GENI Global Energy Network Institute

The Water-Energy Nexus in the Jordan River Basin: The Potential for Building Peace through Sustainability

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Table of Contents

Table of Figures

Figure 1: The Jordan River Basin

1. Introduction

1.1 The Jordan River Basin

The Jordan River Basin is located in one of the most unstable and conflict-driven regions in the world, encompassing much of Israel and the Palestinian territory of the West Bank as well as parts of Lebanon, Syria, and Jordan. A series of wars and violent clashes in the region have claimed thousands of lives and continue to foment instability throughout the greater Middle East.

The Jordan River Basin is also located in one of the most heavily populated and water-scarce regions of the world, placing the region's energy and freshwater resources under severe stress. As a result, the once mighty Jordan River has been reduced to just 2% of its original flow[1] and under-ground aquifers are being pumped at unsustainable rates. Compounding these issues further, current climate models predict that the Jordan River Basin will become hotter and drier, increasing concerns over water supply, energy production, food security, and international relations.[2]

Figure 2: The Jordan River Valley

In light of these concerns, sustainable solutions for energy and water issues in the Jordan River Basin are necessary to avert environmental and humanitarian crises. Fortunately, some progress has been made towards more sustainable management of the Jordan River Basin's freshwater resources and the region's renewable energy potential has only just begun to be tapped. This report will present an overview of the current energy and water needs in the Jordan River Basin, examine progress on sustainable energy and water resource development, and make recommendations for needed policies and investments for the future.

Many will argue that against a backdrop of violence and instability, progress on sustainable energy and water development in the Jordan River Basin is impossible. Indeed, in the past half-century, regional instability has been one of the major obstacles to achieving sustainable development in the region. However, more recent experiences demonstrate that cooperation over water and energy issues in the region is in fact attainable and may even help drive greater regional stability. With so much at stake, regional policymakers and the global community alike have an obligation to work towards sustainable solutions for both water and energy within the Jordan River Basin.

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[1] Gafny, Talozi, Sheikh, and Ya'ari, "Towards a Living Jordan River: An Environmental Flows Report on the Rehabilitation of the Lower Jordan River," May 2010. Page 15. http://foeme.org/www/?module=publications&project_id=23. Accessed 23 May 2011.

[2] Brown, Oli and Alec Crawford. "Rising Temperatures, Rising Tensions: Climate Change and the Risk of Violent Conflict in the Middle East." International Institute for Sustainable Development, 2009, page 2. http://www.iisd.org/publications/pub.aspx?pno=1130. Accessed 23 May 2011.

1.2 Why Water and Energy are Important: The Water-Energy Nexus

The safe and reliable supply of water and energy is a basic need of any society and essential for continued economic development. However, the global demand for both water and energy is increasing at an unsustainable rate, which is largely a result of an exploding global population, inefficient water and energy management, and the impacts of global climate change. A recent report by McKinsey & Company, for example, predicts that if water consumption continues at current rates, 40% of the global water demand will not be met by 2030.[3] This unmet demand will likely lead to further depletion of nonrenewable water sources, reduction of water flows necessary to sustain environmental ecosystems, and in many cases, the failure to meet basic human needs.[4]

At the same time, the International Energy Agency predicts that by 2035, the global energy demand will increase by 36% over 2008 levels assuming all countries fully implement their respective national climate change goals.[5] The global demand for electricity will experience the largest increase of all energy sectors and is predicted to nearly double over 2008 levels by 2035.[6] In the absence of efficiency standards and new renewable technologies, the increase in global energy demand will continue to drive rising fuel prices up and intensify the environmental impacts of global climate change.

As resources are strained, the provision of water and energy has become increasingly interdependent, such that enhancing the supply of one is largely contingent on the availability of the other. For example, huge amounts of energy are necessary to deliver clean and safe water, which includes pumping water through pipes and aqueducts, lifting groundwater from underground sources, and treating water for pollution. When water scarcity increases, additional energy is required to pump water across longer distances or to produce water through alternative means, such as desalination.[7] In water-scarce California, for example, the conveyance, storage, treatment, distribution, collection and discharge of water now accounts for 19% of the state's total electricity use, and 31% of its natural gas consumption.[8]

Figure 3: The California Aqueduct

[3] "Charting our Water Future: Executive Summary." Prepared by McKinsey & Company, et al., 2009, page 11. http://www.mckinsey.com/en/Client_Service/Sustainability/Latest_thinking/Charting_our_water_future.aspx. Accessed 29 April 2011.
[4] "Charting our Water Future: Executive Summary," page 13.
[5] "World Energy Outlook 2010." International Energy Agency, 2010, page 4. http://www.worldenergyoutlook.org/2010.asp. Accessed 2 May 2011.
[6] "World Energy Outlook 2010," 2010, page 8.
[7] Granit, Jakob. "Elaborating on the Nexus between Energy and Water." Journal of Energy Security, March 2010. http://www.ensec.org/index.php?option=com_content&view=article&id=238:elaborating-on-the-nexus-between-energy-and-water&catid=103:energysecurityissuecontent&Itemid=358. Accessed 2 May 2011.
[8] California Energy Commission. "California's Water – Energy Relationship: Final Staff Report," November 2005. Page 8. http://www.energy.ca.gov/process/water/index.html. Accessed 3 May 2011.

At the same time, large amounts of water are also necessary for the production of almost all energy sources. Water is needed to extract and refine raw materials such as coal and petroleum, as well as for hydroelectric power generation, cooling for thermoelectric and nuclear plants, and scrubbing emissions from all traditional power plants.[9] In the United States, for example, the energy sector now accounts for 27% of all non-agricultural freshwater consumption.[10] Compounding these issues further, as countries look to diversify their energy profiles and reduce their carbon footprints, many of the new technologies are significantly more water-intensive than existing ones. For example, new coal, natural gas, and oil shale technologies use 3 to 5 times more water than conventional oil and gas production.[11] Even many "renewable" energy sources have proven to be prohibitively water-intensive: irrigated corn ethanol, for example, is 1,000 times more water-intensive than conventional oil production.[12]

Figure 4: Power Plant on the Ohio River

The water-energy nexus is particularly pronounced in the Jordan River Basin, which is water-scarce, energy-poor, and home to a rapidly growing population. The Middle East as a whole is in fact the world's most water-scarce region,[13] and despite its close proximity to the oil-producing Gulf States, the Jordan River Basin itself has limited natural energy resources. As a result, water shortages will become more acute in the Jordan River Basin, with demand projected to reach 120% of available supplies in Jordan, 130% in Israel, and 150% in the Palestinian territories within the next ten years.[14] At the same time, energy demand in the Middle East will experience the fastest rate of growth outside of Asia, which intensifies the need for reliable and secure sources of energy.[15]

The limited resources and unique circumstances of the Jordan River Basin mean that creative solutions are essential to manage water and energy resources in a complementary and sustainable manner. Cooperation over shared water resources and renewable energy projects in the Jordan River Basin is needed to avert impending shortages of both in the coming years.

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[9] Soloman, S. "Thirsty Energy, Scarce Water: Interdependent Security Challenges." Journal of Energy Security, December 2010. http://www.ensec.org/index.php?option=com_content&view=article&id=274:thirsty-energy-scarce-water-interdependent-security-challenges&catid=112:energysecuritycontent&Itemid=367. Accessed 2 May 2011.

[10] Hightower, M. "Energy and Water: Issues, Trends, and Challenges." Sandia National Laboratories, presented at the Electric Power Research Institute Workshop, July 2008. http://my.epri.com/portal/server.pt?open=512&objID=370&PageID=224944&cached=true&mode=2. Accessed 3 May 2011.

[11] Soloman, S., 2010.

[12] Soloman, S., 2010.

[13] "ESCWA Water Development Report 1: Vulnerability of the Region to Socio-Economic Drought." United Nations Economic and Social Commission for Western Asia, 2005. Page iii. http://www.escwa.un.org/information/pubsearch.asp. Accessed 2 May 2011.

[14] *IPCC Fourth Assessment Report: Climate Change 2007.* "Asia: Regional Characteristics." Intergovernmental Panel on Climate Change, 2007. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10s10-2.html#10-2-1. Accessed 28 April 2011.

[15] "World Energy Outlook 2010," 2010. Page 4.

2. Background on the Jordan River Basin

2.1 Geography of the Jordan River Basin

Figure 5: The Jordan River Basin From Space

The Jordan River is the longest freely flowing river in the water-scarce East Mediterranean and is one of the most important sources of freshwater for the region. The Jordan River Basin is a transboundary watershed, meaning that water sources that supply the Jordan River cross international and political boundaries. The Jordan River Basin is located primarily in present-day Israel and the Palestinian territories, but also includes parts of Jordan, Syria, and Lebanon, with a total surface area of roughly 18,000 square kilometers.[16]

The headwaters of the Jordan River Basin begin in the mountainous southern region of Lebanon and Syria and flow south into Lake Tiberius, which is referred to in the Bible as the Sea of Galilee. The Jordan River then flows out of Lake Tiberius and is joined by the Yarmouk River about 10 kilometers to the south, forming the boundary between Israel and Jordan, and later, the boundary between Jordan and the West Bank. The River ultimately drains into the Dead Sea 100 aerial kilometers south of Lake Tiberius, which at 420 meters below sea level is the lowest point on earth.[17] The Jordan River once formed a fertile wetland ecosystem rich in biodiversity, but competing water demands in the region have reduced the River to just 2% of its original flow.[18]

The Jordan River Basin has a Mediterranean climate, characterized by long, hot summers and cool, rainy winters. The region is therefore typified by high variability in precipitation, with strong seasonal floods and frequent droughts.[19] Rainfall is also unevenly geographically distributed, with the mountainous northern areas in northern Israel and southern Lebanon receiving up to 40 inches of precipitation annually, while the southern desert areas in Israel, Jordan, and Syria sometimes receive as little as one inch of precipitation per year.[20]

2.2 Demographics of the Jordan River Basin

The Jordan River Basin is one of the most densely populated regions of the world and it is growing rapidly.[21] The combined populations of Israel, Jordan, Syria, Lebanon and the Palestinian territories is about 44 million people, and it is expected to increase to more than 73

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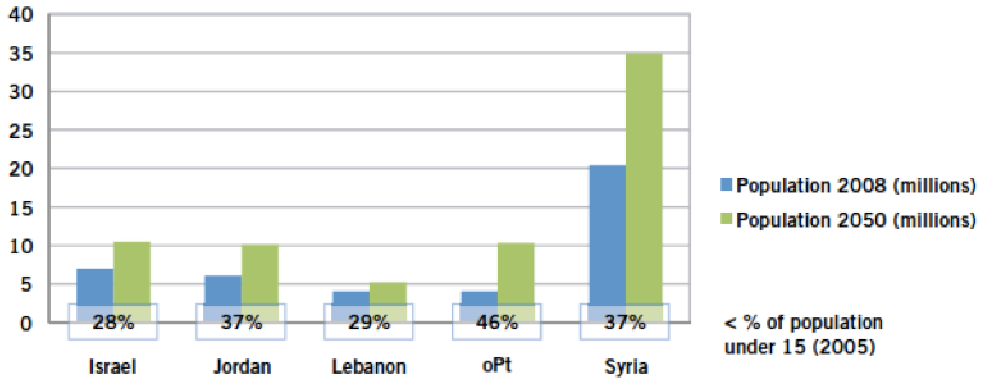
[16] Turner, Khateeb, and Nasser. "Crossing the Jordan: Concept Document to Rehabilitate, Promote Responsibility and Help Bring Peace to the Lower Jordan River Valley," March 2005. Page 7. http://foeme.org/www/?module=publications&project_id=23. Accessed 28 April 2011.
[17] Encyclopedia Britannica. "Jordan River." http://www.britannica.com/EBchecked/topic/306217/Jordan-River. Accessed 28 April, 2011.
[18] Gafny, Talozi, Sheikh, and Ya'ari, page 13.
[19] Gafny, Talozi, Sheikh, and Ya'ari, page 20.
[20] Helen Chapin Metz, ed. *Israel: A Country Study*. Washington: GPO for the Library of Congress, 1988. http://countrystudies.us/israel/. Accessed 24 March 2011.
[21] CIA World Factbook: Israel, Jordan, Syria, Lebanon, and West Bank. https://www.cia.gov/library/publications/the-world-factbook/. Accessed 4 May 2011.

million people by 2050.[22] Syria's population alone is predicted to increase by more than two-thirds by 2050, adding an estimated 15 million people, and the population in the Palestinian territories is expected to more than double over the same period.[23] The population is also very young: in Jordan and Syria more than one-third of the population is under the age of 15, while in the Palestinian territories nearly half of the population is under the age of 15.[24]

Figure 6: Projected Population Growth in the Jordan River Basin



Source: International Institute for Sustainable Development

There is significant economic inequality between the countries in the Jordan River Basin. Israel is by far the most economically advanced country in the region, and has a high standard of living that is comparable to most other countries in the western world. The Palestinian territories, which are occupied by Israel, have the lowest standard of living in the region, where GDP per capita is estimated to be just one-tenth of Israel's and the population has limited access even to basic services such as drinking water, sanitation, and electricity.[25] In general, the region is still characterized by a relatively low standard of living, albeit one that is growing rapidly, and also by high unemployment: 16% of the West Bank is unemployed, while the figure is 30% in Jordan and 40% in the Gaza Strip.[26]

2.3 Water and Energy Resources in the Jordan River Basin

The Middle East as a whole is the most water-scarce region in the world, accounting for nearly 5% of the world's population but just 1% of the world's renewable freshwater resources.[27] In the East Mediterranean region, the Jordan River and two natural underground aquifers alone provide all of the freshwater for millions of people who live in the Jordan River Basin. Israel,

[22] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. "World Population Prospects: The 2008 Revision," 2008. http://esa.un.org/unpp. Accessed 28 April 2011.
[23] "State of the World Population in 2008: Reaching Common Ground- Culture, Gender, and Human Rights." UNFPA, 2008. http://www.unfpa.org/public/pid/1382. Accessed 23 May 2011.
[24] CIA World Factbook: Jordan, Syria, West Bank, and Gaza. https://www.cia.gov/library/publications/the-world-factbook/. Accessed 4 May 2011.
[25] CIA World Factbook: Israel, West Bank, and Gaza. https://www.cia.gov/library/publications/the-world-factbook/. Accessed 4 May 2011.
[26] CIA World Factbook: Jordan, West Bank, and Gaza. https://www.cia.gov/library/publications/the-world-factbook/. Accessed 4 May 2011.
[27] AquaStat, "General Summary Middle East Region." Food and Agriculture Organization of the United Nations, 2008. http://www.fao.org/nr/water/aquastat/countries_regions/meast/index.stm#a4. Accessed 23 May 2011.

