great impact on future development strategies, and indeed could become a decisive factor in political tension and thus, world security. Our Government has plans to increase our country's water resources to meet our national requirements without arduously affecting the demands of conservation."[21]

Oman's emphasis on maintaining traditional Islamic religious and cultural values as the country undertakes modernization efforts sets it apart, in its view, from other water-scarce states on the Arabian Peninsula. As the Sultan's speech indicates, modern water management and traditional Islamic values are not incompatible. Indeed, water conservation and equitable distribution are core values in Islam. The Qur'an stresses the importance of not wasting water, even when supplies are plentiful. It also teaches that water belongs to everyone and cannot be owned—of the three people Allah will ignore on the day of resurrection, one is the man who had more water than he could personally use and refused to share it with travelers. Further, the IWRM principle of involving all water stakeholders in decision-making is echoed in the Islamic principle of *shura*, which states that decisions that affect a community should be made through group consultation and consensus within the community. Oman's approach of integrating Islamic values with sustainable water management techniques ought to be noted by policymakers, water managers, and environmental experts across the region.

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[21] "Speech of His Majesty Sultan Qaboos bin Said on the occasion of the 21st National Day." November 18, 1991. http://www.omanet.om/english/hmsq/royalspeechese/royalspeeches21.pdf.

Like Oman, many Islamic countries in the Middle East have used Islamic principles to further their water management goals. Perhaps the clearest example of this was a 1978 *fatwa* dealing with the issue of reused wastewater, issued by Saudi Arabia's Council of Leading Islamic Scholars (CLIS). According to Islam, water purity is extremely important, yet in a water-poor country like Saudi Arabia, treated wastewater represents an important water source. The fatwa stated, in part, that "impure wastewater can be considered as pure water and similar to the original pure water, if its treatment using advanced technical procedures is capable of removing its impurities with regard to taste, color, and smell, as witnessed by honest, specialized, and knowledgeable experts. Then it can be used to remove body impurities and for purifying, even for drinking."[22] Similarly, Jordan has been using Islamic teachings in its IWRM-based public awareness campaigns about water conservation for years, a fact that was ignored in the fourth World Water Forum report acknowledging Jordan's success in implementing IWRM.

Saudi Arabia and Jordan provide examples of how traditional Islamic values can complement modern integrated water policies. Indeed, it is important not to use international IWRM standards exclusively when judging a country's progress in achieving integrated water management. In particular, Oman demonstrates the importance of examining a nontraditional Middle Eastern security concern—such as water scarcity—from a perspective that takes into account how the resource is viewed within the context of that region's culture. While Oman's emphasis on incorporating Islamic values into its water policy conversation may turn off many western observers, the success of the approach should not be discounted. As water becomes more of a security concern across the MENA region in the coming decades, it will become even more critical to understand the mechanisms through which IWRM can be implemented, understood within the context of Islamic discourse and values.

Concluding Remarks and Questions for Discussion

Demographic shifts, rapid urbanization, political uncertainty, and shifting climate patterns are collectively pushing the MENA region into uncharted territory as far as water resource management is concerned. In the years and decades ahead, it will be in the interests of the region's countries to pursue collaborative approaches to managing scarce water resources, at both the domestic and regional levels. This can be achieved through (1) sharing of best water management practices, (2) strengthening networks of MENA water

[22] Bahadar Nawab et al,"Cultural preferences in designing ecological sanitation systems in North West Frontier Province, Pakistan." Journal of Environmental Psychology. 26. no. 3 (2006). http://www.sciencedirect.com/science/article/pii/S0272494406000569

experts, (3) building broader and deeper cooperative relationships among MENA experts with water experts in other areas of the world, (4) demonstrating an openness to incorporating Islamic values to ensure efficient and sustainable use of surface and groundwater resources, and (5) identifying intellectual and technical tools to foster greater transparency in water management, such as climate change modeling, remote-sensing data, and satellite imaging.

To establish a foundation for identifying and addressing water management issues within and across national boundaries in the MENA region, a few questions might be considered as starting points for fostering greater transparency and cooperation:

- What are the social, economic, and political consequences of water resource changes, and changes in water demands and use patterns?
- How do various communities and interest groups within each country define the water-related issues of principal concern?
- What responses have been adopted by various countries to address the challenges as they define them?
- What institutions exist to address these challenges?
- What roles are played by education, awareness-raising, community empowerment, and mobilization of local knowledge?
- What cooperation takes place between communities and between countries?
- What steps could be taken to strengthen cooperation, particularly in the sharing of institutional models, knowledge, and technical tools such as water balance estimates, water modeling, and hydrological mapping?

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[*] This paper draws extensively on the research and analysis done by the Stimson Center's Regional Voices: Transnational Challenges Project and the Environmental Security Program, in particular *Transnational Trends: Middle Eastern and Asian Views* (2008) and *Troubled Waters: Climate Change, Hydropolitics, and Transboundary Resources* (2009). The authors would like to acknowledge their indebtedness to the work of Kendra Patterson and Corey Sobel.