Jordan, and the Palestinian territories are all characterized by "severe water scarcity," meaning that each has fewer than 500 cubic meters of available renewable water resources per person per year.[28] All three also currently withdraw more than 100% of their renewable freshwater supply, through a combination of water diversions from the Jordan River and groundwater pumped from aquifers.[29] Although Syria and Lebanon have access to additional water resources, demand in both countries is still expected to outstrip renewable supply within the next five to ten years.[30]

Despite the proximity to the petroleum-producing Gulf States, the Jordan River Basin itself has few natural energy resources. At the same time, rapid population growth, rising standards of living, and growing energy needs associated with increasing water scarcity have caused regional electricity demand to increase at very high rates. For example, electricity consumption rose by 6% in Syria and Lebanon from 2007 to 2008, and by more than 8.5% in Jordan over the same period of time.[31] Fossil fuels, including petroleum products, natural gas, and coal, are currently the main sources of electricity, although the Jordan River Basin has vast solar energy potential that is only just beginning to be tapped.

2.4 Geographic and Demographic Profiles by Country

While there are many similarities between the countries within the Jordan River Basin, there are also significant differences between each country, which inevitably affects how the region will manage its growing energy and water needs and plan for future sustainable development.

Figure 7: Map of Israel

2.4. a. Israel

Israel is a small country, with a total area of just slightly larger than the state of New Jersey. Israel's geography, however, is diverse: the Negev desert makes up southern half of the country, while mountain ranges dominate the central and northern regions of the country. To the east is the Jordan Rift Valley, and to the west, Israel has a long coastline along the Mediterranean Sea and a fertile, coastal plain, which stretches from Lebanon in the north to Gaza in the south.

Israel's population is roughly 7.5 million people and is growing at an annual rate of roughly 1.6%. In addition, there are more than 500,000 Israeli settlers living in the occupied territories in the West Bank, Golan Heights, and East Jerusalem.[32] The Israeli government is a parliamentary

[28] *IPCC Fourth Assessment Report: Climate Change 2007.* "Asia: Regional Characteristics."
[29] Brown, Oli and Alec Crawford, page 11.
[30] Ibid., page 11.
[31] U.S. Energy Information Administration, *Country Profiles: Israel, Jordan, Syria, and Lebanon*, 2011. http://www.eia.doe.gov/countries/. Accessed 29 April 2011.
[32] CIA World Factbook: Israel. 2011. https://www.cia.gov/library/publications/the-world-factbook/geos/is.html. Accessed 3 May 2011.

democracy and is the United States' strongest ally in the Middle East region. The current Prime Minister is Benjamin Netanyahu, a member of the right-leaning Likud party.

Israel is also the most economically advanced of all the countries in the Jordan River Basin. Israel has intensively developed its agricultural and industrial sectors despite its limited natural resources, although it still depends heavily on foreign aid, particularly from the United States. Israel's GDP is estimated to be $201.3 billion, with a 3.4% growth rate in 2010. The GDP per capita is $29,500, although an estimated 23.6% of the population lives below the poverty line.[33] Israel's high standard of living has led to increasing demands for both energy and water. Total energy demand has increased by 50% over the last decade, and electricity production and consumption have doubled in the same period of time.[34] Within ten years, demand for water is also expected to reach 130% of Israel's available water supplies, which is estimated to be 265 million cubic meters per year.[35]

2.4. b. Jordan

Jordan is located directly east of Israel, sharing a border with both Israel and the West Bank. The western portion of Jordan is made up of mountainous highlands that line the Jordan Rift Valley, but the vast majority of Jordan is desert. Aside from the Palestinian territories, Jordan has the lowest available water supply per capita in the Jordan River Basin, at just 169 cubic meters per year.[36]

Figure 8: Map of Jordan

Jordan has a population of about 6.5 million people, of which almost 2 million are Palestinian refugees. Jordan's population is young, urban, and growing fairly rapidly at about 1% annually. The median age is just 22 years, and fully 35% of Jordan's population is under the age of 15. 98% of Jordan's population is ethnically Arab, and nearly 80% live in urban areas.[37]

Jordan has a constitutional monarchy and is ruled by Kind Abdullah II. It is also the only country in the Jordan River Basin that has established peaceful relations with Israel. Jordan has one of the smallest economies in the Middle East, which is largely due to its limited natural resources, and the country faces chronic high rates of poverty, unemployment, inflation, and a large budget deficit. GDP is estimated at just $33.79 billion, albeit with a 3.2% annual growth rate in 2010. GDP per capita is $5,300, and 14% of the population falls below the poverty line.[38]

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[33] CIA World Factbook: Israel. 2011.
[34] Grossman, G/ "Chapter 2.4: Renewable Energy Policies in Israel." *Handbook of Energy Efficiency and Renewable Energy,"* 2007. Ed. by Kreith, F. and Goswani, Y.
[35] "ESCWA Water Development Report 1: Vulnerability of the Region to Socio-Economic Drought." United Nations Economic and Social Commission for Western Asia, 2005. Page iii.
[36] *IPCC Fourth Assessment Report: Climate Change 2007.* "Asia: Regional Characteristics."
[37] CIA World Factbook: Jordan. 2011. https://www.cia.gov/library/publications/the-world-factbook/geos/jo.html. Accessed 4 May 2011.

2.4. c. Syria

Syria lies to the north of Jordan and northwest of Israel, and includes about 1,300 square kilometers of Israeli-occupied territory in the Golan Heights on the Israeli border. Syria is primarily a semiarid desert plateau, with a narrow coastal plain and mountains in west. The Euphrates River also runs through the northern half of the country, which allows Syria access to 1,540 cubic meters of available water resources per capita per year.[39] However, Syria's water supply is coming under increasing stress, largely as a result of rapid population growth, industrial expansion, water pollution, and economic dependence on water-intensive agriculture. In addition, Syria's freshwater supply from the Euphrates River has been limited by upstream projects in Turkey, which are predicted to reduce up to 70% of the Euphrates' flow to Syria in the coming years.[40]

Figure 9: Map of Syria

Syria is the most populous country in the Jordan River Basin with a population of roughly 22.5 million people. Syria is also a young country, with a median age of 22 years and 35% of the population below the age of 15. 90% of Syrians are ethnically Arab, and in addition, about 20,000 Israeli settlers live in the Golan Heights occupied territory.[41] Syria is currently ruled by an authoritarian regime under President Bashar al-Assad, although in recent months, mass civilian protests against the government have broken out within the country. The government of President Assad has responded harshly by firing at peaceful protesters and cracking down on dissent.

Syria's economy has maintained a fairly robust annual growth rate of between 4 and 5% annually despite the global recession. Syria is the only country in the Jordan River Basin with significant oil reserves, which allows the country to be a net-energy exporter.[42] However, Syria's GDP is still only $106.4 billion, placing GDP per capita at just $4,800. Syria's unemployment rate is also about 8.5% and roughly 12% of it population lives below the poverty line. Other economic constraints include declining oil production, rising budget deficits, and increasing pressure on its water supplies.[43]

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[38] CIA World Factbook: Jordan. 2011.
[39] *IPCC Fourth Assessment Report: Climate Change 2007*. "Asia: Regional Characteristics."
[40] Daoudy, Marwa. "Syrian-Turkey Hydrodiplomacy." *Syria Today*, April 2011. http://www.syria-today.com/index.php/focus/5260-syrian-turkish-hydrodiplomacy. Accessed 6 May 2011.
[41] CIA World Factbook: Syria. 2011. https://www.cia.gov/library/publications/the-world-factbook/geos/sy.html. Accessed 6 May 2011.
[42] "Country Analysis Brief: Syria." U.S. Energy Information Agency, 2010. http://www.eia.doe.gov/countries/country-data.cfm?fips=SY. Accessed 6 May 2011.
[43] CIA World Factbook: Syria. 2011.

2.4. d. Lebanon

Lebanon is a small country, about half the size of Israel, located to the west of Syria and north of Israel. The terrain is mountainous and receives high levels of precipitation, providing the country with more than 1,200 cubic meters of available water per capita each year.[44] However, the rugged terrain has also allowed numerous factional groups to develop throughout the country that has fueled a history of violent conflict.

Figure 10: Map of Lebanon

Lebanon has a population of about 4 million people, nearly half of whom live in the capital city of Beirut. Lebanon is 95% Arab; however, the population is divided between a number of clans and religions, which helped fuel a 15-year civil war in the country from 1975-1990.[45] The most recent demographic survey conducted indicates the makeup of the population is currently 27% Shia Muslim, 27% Sunni Muslim, 21% Maronite Christian, 8% Greek Orthodox, 5% Druze, and 5% Greek Catholic, while the remaining 7% includes various smaller Christian denominations.[46] Lebanon's government is a republic led by Prime Minister Sa'ad al-Din al-Hariri, with a complex legislative system that balances power among Lebanon's various factions.

Lebanon once had one of the most robust economies in the Middle East, but the 1975-1990 civil war devastated Lebanon's economy, cutting national output by half. In the years since the conflict ended, Lebanon has rebuilt much of its infrastructure by borrowing heavily, which has led to a reliance on foreign aid to support its economy. In 2006, a war between Israel and Hezbollah caused an additional $3.6 billion of economic damage to the country. Political stability since 2008, however, has boosted tourism and the banking sector, Lebanon's two leading industries, and enabled a GDP growth of 7.2% per year in 2010. GDP is now estimated to be $58.6 billion, with GDP per capita at $14,200.[47]

2.4. e. The Palestinian Territories

The West Bank and the Gaza Strip have been under Israeli occupation since 1967. Palestinians have long fought for an independent state in the region, but the exact borders have remained a primary source of contention.

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[44] *IPCC Fourth Assessment Report: Climate Change 2007.* "Asia: Regional Characteristics."
[45] CIA World Factbook: Lebanon. 2011. https://www.cia.gov/library/publications/the-world-factbook/geos/le.html. Accessed 6 May 2011.
[46] "International Religious Freedom Report 2010: Lebanon." U.S. Department of State, Bureau of Democracy, Human Rights, and Labor, 2010. http://www.state.gov/g/drl/rls/irf/2010/148830.htm. Accessed 6 May 2011.
[47] CIA World Factbook: Lebanon. 2011.

The West Bank is the larger of the two Palestinian territories, located in the eastern half of Israel. The Gaza Strip is located in the southwest corner of Israel and has an area about twice the size of Washington, D.C.[48] Despite the riparian border with the Jordan River in the West Bank, Palestinians are denied direct access to the Jordan River and instead depend on water from underground aquifers and water supplies from Israel. As a result, the Palestinian territories have access to just 90 cubic meters of water per person per year, the lowest level in the Jordan River Basin.[49]

The 1993 Oslo Accords established the Palestinian Authority as a semi-autonomous, interim government for the Palestinian territories, but in the absence of a final status peace agreement, the Palestinian Authority continues to function as the governing body for the Palestinian territories. In 2007, the extremist political party Hamas seized control of the Gaza Strip from the ruling Fatah party, dividing the government between the Palestinian territories in Gaza and the West Bank. In April 2011, however, Hamas and Fatah reached a reconciliation deal and agreed to form a unity government.

Figure 11: Map of the West Bank

Figure 12: Map of the Gaza Strip

Both the West Bank and the Gaza Strip have extremely high population densities. The West Bank has a population of roughly 2.6 million people, of which 700,000 are Palestinian refugees. In addition, 500,000 Israeli settlers live in the West Bank territory and the disputed areas of East Jerusalem. The tiny Gaza Strip has a population of about 1.7 million people, more than a million of which are Palestinian refugees. The population in the Palestinian territories is also very young: 36% of the population in the West Bank is under the age of 15, and 44% of the population in the Gaza Strip is under 15, with a median age of just 18. As a result, the population of the Palestinian territories is growing rapidly, with an annual growth rate of 2.1% in the West Bank and 3.2% in Gaza.[50]

[48] CIA World Factbook: West Bank and Gaza Strip. https://www.cia.gov/library/publications/the-world-factbook/geos/we.html; https://www.cia.gov/library/publications/the-world-factbook/geos/gz.html. Accessed 10 May 2011.
[49] *IPCC Fourth Assessment Report: Climate Change 2007.* "Asia: Regional Characteristics."
[50] CIA World Factbook: West Bank and Gaza Strip. 2011.

Although the West Bank experienced economic growth in 2010, overall standard of living has not improved above 2000 levels. The economic stagnation has largely been a result of Israeli restrictions on movement and access across the Palestinian territories, which have disrupted trade and labor flows, industrial capacity, and basic commerce. Economic conditions have also worsened drastically in Gaza since Hamas seized control in 2007, after which Israel imposed restrictions and blockades that have caused a collapse of Gaza's private sector and extremely high unemployment, high poverty rates, and severe shortages of basic goods.[51]

The combined GDP for the West Bank and Gaza is about $13 billion, and GDP per capita is $2,900, the lowest in the Jordan River Basin. The unemployment rate in the West Bank stands at 16.5%, and approximately 46% of the population was below the poverty line in 2007. In Gaza Strip, the unemployment rate is 40% and an estimated 70% of the population was below the poverty line in 2009. Both Palestinian territories rely heavily on donor aid to meet basic needs, including water, sanitation, and electricity.[52]

3. A History of the Jordan River Basin

In order to move forward on sustainable energy and water development in the Jordan River Basin, it is also necessary to understand the history of the region itself. In many ways, the complicated and violent history of the Jordan River Basin also proves the necessity of finding new means to promote cooperation and peace in the region.

3.1. Historical and Religious Significance of the Jordan River Basin

Figure 13: Baptism on the Jordan River

The Jordan River has great religious significance for Christianity, Islam, and Judaism, making it an important cultural symbol for over half of the world's population.[53] Christians believe that John the Baptist baptized Jesus in the waters of the Jordan River, and all three religions believe Moses delivered the Ten Commandments here. As a result, hundreds of thousands of tourists visit the Jordan River every year to be baptized in its waters and visit other holy sites.[54] Therefore, ensuring sustainable management of the Jordan River is important not just to protect the environment and guarantee freshwater supplies in the Jordan River Basin, but also to preserve an important historical site.

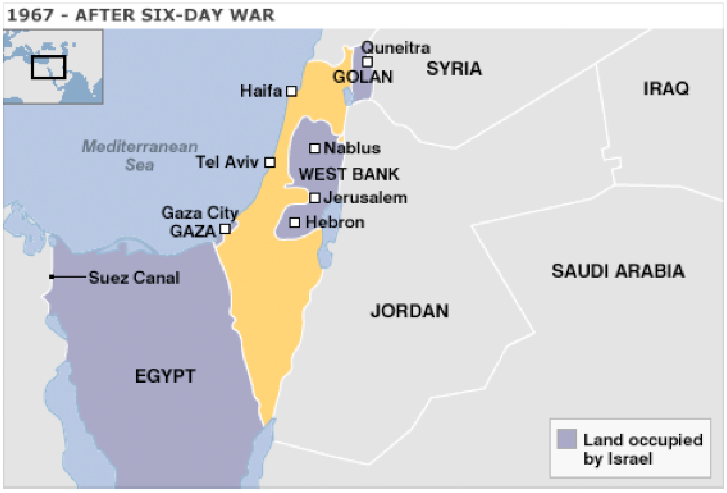
[51] CIA World Factbook: West Bank and Gaza Strip. 2011.
[52] Ibid.
[53] Gafny, Talozi, Sheikh, and Ya'ari, page 20.
[54] Ibid., page 16.

3.2 A History of Conflict in the Jordan River Basin

Over the past 60 years, the site that gave rise to three of the world's most important religions has also witnessed five major wars and dozens of violent clashes. This history of conflict has imposed significant economic, political, and environmental costs that severely limit the development of water and energy resources in the Jordan River Basin. The roots of the conflict extend to the British Mandate of Palestine, when an influx of Jewish immigrants began to settle alongside existing Palestinian Arab populations, both of which hoped to establish an independent state in the region. When the British Mandate ended in 1948, Arab armies invaded to fight the Jewish settlers. The outcome of this war established the general borders of Israel, the West Bank, and the Gaza Strip and displaced hundreds of thousands of Palestinians.

Israel and the Arab states fought additional wars in 1956, 1967, and 1973. In 1967, tensions rose between Israel and its neighbors partly in response to Syrian plans to divert the Jordan River.[55] Israel won a resounding victory against the Arab states in what came to be known as the "Six Day War," capturing control of and seizing water rights to the Sinai Peninsula in Egypt, the Shebaa Farms in Lebanon, the Golan Heights in Syria, and the Gaza Strip, the West Bank and eastern Jerusalem. The results of this war continue to impact the region's geopolitical relations to this day, and Israel still occupies parts of the West Bank, the Shebaa Farms, and the Golan Heights.

Figure 14: The Six Day War



During this time, the Palestinians organized a political arm called the Palestinian Liberation Organization ("PLO"), which also carried out attacks against Israel. However, the PLO failed to establish an independent Palestinian state in the region, even as Palestinians living in the occupied territories grew increasingly frustrated with the Israeli occupation.[56] In 1987, the First Intifada broke out, which was a popular uprising in the Palestinian territories against the Israeli occupation and lasted until the Oslo Peace Accords were signed in 1993. The Oslo Accords paved a way forward for Israel to hand over full control of the West Bank and Gaza to the Palestinians and included water and electricity sharing agreements.[57] The outbreak of the Second Intifada in 2000, however, derailed implementation of the Oslo Accords, including many of the water and energy arrangements. In addition, large-scale Israeli attacks on Palestinian

[55] Wolf, A. et al. "Chapter 5: Managing Water Conflict and Cooperation," in *State of the World 2005: Redefining Global Security*. http://tbw.geo.orst.edu/publications/. Accessed 23 May 2011.
[56] "From the First Intifada to the Oslo Peace Agreement." *The Mideast: A Century of Conflict.* National Public Radio, 7 October 2002. http://www.npr.org/news/specials/mideast/history/transcripts/num.6-from_intifada-2002-10-07.html. Accessed 26 April 2011.
[57] "Declaration of Principles on Interim Self-Government Arrangements," 13 September 1993. http://www.jewishvirtuallibrary.org/jsource/Peace/dop.html. Accessed 26 April 2011.

towns in response to the uprising destroyed much of the existing energy and water infrastructure.[58] When extremist group Hamas forcefully gained control over Gaza in 2007, Israel responded with a month-long air attack from December 2008 to January 2009 and a harsh trade blockade, which have further devastated energy and water supplies in the Gaza Strip.

Figure 15: The First Intifada

Israel also fought two wars in Lebanon, first in 1982 to expel the PLO from Beirut, and a second in 2006 in an attempt to shut down rocket attacks into Israel from the extremist Shi'ite Muslim group Hezbollah. Both wars caused immense destruction to Lebanon's water and energy infrastructure, which had already been damaged from years of civil war.

The countries in the Jordan River Basin remain in various states of conflict, and over the years, cooperation on water and energy issues has often been thwarted by violence and mistrust. It is therefore easy to see why many are critical of the potential for sustainable development in the Jordan River Basin. However, as issues of water and energy security are exacerbated and begin threatening the social and economic fabric of the region, it will be in the best interests of Israel, Jordan, Syria, Lebanon, and the Palestinian territories to engage in cooperation on water and energy, even when they fail to do so on other issues.

4. The Game-Changer: Global Climate Change

The predicted impacts of global climate change could very well be the final impetus needed to push the Jordan River Basin to engage in cooperation on water and energy issues. Current climate models suggest that global climate change will cause the world's most water-scarce region to become even hotter and drier.[59] According to the United Nation's Intergovernmental Panel on Climate Change, average temperatures in the Jordan River Basin are expected to increase by up to 3.1 degrees Celsius in the winter and as much as 3.7 degrees Celsius in the summer, which would cause average rainfall to decrease by 20-30% over the next thirty years.[60] Climate scientists predict that this would result in further reductions to the Jordan River's flow, a decrease the recharge rates of natural aquifers, cause desertification of arable land and soil erosion along the Mediterranean coast, and increase unpredictability of climatic events.[61]

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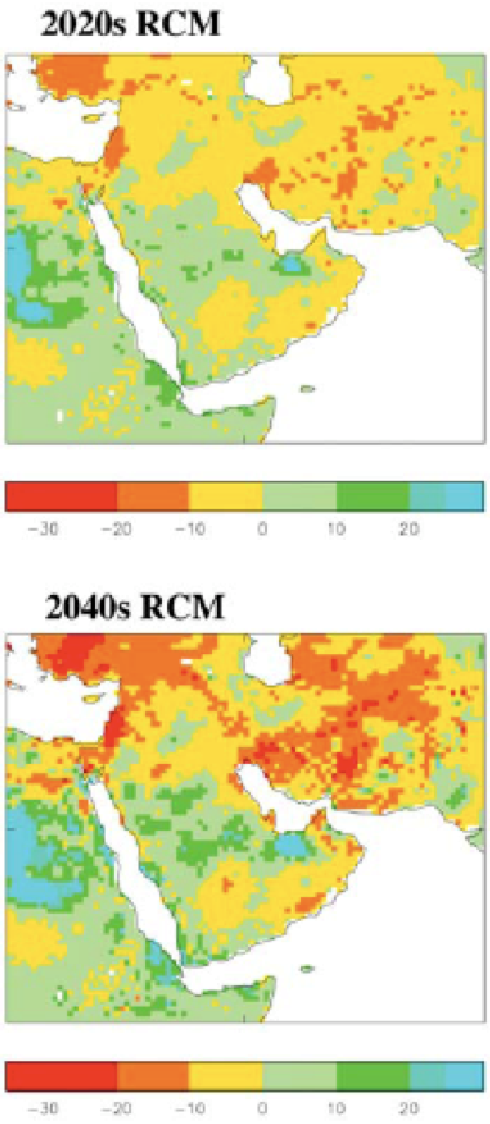
[58] "Troubled Waters: Palestinians Denied Fair Access to Water." Amnesty International, 2009. Page 10. http://www.amnesty.org/en/news-and-updates/report/israel-rations-palestinians-trickle-water-20091027. Accessed 11 May 2011.
[59] Brown, Oli and Alec Crawford, page 6.
[60] Cruz, et al. "Chapter 10: Asia," *IPCC Fourth Assessment Report: Climate Change 2007*. United Nations Intergovernmental Panel on Climate Change, 2007. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10.html. Accessed 13 May 2011.
[61] Brown, Oli and Alec Crawford, page 9.

These changes would likely have devastating impacts on the Jordan River Basin. Agriculture, which consumes an estimated 85% of water supplies in the region, will be particularly hard hit. Water scarcity and more frequent droughts would decrease agricultural yields and intensify food insecurity. [62] Paradoxically, it would also likely result in higher demands on existing water and energy resources in order to provide greater irrigation for crops.[63]

The impacts of climate change will also have serious economic consequences for the Jordan River Basin. In Israel, for example, models project that agricultural revenues will be reduced by 10% by 2050 directly as a result of climate change.[64] Tourism, which is a major source of revenue and employment in Israel, Lebanon, and Jordan, will also be seriously impacted, as the historic Jordan River is further degraded and sea level rise erodes Mediterranean beaches and coastal areas.[65] Overall, the United Nations predicts that if climate change continues unabated, the average cost in the Middle East will be a 1.9% loss of GDP.[66]

Without proper management, the effects of climate change could also have significant implications for regional security issues. For example, increasing water scarcity will complicate existing peace and water-sharing agreements, and could lead to rising tensions or competition over limited resources.[67] The effects of climate change will also likely lead to increased rates of migration, particularly into the region's already rapidly growing urban areas. Such rapid growth could foment greater instability and would undoubtedly place huge strains on existing energy and water

Figure 16: Regional Climate Model: Projections of changes (%) in precipitation from 2020-2040, relative to 1990.



[62] Bou-Zeid, E. and El-Fadel, M. "Climate change and water resources in Lebanon and the Middle East," *Journal of Water Resources Planning and Management*. September/ October 2002. http://www.siswebs.org/water/story.php?title=Climate_change_and_water_resources_in_Lebanon_and_the_Middle_East-. Accessed 13 May 2011.
[63] Brown, Oli and Alec Crawford, page 22.
[64] Kan I. et al. "Assessing Climate Change Impacts on Water, Land-Use and Economic Return in Agriculture." *Agricultural & Natural Resource Economics*, December 2007. http://www.economicsclimatechange.com/2007/10/ssessing-climate-change-impacts-on.html. Accessed 13 May 2011.
[65] Brown, Oli and Alec Crawford, page 24.
[66] Granit, J. "Water and Energy Linkages in the Middle East." *Middle East Seminar Report from World Water Week 2009*. http://www.siwi.org/sa/node.asp?node=52&skip=20&sa_content_url=%2Fplugins%2FResources%2Fresource.asp&id=61. Accessed 24 May 2011.
[67] Ibid, page 21.

infrastructure in cities, which is already under severe stress.[68] The likely combination of higher unemployment, reduced government revenue, and increased demands on services could be a severely destabilizing force throughout the region.

In light of these threats, it will be necessary to achieve cooperation within the Jordan River Basin to achieve sustainability along the water-energy nexus to combat global climate change. As water resources are further constrained in the coming years, Israel, Jordan, Syria, Lebanon, and the Palestinian territories will need to collaborate to manage the Jordan River and their shared aquifers. Investments in clean, renewable energy and the interconnection of electrical grids are necessary both to meet higher energy needs and to curb the impacts of climate change. Therefore, to begin working towards these goals, it is first necessary to examine the current status of water and energy development in the region.

5. Water Resource Management in the Jordan River Basin

To meet the region's growing water supply needs, water resources have been highly developed within the Jordan River Basin over the years. In general, sustainable management of these resources has given way to large infrastructure projects and unsustainable practices, which are now exacerbating regional water scarcity by depleting the region's nonrenewable sources. In recent years, some efforts have been made to better coordinate management of shared water resources, but more must be done to achieve sustainability.

5.1. Water Resource Development on the Jordan River

An estimated 1.3 billion cubic meters of water once flowed annually from the Jordan River into the Dead Sea, but decades of development have reduced the Jordan River to a tiny trickle of its original flow. The first efforts to manage the Jordan River began in 1932 with the construction of the Degania Dam at the southern exit of Lake Tiberius, which supplied hydroelectricity to the British Mandate of Palestine and regulated water flows into the Jordan River for the first time.[69] In the following years, Jewish and Arab constituencies undertook various water diversion projects to irrigate farmland and control seasonal flooding, although these were generally minor, small-scale projects.[70]

Figure 17: The National Water Carrier
(shown in red)

In 1964, Israel completed the first major water diversion project from the Jordan River, called the National Water Carrier, as part of the Zionist goal of

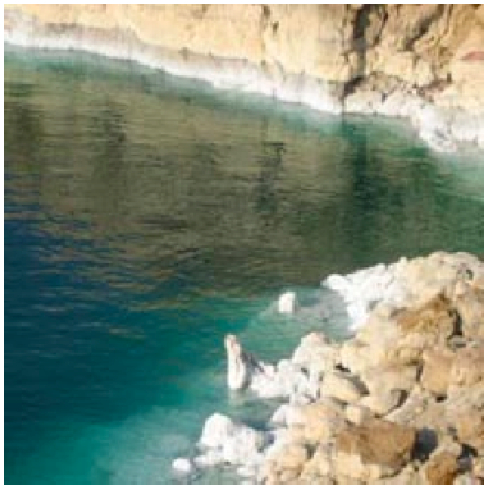
[68] Brown, Oli and Alec Crawford, page 26.
[69] Avitzur, S. "The Power Plant on Two Rivers." Israel Ministry of Foreign Affairs, 2003. http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2003/5/The%20Power%20Plant%20on%20Two%20Rivers. Accessed 16 May 2011.
[70] Gafny, Talozi, Sheikh, and Ya'ari, page 23.

"making the desert bloom." The massive project diverted water directly out of Lake Tiberius (Sea of Galilee) and delivered it to arid regions in the south and west of Israel, greatly reducing flows from the lake into the Jordan River. Three years later, Israel also completed a bypass canal to divert saline tributaries away from Lake Tiberius and directly into the lower Jordan River, reducing the salinity of water delivered by the National Water Carrier, but dramatically increasing the salinity of the Jordan River.

Jordan undertook its own water diversion project in 1966, called the King Abdullah Canal, which diverted additional water from the Jordan River for agricultural and domestic needs in Jordan. The final stage of this project was completed in 1987, after which the Yarmouk River essentially became the Jordan River's only source of freshwater. As a result, the Jordan River was reduced to just 10% of its original flow.[71]

Then, in 2007, Syria and Jordan completed construction of the Unity Dam on the Yarmouk River, which eliminated the remaining flows from the Yarmouk River into the Jordan River. This project further reduced the Jordan River's flow to an estimated 20-30 million cubic meters annually, or just 2% of its original flow.[72] Overall, the annual diversion rates of the Jordan River and its tributaries are now estimated at 46.47% by Israel, 25.24% by Syria, 23.24% by Jordan, and 5.05% by the Palestinian Authority.[73]

Figure 18: Water Level Drop in the Dead Sea



While these diversion projects have helped fuel development throughout the region, the cumulative impact is unsustainable, threatening the continued existence of the Jordan River and creating serious economic and environmental consequences for the Jordan River Basin. The Jordan River's ecosystem has lost about 50% of its historical biodiversity and suffers from high salinity and severe water pollution. Ironically, parts of the Jordan River would now run completely dry if not for the discharge of raw sewage into its waters.[74] In addition, the Dead Sea, another popular tourist destination, has seen its water level drop at an alarming rate, losing fully one-third of its surface area and falling 25 meters over the past century.[75]

The various water diversion projects on the Jordan River are also extremely energy-intensive, thus further exacerbating water scarcity by contributing to global climate change. Israel's National Water Carrier, for example, requires significant amounts of energy to lift water over a mountain range from 200 meters below sea level at Lake Tiberius to 150 meters above sea level, after which the system uses gravity to deliver water throughout the south and west. The National Water Carrier consumes approximately 100 megawatts of electricity per hour, or

[71] Gafny, Talozi, Sheikh, and Ya'ari, page 23-25.
[72] Ibid., page 25.
[73] Ibid., page 15.
[74] Ibid., page 13.
[75] "The Dead Sea." Friends of the Earth Middle East. http://foeme.org/www/?module=projects&project_id=21. Accessed 16 May 2011.

roughly 4% of all the electricity produced in Israel.[76] It is powered mainly by fossil fuels such as coal and natural gas, which not only exacerbates global climate change, but also undermines energy security in a region of scarce energy resources.

5.2 Planned Development in the Jordan River Basin

As demand for water increases, new projects are also being developed to provide additional supplies of water throughout the Jordan River Basin. Many of these projects are similarly energy-intensive, and are predicted to have significant adverse impacts on the environment, which may often outweigh their benefits.

One of these projects is the proposed Red Sea-Dead Sea Water Conveyance Project. The proposed canal would pump seawater from the Red Sea, through the Gulf of Aqaba, to the Dead Sea 110 miles to the north. The project is supposed to replenish water to the declining Dead Sea, and along the way, generate hydroelectricity and provide freshwater through desalination for both Jordan and Israel. The massive project would take up to 20 years to complete and would cost an estimated $5 billion.[77] Significant environmental concerns have been raised over the project, however, including questions about the effect on the fragile coral reefs in the Gulf of Aqaba, the impact of discharging brine from desalination into the Dead Sea, and the overall energy costs of the project.[78] The World Bank is currently conducting a feasibility study to assess environmental impacts of the conveyance project, but Jordan and Israel have each announced competing projects that seem to preempt the World Bank project study.

Figure 19: The Red Sea-Dead Sea Water Conveyance Project

Other major saltwater desalination projects have also become prevalent throughout the Jordan River Basin as a means of supplementing dwindling water supplies. Israel in particular has invested heavily in desalination, with five large plants built or in the works along the Mediterranean coast and 31 smaller facilities in the south. These currently provide 15% of Israel's domestic water supply, but planned facilities could eventually provide as much as 50% of Israel's potable water.[79]

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[76] "Israel's Water Supply System." Mekorot website, 2011. http://www.mekorot.co.il/Eng/Mekorot/Pages/IsraelsWaterSupplySystem.aspx. Accessed 4 May 2011.
[77] "The Red-Dead Conduit." Friends of the Earth Middle East website, 2011. http://foeme.org/www/?module=projects&project_id=51. Accessed 16 May 2011.
[78] "The Red-Dead Conduit." Friends of the Earth Middle East website, 2011.
[79] Dreizin, Y. et al. "Integrating large scale seawater desalination plants within Israel's water supply system." Sponsored by the European Desalination Society and Center for Research and Technology Hellas. www.sciencedirect.com. Accessed 16 May 2011.

Significant concerns have also been raised about such heavy reliance on desalination, including the environmental impacts of discharging brine and chemicals into marine ecosystems and the public health impacts of high boron concentrations in desalinated water. In addition, there are major concerns over the enormous amount of energy required for the desalination process.[80] A typical reverse osmosis desalination system, for example, uses three to seven kilowatt hours of energy to produce one cubic meter of fresh water.[81]

Figure 20: Ashkelon Desalination Plant

In Israel, the Ashkelon desalination plant, the largest desalination plant in the world, uses 500,000 megawatt-hours of energy per year to produce roughly 110 million cubic meters of fresh water.[82] Putting this into perspective, operating the equivalent of five of these plants, which Israel plans to do, will constitute more than 1% of Israel's total energy consumption based on 2008 levels.[83] Therefore, expanding the operation of desalination plants would indeed help address water scarcity in the Jordan River Basin, but it would also mean huge increases in the region's total energy usage.[84]

5.3 Additional Water Resources in the Jordan River Basin: Shared Aquifers

Besides the Jordan River, the only other natural water source in the Jordan River Basin are several underground aquifers, which provide important additional supplies of water through a series of disparate and separately managed wells. The most important of these aquifers is the Mountain Aquifer, which lies under the entirety of the West Bank and a large part of Israel and is actually made up of three smaller aquifers: the Western Aquifer, North Eastern Aquifer, and Eastern Aquifer. Four-fifths of the Mountain Aquifer is replenished by precipitation in the West Bank, but the water flows outwards into Israel and the majority of the withdrawals take place in Israeli territory or in Israeli settlements in the West Bank.[85] The renewable yield of the

[80] Garb, Y. "Desalination in Israel: Status, Prospects, and Contexts." *Water Wisdom: Preparing the Groundwork for Cooperative and Sustainable Water Management Between Israelis and Palestinians*, 2010. http://bgu.academia.edu/yaakovGarb/Papers/267091/_YAML_Syck_MergeKey_0xb4ecf39c_Desalination_In_Israel_Status_Prospects_and_Contexts_. Accessed 16 May 2011.
[81] Zander, A. et al. "Desalination: A National Perspective." National Research Council of the National Academy of Sciences, 2008. http://www.nap.edu/openbook.php?record_id=12184&page=R1. Accessed 16 May 2011.
[82] "Ashkelon Seawater Seawater Reverse Osmosis Plant (SWRO), Israel." Water-Technology.net. http://www.water-technology.net/projects/israel/. Accessed 16 May 2011.
[83] Based on energy consumption data from the U.S. Energy Information Administration. http://www.eia.doe.gov/countries/country-data.cfm?fips=IS. Accessed 16 May 2011.
[84] Garb, Y. "Desalination in Israel: Status, Prospects, and Contexts."
[85] Weinthal, E. and Marei, A. "One Resource, Two Visions: The prospects for Israeli-Palestinian Water Cooperation." *Water International*, Vol. 27, No. 4. December 2002.

Mountain Aquifer is estimated between 679 and 887 million cubic meters of water per year, but current withdrawals are about 50% more than the aquifer's renewable potential.[86]

In addition, the Coastal Aquifer is an important source of freshwater for Israel and the sole source of freshwater for Gaza. The Coastal Aquifer is located under the coastal plain of Israel and the Gaza Strip and has a renewable yield of between 360 and 420 million cubic meters per year, 57 million cubic meters of which are located in Gaza. Like the Mountain Aquifer, the Coastal Aquifer is also being pumped at an unsustainable rate: in Gaza, the overdraft is estimated to be 100 million cubic meters per year, or almost 200% more than the aquifer's renewable potential. This has resulted in a continual decline of the aquifer's water level and severe water pollution from saltwater intrusion and sewage infiltration. In Gaza, 90-95% of the water from the aquifer is now unfit for human consumption, based on World Health Organization standards.[87]

Figure 21: Aquifers in the Jordan River Basin

There are additional smaller underground aquifers in the Jordan River Basin, including the Western Galilee and Carmel Aquifers in northern Israel and the Negev-Aravah Aquifer in southern Israel, which have no reliable figure for renewable yields.[88] To the east, Jordan and Syria also share the Azraq Aquifer, where overdraft has caused the water table to sink as much as 20 meters and created the risk of severe saltwater intrusion.[89] Jordan is attempting to supplement water supplies to its capital city, Amman, by constructing an expensive water pipeline from the non-

[86] "West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page 11. http://www.source.irc.nl/page/48226. Accessed 11 May 2011.
[87] "West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page 27.
[88] "Troubled Waters: Palestinians Denied Fair Access to Water." Amnesty International, 2009. Page 10. http://www.amnesty.org/en/news-and-updates/report/israel-rations-palestinians-trickle-water-20091027. Accessed 11 May 2011.
[89] "Azraq Oasis Restoration Project." International Union for Conservation of Nature website, 2011. http://www.iucn.org/about/union/secretariat/offices/rowa/iucnwame_ourwork/iucnwame_reward/iucnwame_azraqoasisdialogue/. Accessed 16 May 2011.

renewable Disi Aquifer, which lies underneath the border between Jordan and Saudi Arabia. The project must be a temporary solution, however, because the Disi Aquifer will be completely depleted in 50 years if the project moves forward as planned.[90]

5.4 Current Water-Sharing Agreements in the Jordan River Basin

While most water development within the Jordan River Basin is not coordinated on a regional scale, several water-sharing agreements do exist to help manage the water resources in the region. Two of the most important agreements are the Oslo II Accords between Israel and the Palestinian territories and the 1994 Israel-Jordan Peace Treaty.

- **Article 40 of the Oslo II Accords**

Article 40 of the Oslo II Accords, signed in 1995, is the first water-sharing agreement between Israel and the Palestinian Authority. Article 40 was meant to last for a five-year interim period until Israel and the Palestinian Authority reached a final status peace agreement, but in the absence of such an agreement, it continues to be the prevailing water-sharing arrangement between Israel and the Palestinian territories.

Under Article 40, a Joint Water Committee was set up to coordinate water and sewage management between Israel and the Palestinian territories, with decisions about water development to be based on a consensus. Article 40 also allocates specific quantities of water for Israel and the Palestinian territories from the shared Mountain Aquifer, although it denies the Palestinians any direct access to the Jordan River. It also hands responsibility to the Palestinian Authority for maintaining water infrastructure and services. Under the agreement, Israel is allocated roughly 80% of the Mountain Aquifer's renewable yield, and the West Bank is allocated the remaining 20%, with the acknowledgement that an additional 100 million cubic meters of freshwater must be developed in the Palestinian territories to meet the growing need.[91]

Figure 22: Article 40 Allocations from the Mountain Aquifer
(in millions of cubic meters)

		Article 40 allocation		
Aquifer	**"Estimated potential"**	**Total Palestinian**	**Total Israeli**	**Total**
Western	362.0	22.0	340.0	362.0
North Eastern	145.0	42.0	103.0	145.0
Eastern	172.0	54.0	40.0	94.0
Eastern (unallocated)				78.0
Total	**679.0**	**118.0**	**483.0**	**601.0**

[90] Mahsaneh, D. "Bring the People to Disi not Disi to the People." Jordan Business Magazine, 2007. http://www.jordan-business.net/magazine/index.php?option=com_content&task=view&id=76&Itemid=40. Accessed 16 May 2011.
[91] West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page 33-34.

Article 40 has at times been held up as an example of how environmental cooperation can help build trust and peace in the Middle East region. Indeed, the Joint Water Committee is only one of two joint committees set up under the Oslo process that continued to meet throughout the Second Intifada. However, there are also serious concerns about both the equity and the environmental sustainability of the existing arrangement. Fourteen years after Oslo II was signed, the availability of water in the Palestinian territories still lags far behind availability in Israel. In fact, Israel has more than four times the amount of freshwater per capita than the West Bank, and water withdrawals per capita have actually declined since Oslo II.[92] Domestic water supply in the West Bank averages just 50 liters per capita per day,[93] which is half of the 100 liters recommended by the World Health Organization to meet basic human needs for consumption and hygiene.[94] Water supply is also highly variable and discontinuous, meaning that some populations receive as little as 10-15 liters per capita per day.[95]

In addition, the over-withdrawal of water supplies and inadequate waste management under Article 40 are draining renewable water resources and taking a huge toll on the environment. Israel withdraws 80% of the Mountain Aquifer's renewable yield, and in addition, overdraws 50% more than the aquifer's estimated potential, which is 1.8 times its allocation under Article 40.[96] As a result, the Mountain Aquifer is being depleted at an alarming rate, which further limits water supply and could lead to saltwater infiltration from surrounding saltwater sources.[97] Compounding these issues further, there has been little progress on wastewater collection and treatment since Oslo II: only 31% of Palestinians in the West Bank are connected to a sewage network, and an estimated 25 million cubic meters of raw sewage per year is being discharged untreated into the environment.[98] The result is contamination of water sources that further limits supply and causes severe pollution of the environment.

Figure 23: Israeli and Palestinian Withdrawal Rates from the Mountain Aquifer (1999)

		Abstractions			Excess over Article 40 allocation		
Aquifer	**"Estimated potential"**	**Total Palestinian**	**Total Israeli**	**Total Abstracted**	**Palestinian [26]**	**Israeli**	**Total over-extraction**
Western	362.0	29.4	591.6	621.0	7.4	251.6	259.0
North Eastern	145.0	36.9	147.1	184.0	(5.1)	44.1	39.0
Eastern	172.0	71.9	132.9	204.8	(2.6)	92.9	90.3
Total	**679.0**	**138.2**	**871.6**	**1,009.8**	**(0.3)**	**388.6**	**388.3**

[92] West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page 14. This decline has occurred despite the fact that there has been a 50% increase in the number of Palestinians with freshwater access. The reason for this is because water supply expansion has not kept pace with high Palestinian population growth in the West Bank, which has increased by 40% since Oslo II was signed in 1995.
[93] Ibid., page v.
[94] Howard, G. and Bartram, J. ""Domestic Water Quantity: Service Level and Health." World Health Organization, 2003. http://www.who.int/water_sanitation_health/diseases/wsh0302/en/. Accessed 17 May 2011.
[95] "West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page v.
[96] Ibid, page v.
[97] "Troubled Waters: Palestinians Denied Fair Access to Water." Amnesty International, page 10.
[98] "West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page v-vi.

In 2009, the World Bank conducted an in-depth study to assess Israeli and Palestinian water sector development, which concludes that a combination of inequitable management structures under Article 40 and weaknesses in Palestinian institutions have caused the currently unsustainable situation. In particular, the study concludes that despite the appearance of joint management committee, Israel ignores many of its water-sharing obligations and exercises de facto control over shared resources through restrictions on Palestinians in the occupied territories and a complex permitting system that constrains Palestinian water sector development.[99] At the same time, the Palestinian Authority has failed to adequately maintain its existing water infrastructure or invest in water conservation measures, which allows scarce resources to be wasted.[100] Therefore, in order to improve water supplies and to protect the environment, changes to the water-sharing agreement under Article 40 will be necessary.

- **Article 6 of the 1994 Israel-Jordan Peace Treaty**

The water-sharing arrangement under Article 6 of the Israel-Jordan Peace Treaty is an essential component of the 1994 peace agreement that normalized relations between Jordan and Israel, which was only the second Arab country to do so after Egypt signed a peace treaty with Israel in 1978. Article 6 sets up a complex system of water transfers between Israel and Jordan and commits the two countries to cooperate to alleviate water shortages, develop new water resources, and prevent contamination of existing resources. To achieve these goals, the agreement creates a Joint Water Committee to oversee implementation of the treaty and resolve any future water-related issues that may arise.[101]

Article 6 declines to mention "water rights" between Israel and Jordan, thus avoiding vague and sometimes contradictory international water laws,[102] and instead, sets up a system of water allocation and transfers using specific quantities, times, and locations. Article 6, Annex II grants Israel specific flows from the Yarmouk River and allows Israel to pump additional flows from the River in the winter. In exchange, Jordan is able to pump 20 million cubic meters from Lake Tiberius during the summer using a pipeline constructed by Jordan that is located partly on Israeli territory. In addition, Jordan is entitled to 20 million cubic meters of water from the Jordan River south of the Yarmouk River and 10 million cubic meters of water either directly from Lake Tiberius or from desalination of northern saline springs. In exchange for the total of

Figure 24: Water from Lake Tiberius Piped to the King Abdullah Canal in Jordan

[99] "West Bank and Gaza: Assessment of Restrictions on Palestinian Water Sector Development." The World Bank, page 33-34.
[100] Ibid., page 39.
[101] "Israel-Jordan Peace Treaty." Israel Ministry of Foreign Affairs website, 1994. http://www.mfa.gov.il/MFA/Peace+Process/Guide+to+the+Peace+Process/Israel-Jordan+Peace+Treaty.htm. Accessed 20 May 2011.
[102] Shamir, U. "Water Agreements between Israel and its Neighbors." *Transformations of Middle Eastern Natural Environments: Legacies and Lessons,* Number 103, Bulletin Series. Yale School of Forestry and Environmental Studies, 1998. Page 277.

50 million cubic meters of water provided to Jordan, Annex II allows Israel to pump groundwater from wells in the Arava Valley, part of which lie in Jordanian territory.[103] In addition, Article 6 also commits to finding an additional 50 million cubic meters of water supply for Jordan, although it does not specify the sources of this additional allocation.[104]

In effect, Article 6 allows Jordan to store winter runoff in Lake Tiberius in Israel, the only major surface reservoir in the region, and in exchange, Israel is allowed to use land located in Jordan for groundwater wells and conveyance systems.[105] Article 6 therefore provides an example of how cooperation over environmental issues can be part of a means toward building greater trust and peace between rival states. The agreement is particularly unique in that it interlinks the water supply systems of the two countries and allows entry of each country into the territory of the other, causing Israel and Jordan to become mutually reliant on each other for their water supply.[106]

However, there are also problems with the current arrangement, the most significant of which is the fact that it sets transfers in terms of volume instead of percentage, which has given rise to complications during periods of drought when limited water supplies are further constrained.[107] In addition, despite commitments to water conservation within the agreement, Jordan in particular has not adequately invested in conservation and efficiency measures. It is estimated that Jordan currently loses 51% of its water supply to ageing water infrastructure, lack of social awareness, and to water theft.[108] These issues will need to be addressed to achieve true sustainable water management under Article 6 of the Israel-Jordan Peace Agreement.

6. Energy Sector Development in the Jordan River Basin

As global climate change accelerates and water scarcity increases within the Jordan River Basin, a necessary component of sustainable management of water resources includes new investment in renewable energy sources to meet the resulting energy demands. Fortunately, the Jordan River Basin has vast solar energy potential that has only just begun to be tapped, and the region can benefit greatly from establishing electrical grid interconnections to pool its energy resources. There has been some progress in this effort so far, but much more will need to be done in the future to realize the region's true renewable energy potential.

6.1 Current Energy Trends in the Jordan River Basin

Even as energy and electricity demands in the Jordan River Basin soar, the energy sector in the Jordan River Basin is dominated by primarily by nonrenewable fossil fuels that are

[103] Israel-Jordan Peace Treaty: Annex II." Israel Ministry of Foreign Affairs website, 1999. http://www.mfa.gov.il/MFA/Peace%20Process/Guide%20to%20the%20Peace%20Process/Israel-Jordan%20Peace%20Treaty%20Annex%20II. Accessed 20 May 2011.
[104] "Water Conflict and Cooperation/Jordan River Basin, Part II." Waterwiki.net website, 2003. http://waterwiki.net/index.php/Water_Conflict_and_Cooperation/Jordan_River_Basin_Part_II. Accessed 20 May 2011.
[105] Medzini, A. and Wolf A. "Toward a Middle East at Peace: Hidden Issues in Arab-Israeli Hydropolitics." *Water Resources Development*, Vol. 20, No. 2. June 2004, page 203. http://www.transboundarywaters.orst.edu/publications/. Accessed 20 May 2011.
[106] Shamir, U. "Water Agreements between Israel and its Neighbors," page 279.
[107] Brown, Oli and Alec Crawford, page 21.
[108] Mahsaneh, D. "Bring the People to Disi not Disi to the People." Jordan Business Magazine, 2007.

imported from other countries. In addition to creating significant challenges for regional efforts to address global climate change, this reliance on imported fossil fuels also imposes high economic costs and undermines energy security throughout the Jordan River Basin.

Oil products are a particularly important energy source and the largest source for electricity in Lebanon and Syria, accounting for 95% and 60% of each country's respective electricity production levels.[109] Natural gas is also an important energy source in the region and is the primary energy source for electricity in Jordan. About 80% of Jordan's electricity comes from natural gas, which is supplied through the Arab Gas Pipeline from Egypt.[110] In addition, natural gas accounts for roughly 25-30% of Syria and Israel's electricity supply,[111] although this figure will soon increase in Israel with the recent discovery of significant natural gas reserves off its northern Mediterranean coast.[112] Israel also depends heavily on imported coal for its electricity, which currently supplies about 60% of the country's electricity generation.[113] The Palestinian territories, which lack basic infrastructure for any significant energy production, import nearly all of their electricity directly from Israel.[114]

Countries in the Jordan River Basin import the vast majority of their fuel sources, which often comes at significant economic cost. In Jordan, for example, energy imports in 2010 were estimated to cost the country around $3.6 billion, about 13.5% of GDP,[115] while in Israel, fuel imports cost $10 billion, or 5% of GDP.[116] At the same time, the over-reliance on fuel imports has also created major issues for energy security in the region. This is especially pronounced in the Palestinian territories, where any disruption in the Israeli market severely impacts their supply and associated costs.[117] In addition, two recent attacks on the pipeline that transports natural gas from Egypt to Jordan and Israel exposed underlying security issues when natural gas supplies were temporarily cut off to both countries. According to Jordan's Energy Minister, these attacks cost Jordan's economy $4.2 million each day while supplies were halted.[118]

Figure 25: Attack on the Arab Gas Pipeline

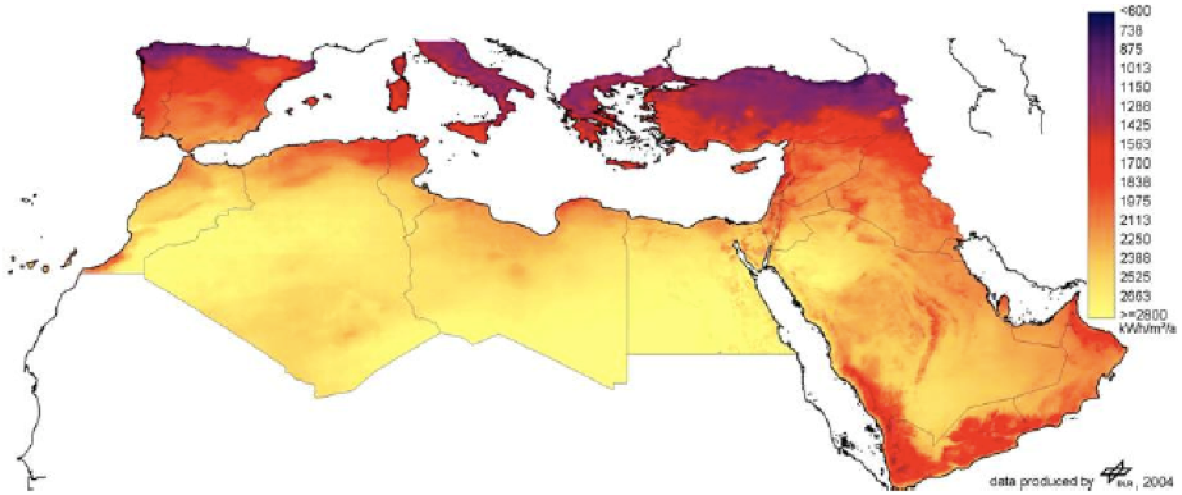
[109] International Energy Agency: Electricity/Heat Data for Lebanon and Syria, 2008. http://www.iea.org/country/index_nmc.asp. Accessed 24 May 2011.
[110] International Energy Agency: Electricity/Heat Data for Israel, Jordan, Lebanon, and Syria, 2008.
[111] International Energy Agency: Electricity/Heat Data for Israel and Syria, 2008.
[112] Bronner, E. "Gas Field Confirmed off Coast of Israel." *The New York Times*, 30 December 2010. http://www.nytimes.com/2010/12/31/world/middleeast/31leviathan.html. Accessed 24 May 2011.
[113] Economist Intelligence Unit. "Israel: Energy Report." http://www.eiu.com/index.asp?layout=homePubTypeVW. Accessed 24 May 2011.
[114] CIA World Factbook: The West Bank. 2011. https://www.cia.gov/library/publications/the-world-factbook/geos/we.html. Accessed 24 May 2011.
[115] "Minister Puts Jordan's Energy Import Bill at $3.6Bn." Middle East Economic Survey, 25 April 2011. http://www.mees.com/en/articles/1136-minister-puts-jordan-s-energy-import-bil-at-3-dolars-dot-6bn-in-2010. Accessed 27 May 2011.
[116] "Israel and its Natural Gas Resources: What a Gas!" *The Economist*, 11 November 2010. http://www.economist.com/node/17468208. Accessed 24 May 2011.
[117] Gressani, D. et al. "West Bank and Gaza Energy Sector Review." The World Bank, 2007. Page 1. http://unispal.un.org/UNISPAL.NSF/0/99A0D97F24B98A5F85257305006F3507. Accessed 25 May 2011.

6.2 Renewable Energy Potential in the Jordan River Basin

Despite the region's current reliance on nonrenewable fuels, the Jordan River Basin has vast renewable energy potential, mainly in the form of direct solar energy. In fact, the same conditions that cause water scarcity in the Jordan River Basin create ideal conditions for solar energy development: abundant sunshine, low precipitation, and large swaths of unused desert.[119]

In the greater Mediterranean region, desert land receives, on average, about 2400 kilowatt-hours of direct solar irradiance (sunlight) per cubic meter of land each year (kWh/m^2/yr), **which is more than enough energy needed to power the entire world**.[120] Although small by comparison in total land area, the Jordan River Basin receives similarly high levels of solar energy per cubic meter: Jordan leads with an average of 2700 kWh/m^2/yr, followed by Israel with 2400 kWh/m^2/yr, Syria with 2200 kWh/m^2/yr, and Lebanon with 2000 kWh/m^2/yr.[121]

Figure 26: Annual Direct Solar Irradiance in the Mediterranean Region



Given this high degree of annual direct solar irradiance throughout the Mediterranean region, only a tiny portion of total land area would be necessary to supply the growing energy needs of this region and beyond. Studies by the German Aerospace Center (DLR) indicate that just 0.3% of the desert area located in the Middle East and North Africa could provide enough

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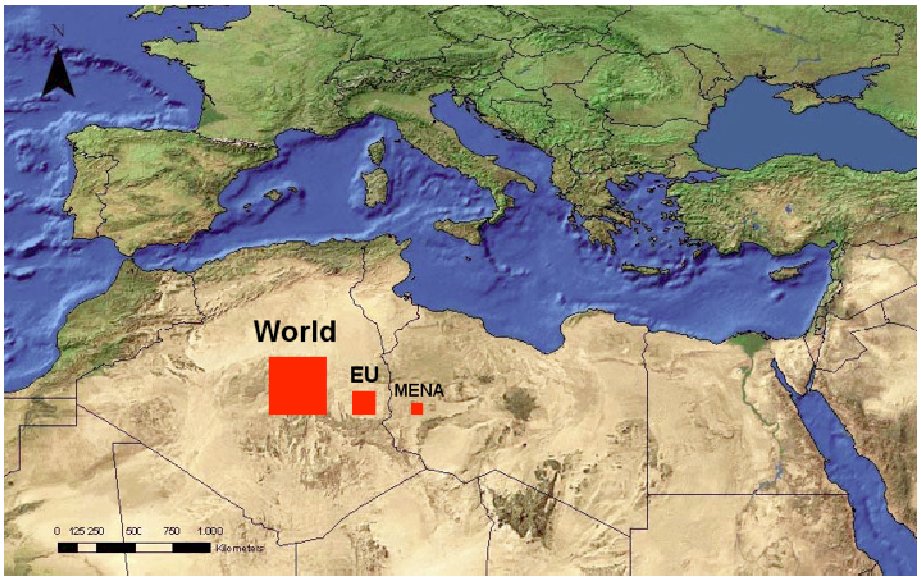
[118] "Explosion Rocks Egypt Gas Pipeline." Al Jazeera Middle East, 27 April 2011. http://english.aljazeera.net/news/middleeast/2011/04/201142734443313150.html. Accessed 25 May 2011.
[119] "Middle East and North Africa Region Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP) Projects: Forward." The World Bank, January 2011. http://arabworld.worldbank.org/content/awi/en/home/research/mena_solar.html. Accessed 25 May 2011.
[120] Trieb, F. and Muller-Steinhagen, H. "The Desertec Concept: Sustainable Electricity and Water for Europe, Middle East, and North Africa," page 29. German Aerospace Center (DLR), Institute of Technical Thermodynamics, 2008. http://www.desertec.org/en/concept/literature/. Accessed 26 May 2011.
[121] Trieb, F. et al. "Concentrating Solar Power for the Mediterranean Region," page 56. Study by German Aerospace Center (DLR), 2005. http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6562/. Accessed 29 May 2011.

electricity and desalinated seawater to meet the needs for every country in the region and for all Europe.[122] In fact, using existing concentrating solar thermal power technology, DLR estimates that deserts in the Middle East and North Africa could harvest 250 gigawatt-hours of electricity per square kilometer of land every year. Putting this into perspective, this means that each square kilometer of land receives an amount of solar energy roughly equal to 1.5 million barrels of crude oil.[123] In the Jordan River Basin specifically, solar energy could produce an estimated 17,000 terrawatt-hours of renewable electricity every year; by comparison, the region's current consumption level is less than 100 terrawatt-hours of electricity per year.[124]

Figure 27: Land Area Required to Generate Total Electricity Supply for the World, Europe, and the Middle East/North Africa
(based on 2005 levels of demand)



In addition, parts of the Middle East and North Africa have significant wind energy potential, particularly in areas around the Red Sea, which includes parts of Jordan and Syria.[125] Winds in Aqaba and the Jordan Valley, for example, reach speeds of over 7 meters per second, which translates into hundreds of megawatts of electricity generating potential.[126]

6.3 Planned and Existing Investments in Renewable Energy in the Jordan River Basin

The region's vast solar energy potential has led some countries in the Jordan River Basin to begin investing in domestic solar power and other renewable energy supplies. These investments will not only reduce the region's vulnerability to climate change, but also allow countries to diversify their energy portfolios and meet their rapidly growing energy demands.

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[122] DESERTEC Foundation. "The DESERTEC Concept." www.desertec.org/downloads/summary_en.pdf. Accessed 26 May 2011.
[123] Trieb and Muller-Steinhagen, 2008. Page 29.
[124] Goswani, Y. 2007. Page 57.
[125] DESERTEC Foundation, "The DESERTEC Concept."
[126] Al Zoubi, M. "Renewable Energy Potential and Characteristics in Jordan." *Jordan Journal of Mechanical and Industrial Engineering*, Volume 4, Number 1. January 2010.

In many ways, Israel has been a leader in renewable energy technology within the Jordan River Basin. One of the most notable successes is the widespread use of rooftop solar water heaters, which have become ubiquitous throughout Israel and have created huge energy savings for the country. Solar water heaters convert solar energy into heat for water, generally by hooking one or two solar heating panels to an insulated storage tank. Although solar water heaters have been in use in Israel since the 1950s, the Israeli government passed legislation in 1980[127] that required installation of solar water heating systems on all new buildings. Solar water heaters are now found on 90% of Israeli households save an average of 1250 kWh of electricity per year.[128] These energy savings have reduced Israel's domestic electricity consumption by an estimated 20%, and total primary energy consumption by 3%.[129] In addition, the energy cost savings from solar water heaters generally pays for the entire cost of the installation in as little as three years.[130]

Figure 28: Rooftop Solar Water Heaters in Israel

In recent years, Israel has also adopted new incentives for solar power generation as part of its target of achieving 10% renewable energy by 2020. In 2008, Israel's Public Utilities Authority approved a feed-in tariff[131] for electricity from individuals and companies installing photovoltaic rooftop solar panels to encourage private solar energy investments, but only up to a cap of 50 megawatts. This led to a "mini-boom" in Israel's solar industry and the cap was exceeded in 2010, prompting the Public Utilities Authority to add 135 megawatts to the cap.[132]

Israel has also launched a second feed-in tariff for medium-sized solar fields (50 kilowatts to 5 megawatts) with a 300-megawatt cap, and a third tariff is being developed for large solar fields (5 megawatts and up).[133] In late 2010, the Israel Public Utilities Authority and the Israel Electric Corporation signed the first solar energy power purchasing agreement (PPA) with the Arava Power Company for a 4.9-megawatt photovoltaic facility located in Israel's

[127] The mandate was passed in 1980 as Article 9 of the 1970 Law for Planning and Building.
[128] Grossman, G. "Chapter 2.4: Renewable Energy Policies in Israel." *Handbook of Energy Efficiency and Renewable Energy*. Edited by Kreith, F. and Goswani, Y., 2007. Page 28.
[129] Ibid., page 28.
[130] Winter, Rhonda. "Israel's Special Relationship with the Solar Water Heater." *Reuters Press*, 18 March 2011. http://www.reuters.com/article/2011/03/18/idUS311612153620110318. Accessed 26 May 2011.
[131] *The feed-in tariff was set at NIS 2.01 ($0.53 USD) per kilowatt hour, or four times the going price of electricity for consumers. Economist Intelligence Unit. http://www.eiu.com/index.asp?layout=homePubTypeVW.
[132] Waldocks, E. "Is the Sun Setting on the Solar Energy Boom?" *The Jerusalem Post*, 25 June 2010. http://www.jpost.com/Magazine/Features/Article.aspx?id=179386. Accessed 27 May 2011.
[133] Ibid.

Arava Desert. The agreement is worth approximately NIS 250 million ($65 million USD) and commits to purchasing all power generated for at the plant over the next 20 years at a rate of NIS 1.49 ($0.40 USD) per kilowatt-hour.[134] While the project is a modest start that represents only a tiny fraction of Israel's current electricity demand, the deal has paved the way for several other major solar projects that are now moving forward. For example, Israel's Ministry of National Infrastructure is accepting bids for two 125-megawatt concentrating solar thermal power stations in the Negev Desert, which would later be expandable to 500 megawatts, and the Israeli Electric Corporation recently approved a proposal to build an 80-megawatt solar photovoltaic field in the Arava Desert.[135]

Figure 29: Arava Power Company's 4.9-Megawatt Solar Tower Facility

In recent years, Jordan has joined Israel in making progress towards expansion of its renewable energy resources. In 2007, Jordan's government announced a new National Energy Efficiency Strategy that calls for 7% of the country's energy mix to come from renewable sources by 2015, and 10% by 2020. To meet these targets, Jordan plans to install 300-600 MW of new solar power generation and 600-1,000 megawatts of new wind generation by 2020.[136] To spur new investments and help streamline the process, Jordan passed legislation in 2010[137] that obligates Jordan's National Electric Power Company to purchase all electricity produced by renewable energy plants and to establish fixed electricity tariffs for each new facility.[138]

As a result of these policies, several promising solar and wind energy projects are in planning and development stages in Jordan. One notable solar project is the Shams Ma'an Project, a 100-megawatt photovoltaic power plant located in Ma'an that is scheduled to begin

[134] Waldocks, E. "Israel Signs Unprecedented Deal to Buy Solar Energy." *The Jerusalem Post*, 21 November 2011. http://www.jpost.com/HealthAndSci-Tech/ScienceAndEnvironment/Article.aspx?id=196163. Accessed 27 May 2011.
[135] Economist Intelligence Unit. "Israel: Energy Report."
[136] International Energy Agency, "Global Renewable Energy Policies and Measures: National Energy Efficiency Strategy." http://www.iea.org/textbase/pm/?mode=re&id=4553&action=detail. Accessed 27 May 2011.
[137] The Renewable Energy and Energy Efficiency law, passed in January 2010.
[138] Luck, T. "New Law Streamlines Renewable Energy Investment." *The Jordan Times*, 14 January 2010. http://www.jordantimes.com/?news=23153. Accessed 27 May 2011.

operation in 2012 and could expand its production to 500 megawatts.[139] Jordan was also selected as part of the ambitious, $6.4 billion World Bank/African Development Bank Concentrated Solar Power Investment Plan, which will fund nine solar power projects with at least 5 gigawatts of power generating capacity in North Africa and Jordan.[140] In addition, Jordan is planning several major wind energy projects, including a 40-megawatt wind energy facility in Kamsheh and an 80-megawatt facility in Fujeij. A recent study by Jordan's government also identifies three sites in Wadi Araba, Ma'an, and Tafileh where 400 megawatts of wind energy could be developed.[141]

Figure 30: Jordan and Syria Have Significant Wind Energy Potential

Syria and Lebanon are generally less advanced than Jordan and Israel in expanding their renewable energy portfolios, although some progress has been made. Syria will not meet its goal of 4.3% renewable energy by 2011, but the government does have a tentative plan that calls for the installation of 1,000-1,500 megawatts of wind energy, 250 megawatts of solar photovoltaic energy, and one million tons of oil equivalent (Mtoe) in solar heat by 2030. Planned projects include two wind energy facilities that will generate up to 100 megawatts of electricity, installation of solar roofs and solar water heaters on public and private buildings, and adding new photovoltaic solar panels in rural areas, which already generate about 80 kilowatts of electricity.[142] Lebanon, for its part, has pledged to introduce 12% renewable energy into its primary energy mix and has begun installing solar thermal collectors to heat water, with a goal of one million square meters of solar thermal collectors by 2020. In addition, Lebanon is looking to expand both wind and solar electricity production, but faces major obstacles primarily due to a lower solar energy potential and the continued unreliability of its electric transmission grid.[143]

The renewable energy situation in the Palestinian territories is fairly unusual due to the fact that the Palestinian Authority imports all of its fuel and 85-90% of its electricity from Israel. The Palestinian Authority has yet to take renewable energy into consideration in planning, although rooftop solar water heaters are installed on approximately 70% of households.[144]

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[139] "The World's Largest Photovoltaic (PV) Power Plant Expected to Commence Full Production by 2012 in Jordan." Ma'an Development Area press release, 27 May 2009. http://www.mda.jo/PublicNews/Press_Articles.aspx?_lang=3&cat_Id=1. Accessed 27 May 2011.

[140] "Arab World Initiative: Concentrated Solar Plan." The World Bank website, 2009. http://arabworld.worldbank.org/content/awi/en/home/initiatives/solar_power.html. Accessed 29 May 2011.

[141] Luck, T. "Southern Region Wind Energy Potential Promising." *The Jordan Times*, 17 September 2010. http://www.jordantimes.com/index.php?news=30126. Accessed 27 May 2011.

[142] Block, E. "Syria's Renewable Energy Potential." *Power-Gen Worldwide*, 1 June 2010. http://www.powergenworldwide.com/index/display/articledisplay/0415166555/articles/middle-east-energy/Volume_7/Issue_2/features/Syrias_renewable_energy_potential.html. Accessed 27 May 2011.

[143] "Lebanon to Introduce 12% Renewable Energy by 2020." *Global Arab Network*, 11 March 2010. http://www.english.globalarabnetwork.com/201003115146/Energy/lebanon-to-introduce-12-renewable-energy-by-2020.html. Accessed 27 May 2011.

[144] "Palestinian Territories." Reegle website, 2010. http://www.reegle.info/countries/PS. Accessed 27 May 2011.

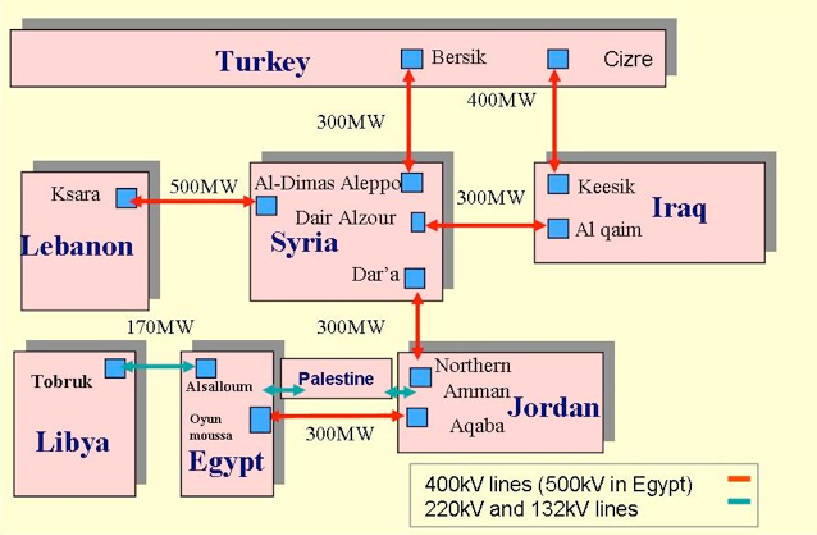
6.4 Existing Power Grid Interconnections in the Jordan River Basin

As Israel, Jordan, Syria, Lebanon, and the Palestinian territories make progress in expanding their renewable energy use, establishing cross-border electrical grid interconnections is increasingly important to maximize efficiencies through electrical power sharing. Some grid interconnections already exist, and efforts to establish new interconnections should be continued.

The first power grid interconnection in the Jordan River Basin was a bilateral connection between Lebanon and Syria that was established in 1973, and later, a second bilateral connection was built between Syria and Jordan. These projects were generally used as only backup systems in case of network outages, and trade has never reached full designed capacity. Beginning in 1993, countries in the Middle East began launching a number of new cross-border interconnection projects, including one that encompasses the Jordan River Basin.[145]

The Eight Country Grid Interconnection (EIJLLPST) project includes all of the countries in the Jordan River Basin except Israel. When complete, it will interconnect the electrical grids of Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria, and Turkey. The first stage of the project, completed in 1998, connected Egypt's and Jordan's electric grids through an underwater transmission under the Gulf of Aqaba, which currently operates at 300 megawatts. Next, Jordan and Syria constructed a second transmission line, rated at 300 megawatts, in 2001, and in 2009, Syria and Lebanon added to their existing connection with transmission line that operates at 500 megawatts. The Palestinian territories also joined the EIJLLPST grid in late 2008, connecting Gaza's power grid to Egypt and the West Bank's power grid to Jordan, although these connections remain low-voltage and supply nominal amounts of electricity.[146]

Figure 31: The Eight Country Grid Interconnection Project (EIJLLPST)



[145] "Chapter 2: Regional Integration for Global Competitiveness." *2008 MENA Economic Developments and Prospects Report*. The World Bank, 2008. Page 66. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,,contentMDK:21822147~pagePK:146736~piPK:226340~theSitePK:256299,00.html. Accessed 28 May 2011.

[146] "Electricity." Arab Fund for Economic & Social Development website, 2010. http://www.arabfund.org/default.aspx?pageId=454. Accessed 27 May 2011.

The EIJLLPST project has led to lower electricity production costs, increased energy supply security, and created more efficient energy use in the Jordan River Basin. In addition, the project has enhanced cooperation and interdependence between the EIJLLPST countries, which work together in joint management committees and must adhere to formal power purchasing agreements.[147] However, there have also been some limitations to the project. For one, the existing interconnections in the Jordan River Basin are still modest and are primarily used to preserve power supply security within individual markets. There are also fairly low levels of trade, even at existing capacities. The Lebanon-Syria interconnection, for example, only uses 53.3% of its designed capacity.[148] In addition, Israel remains entirely isolated from any existing and proposed power linkages aside from those it uses to supply electricity to the Palestinian territories. Therefore, before the EIJLLPST project can support meaningful trade in renewable energy sources in the Jordan River Basin, these complex issues will need to be resolved.

There are also major problems concerning electricity security and supply in the Palestinian territories, which hinder the entire region from making progress in renewable energy power sharing. For one, the Palestinians depend almost entirely on Israel for their electric power supply. The West Bank receives over 95% of its electricity supply from Israel, which is delivered either directly through several small electrical grid substations or indirectly through the Palestinian Authority-operated Jerusalem District Electric Company. Gaza contains the Palestinian territories' only power plant, which supplies roughly 40% of Gaza's electricity, but most of the remaining 60% is imported from Israel through low voltage grid connections.[149]

Electricity in Palestinian territories is both severely limited and very expensive, and there is vast unmet demand in both Gaza and the West Bank. Total electricity supply to the territories is roughly 3.2 billion kilowatt-hours, which equals about 800 kilowatt-hours per capita or roughly 11% of the 7,000 kilowatt-hours per capita available in Israel.[150] According to a study by the World Bank, Israeli policies severely constrain the Palestinians' ability to build new electricity infrastructure or invest in renewable energy sources to meet their growing needs. For example, Israeli control of Palestinian borders undermines the potential for international trade of electricity, and control of land in the West Bank prevents the construction of a unified power network within the Palestinian territories.[151] In addition, Israeli military destruction of Palestinian

Figure 32: 2006 Attack on the Gaza Power Plant

[147] "Transmission Grid Network: The Seven Wonders of Interconnection." *Power-Gen Worldwide*, 1 Match 2007. http://dpwsa.powergenworldwide.com/index/display/articledisplay/288634/articles/middle-east-energy/volume-4/issue-1/features/transmission-grid-network-the-seven-wonders-of-interconnection.html. Accessed 28 May 2011.
[148] "Chapter 2: Regional Integration for Global Competitiveness." *2008 MENA Economic Developments and Prospects Report*. The World Bank, 2008. Page 64.
[149] Gressani, D. et al. "West Bank and Gaza Energy Sector Review." The World Bank, 2007. Page 14-16.
[150] CIA World Factbook: Israel, West Bank, and the Gaza Strip.
[151] Israel maintains full control over "Area C" land, as designated by the Oslo Peace Accords, which accounts for roughly 60% of the land area in the West Bank.

infrastructure, including a military strike that partly destroyed the Gaza Power Plant in 2006, further constrains electricity supplies in the Palestinian territories and undermines Palestinian efforts to attract investment.[152] Therefore, in order to establish a fully interconnected power grid in the Jordan River Basin that includes both Israel and the Palestinian territories, new policies are needed for promoting cooperation between them.

6.5 Future Power Grid Interconnections Planned for the Greater Middle East-North Africa Region

In addition to existing power grid interconnections in the Jordan River Basin, there are several larger, more ambitious plans to interconnect power grids throughout the greater Middle East and North Africa region. These plans, while in various stages of development, represent an important and promising step toward the goal of achieving sustainable energy and water development in the Jordan River Basin and beyond.

➢ The GCC Power Grid Interconnection Project

The Gulf Cooperation Council (GCC) Power Grid Interconnection Project will link the electrical power grids of the six GCC states, allowing for electricity trade between Saudi Arabia, Bahrain, Qatar, Kuwait, Oman, and the United Arab Emirates. The first phase of the project interconnected the power grids of Saudi Arabia, Kuwait, Bahrain, and Qatar and became operational in late 2009. In April 2011, the United Arab Emirates was connected to the grid, and the project will be completed by 2013 when Oman becomes the final country to be connected.[153]

Figure 33: The GCC Power Grid Interconnection Project

[152] Gressani, D. et al. "West Bank and Gaza Energy Sector Review." The World Bank, 2007. Page 1.
[153] Kumar, H. "GCC Electricity Grid is Likely to Save Dh18.4b in Costs." *GulfNews.com*, 21 April 2011. http://gulfnews.com/business/construction/gcc-electricity-grid-likely-to-save-dh18-4b-in-costs-1.796875. Accessed 29 May 2011.

The power grid allows up to 1,200 megawatts of electricity to be traded between the Gulf States and opens the door for introducing renewable energy sources into the energy supply mix. The interconnection grid is also projected to generate surplus electricity for the GCC States that can be traded in the future.[154] The cost of the project is $1.4 billion, but is estimated to generate $5 billion in energy cost savings.[155]

Once completed, the GCC power grid can serve as the backbone of a larger regional transmission grid that would extend throughout the Middle East, North Africa, and even to Europe. Members of the GCC Interconnection Authority have proposed extending the power grid throughout the Middle East and eventually linking it to neighboring power grid interconnection projects, including the EIJLLSPT project.[156] In addition, the World Bank announced in January of 2011 that it will consider proposals to link the GCC power grid to countries in North Africa, including Egypt, Morocco, Libya, and Tunisia, which would serve as the first step in creating a Mediterranean power grid as part of an ambitious plan called the Desertec Initiative.[157]

- **The Desertec Initiative**

The Desertec Initiative envisions linking Europe, North Africa, and the Middle East through a massive supergrid that will transmit electricity generated from renewable sources throughout the entire Mediterranean region. Although plans to create a Mediterranean power pool have been under discussion for several decades, the Desertec Initiative has accelerated the development of this idea and paved the way for its implementation.

The Desertec Initiative was first conceived of by the Trans-Mediterranean Renewable Energy Cooperation (TREC), an initiative of the Club of Rome that is made up of an international network of politicians, scientists, and economists. From 2003-2007, TREC undertook research in cooperation with the German Aerospace Center (DLR) to develop the supergrid concept and demonstrate its technical and economic feasibility. After the final Desertec plan was presented in 2007, TREC founded the Desertec Foundation in 2009 as a nonprofit foundation dedicated to spearheading its implementation.

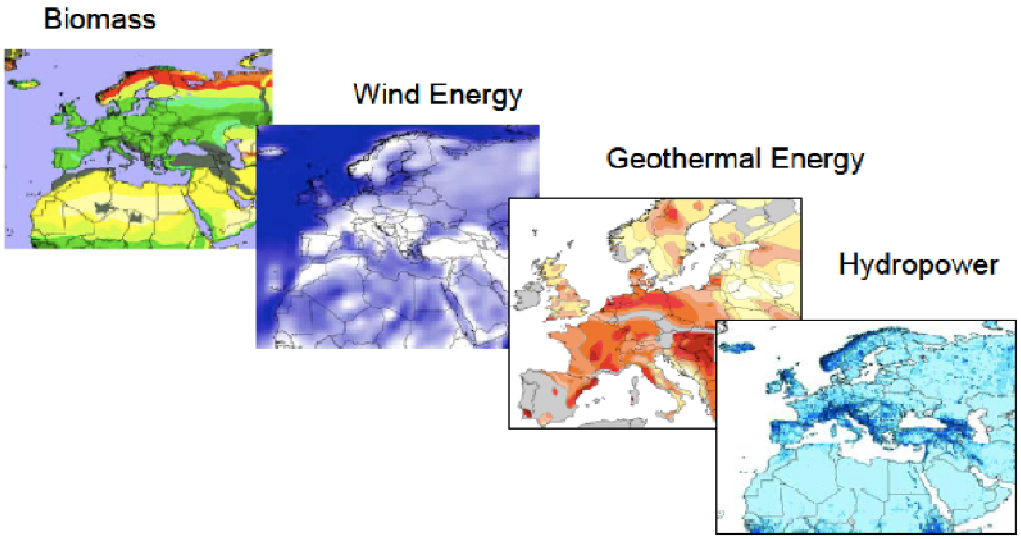
DESERTEC
FOUNDATION

Under the Desertec Initiative, solar power would be tapped from the vast deserts in the Middle East and North Africa using a series of concentrating solar thermal power plants and

[154] Al-Asaad, H. and Brahim, A. "The GCC Power Grid: Benefits & Beyond," page 5. *Oil, Gas, and Energy Law Journal*, 2008. http://www.ogel.org/article.asp?key=2830. Accessed 29 May 2011.
[155] Daya, A. "U.A.E. Says Gulf Power Grid May Save $5 Billion in Costs." *Bloomberg News*, 20 April 2011. http://www.bloomberg.com/news/2011-04-20/u-a-e-says-gulf-power-grid-may-save-5-billion-in-costs-1-.html. Accessed 29 May 2011.
[156] Al-Asaad, H. and Brahim, A. "The GCC Power Grid: Benefits & Beyond," page 5.
[157] "World Bank to Fund GCC-Africa Power Grid." *Trade Arabia Business News and Information*, 9 January 2011. http://www.tradearabia.com/news/ogn_191513.html. Accessed 29 May 2011.

would be fed into the larger Mediterranean power grid. Wind energy from Northern Europe and North Africa would also be fed into the grid, as well as power from hydroelectricity, geothermal heat, and biomass. Electricity would then be transmitted throughout the Middle East, North Africa, and Europe through a combination of conventional alternating current (AC) power grids and high voltage direct current (HVDC) transmission cables.[158] In addition, the Desertec Initiative would also create the potential for "solar desalination," in which solar energy is used to power desalination plants to help meet growing water supply needs.[159] The total cost of the Initiative is estimated to be 400 billion Euros (about $550 billion USD), and these investments would be made in many countries over the next four decades.[160]

Figure 34: Potential Renewable Energy Sources for the Desertec Initiative



Under the Desertec Initiative, solar electricity produced in the Middle East and North Africa will provide a substantial portion of that region's growing energy demands and would meet up to 15% of Europe's electricity needs. This electricity would be transmitted to Europe via HVDC transmission cables under the Mediterranean Sea, which could feasibly transmit around 60 terawatt-hours of electricity per year (TWh/yr) by 2020 and increase to 700 TWH/yr by 2050. Such a proposal is particularly attractive because the high year-round solar irradiance in the Middle East and North Africa would provide firm intermediate and peaking power for Europe's seasonal fluctuations. Combined with low HVDC transmission losses of just 10-15%, DLR predicts this plan will yield a competitive import cost of just 0.05 Euros per kilowatt-hour, making it both technically and economically feasible.[161]

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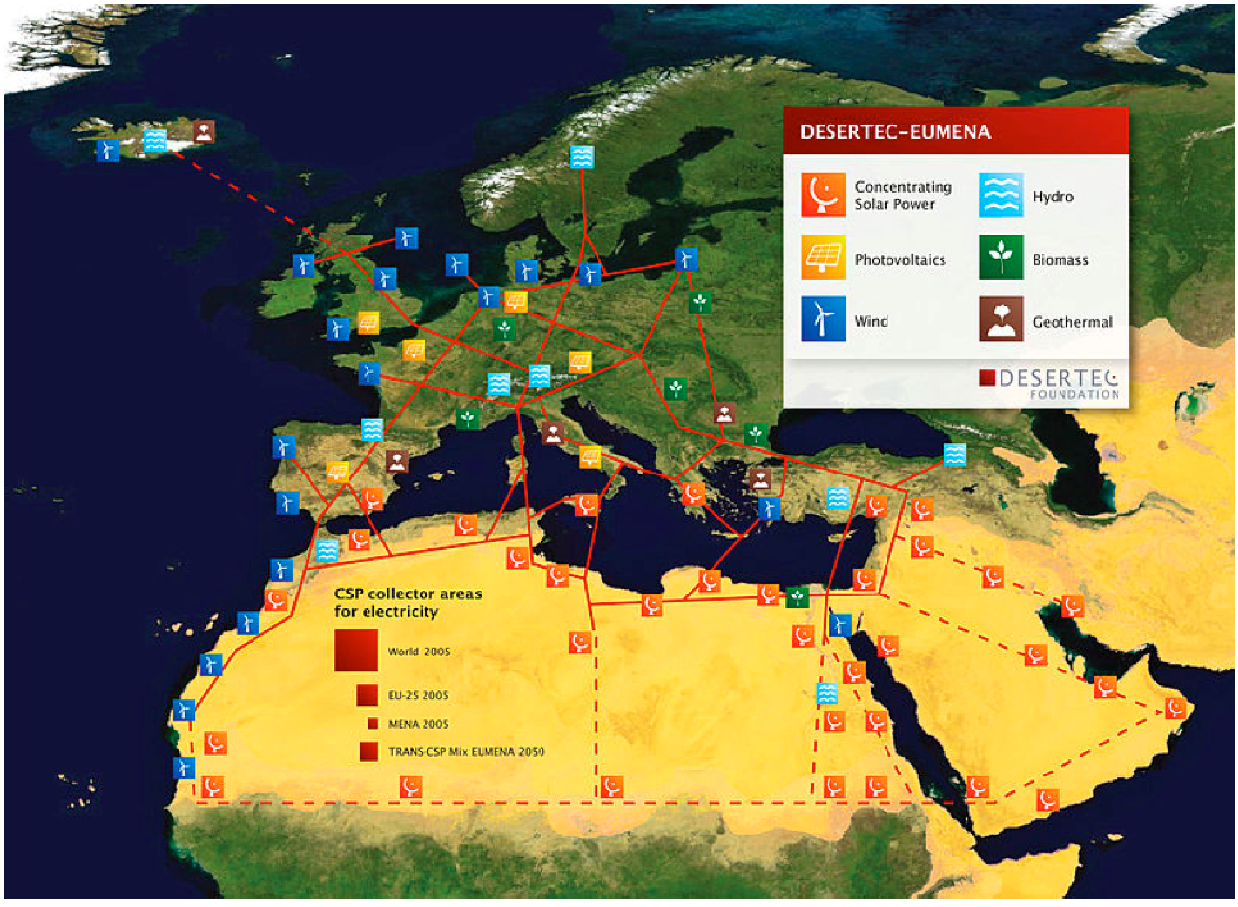
[158] Desertec Foundation website, http://www.desertec.org/en/. Accessed 30 May 2011.
[159] Trieb, F. et al. "Concentrating Solar Power for Seawater Desalination," page 2. Study by German Aerospace Center (DLR). 2007. http://www.dlr.de/tt/desktopdefault.aspx/tabid-3525/5497_read-6611/. Accessed 29 May 2011.
[160] "Answers on Dii and Desertec." Dii Gambh website, http://www.dii-eumena.com/dii-answers/dii-and-desertec.html. Accessed 30 May 2011.
[161] Trieb, F. et al. "Trans-Mediterranean Interconnection for Concentrating Solar Power," page 2. Study by German Aerospace Center (DLR), 2006. http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/. Accessed 29 May 2011.

Overall, full implementation of the Desertec Initiative would achieve 80% renewable electricity use throughout Europe, the Middle East, and North Africa by 2050, and would reduce the region's carbon emissions to just 25% of 2000 levels.[162] The result would be the creation of a huge electricity market that would maximize efficiencies through economies of scale, improve energy supply security and reliability, and help achieve sustainable energy and water use throughout the region.[163] The Desertec Initiative would also bring economic growth to the Middle East and North Africa by creating thousands of new jobs. According to a study completed by the World Bank, up to 80,000 jobs would be created under the existing plan to scale up solar power production to implement the Desertec plan.[164] As a result, the Jordan River Basin and the greater Middle East-North Africa region stand to gain immensely from the ambitious Desertec Initiative and will begin to see these benefits realized as the plan is developed over the coming years.

Figure 35: The Desertec Initiative



[162] Ibid., page 2.
[163] Trieb, F. and Muller-Stainhagen, H. "The Desertec Concept: Sustainable Electricity and Water for Europe, Middle East and North Africa." http://www.desertec.org/en/concept/literature/. Accessed 31 May 2011.
[164] Gazzo, A. et al. "Middle East and North Africa Region Assessment of the Local Manufacturing Potential for Concentrated Solar Power Projects." The World Bank, January 2011. http://arabworld.worldbank.org/content/awi/en/home.html. Accessed 29 May 2011.

7. The Potential for Building Peace through Sustainability

As regional policymakers and international donors begin working toward sustainability in the Jordan River Basin through efforts to manage shared water resources, interconnect international power grids, and implement ambitious plans like the Desertec Initiative, there will likely be critics who argue that such efforts are futile in a place that is so often defined by violence, conflict, and mistrust. As validation, disagreements over shared energy and water resources have in the past exacerbated conflicts in the Jordan River Basin. For example, tensions over Syrian efforts to divert the Jordan River did nothing to ease regional hostilities that ultimately led to the outbreak of the 1967 Six Day War.[165] Water and energy infrastructure have also at times been the target of armed conflict: during the 2006 Lebanon War, for example, Israel destroyed sewage networks, electrical transmission lines, and the largest power plant in Lebanon, causing the contamination of water supplies, severe energy shortages, and an estimated $3.5 billion in damage.[166]

However, despite those that argue that peace must come before sustainability, evidence shows that states will often cooperate on environmental issues even when they do not cooperate on other issues. In fact, hostile states are much more likely to cooperate during water disputes than engage in armed conflict: of 1,831 water-related disputes that occurred between 1948 and 1999, two-thirds resulted in cooperation, and only 37 incidents reached an acute level of conflict.[167] The reason for this is likely because the costs of going to war over water far outweigh the potential benefits, and all parties have a shared interest in the successful development of water systems.[168] Research also shows that it is not the scarcity of natural resources that predicts the outbreak of conflict, but rather the way those resources are governed and managed.[169] Indeed, institutions that are developed to manage shared water resources have generally turned out to be very resilient, even when they are flawed: the Joint Water Committee between Israel and the Palestinian Authority, for example, continued to meet throughout the violence of the Second Intifada.[170]

Critics may also point out that armed conflict has often occurred over energy sources like oil and natural gas, particularly in the Middle East. However, renewable energy sources are virtually inexhaustible and therefore unlikely to drive competition or conflict in the same way.[171] Expanding renewable energy sources will also create greater energy security by diversifying of energy supplies and ending over-reliance on imported fossil fuels.[172] In addition, regional and

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[165] Wolf, A. "Conflict and Cooperation along International Waterways," page 253. *Water Policy*, Vol. 1, No. 2. 1998. http://www.transboundarywaters.orst.edu/publications/conflict_coop/. Accessed 31 May 2011.
[166] "Israel/Lebanon: Deliberate Destruction or Collateral Damage? Israeli attacks on Civilian Infrastructure." Amnesty International, 2006. http://www.amnesty.org/en/library/info/MDE18/007/2006. Accessed 31 May 2011.
[167] Postel, S. and Wolf, A. "Dehydrating Conflict," *Foreign Policy Magazine*, September/October 2001. http://www.globalpolicy.org/component/content/article/198/40343.html. Accessed 1 June 2011.
[168] Wolf, A. "Conflict and Cooperation along International Waterways," page 256-258.
[169] Wolf, A. et al. "Chapter 5: Managing Water Conflict and Cooperation." *State of the World: Redefining Global Security*, 2005. http://tbw.geo.orst.edu/publications/. Accessed 1 June 2011.
[170] Ibid, page 258.
[171] "Answers on the Partnership with North Africa and Middle East." Dii website. http://www.dii-eumena.com/dii-answers/in-partnership-with-north-africa-and-the-middle-east.html. Accessed 1 June 2011.
[172] "Chapter 8: International Grid Interconnections and Energy Security." *Multidimensional Issues in International Power Grid Interconnections*, 2006, page 253-254. UN Department of Economic and Social Affairs, Division of Sustainable Development. http://www.un.org/esa/dsd/resources/res_publsdt_ene_issues_06.shtml.

economic integration from interconnected power grids will also provide a strong incentive for states to avoid military conflict and can even spur new cooperation in other areas by opening up channels of communication.[173] The management committees set up under the EIJLLSPT grid interconnection project will help serve this function in the Jordan River Basin, as will the Desertec Initiative as it continues to be implemented.

Finally, the economic and social benefits of clean, reliable supplies of water and secure sources of energy cannot be underestimated in providing the conditions necessary for building regional stability. Establishing more equitable distributions of energy and water supplies to meet basic socioeconomic needs, particularly between Israel and the Palestinian territories, will also help resolve grievances over perceived injustices and prevent future conflicts. The increased cooperation and trust that arises from such agreements could even provide a foundation on which to build lasting peace and stability in the region.[174]

Open questions do remain regarding the impact of the "Arab Spring" on the future of sustainable development in the Middle East and North Africa. Within the Jordan River Basin, Syria faces growing protests and unrest that have undermined national stability, and Israel has seen its geostrategic position shift since friendly regimes have been toppled and reconciliation has been reached between Hamas and Fatah. However, many see the push for democracy as a powerful force for economic and political stability that could aid efforts toward sustainable development.[175] It remains to be seen whether current unrest will give way to peace and stability and whether that will open the door for sustainability in the Jordan River Basin and the greater Middle East-North Africa region.

Figure 36: Fazael Brook in the Jordan Valley

[173] "Chapter 5: Political Aspects of Grid Interconnection." *Multidimensional Issues in International Power Grid Interconnections*, 2006, page 85-86. UN Department of Economic and Social Affairs, Division for Sustainable Development. http://www.un.org/esa/dsd/resources/res_publsdt_ene_issues_06.shtml. Accessed 1 June 2011.
[174] Kramer, A. "Regional Water Cooperation and Peacebuilding in the Middle East," page 9. Initiative for Peacebuilding, 2008. http://www.initiativeforpeacebuilding.eu/publications/index.php. Accessed 1 June 2011.
[175] Kilian, A. "Arab Spring Boosts Dream of Desert Power." *Spiegel Online*, 26 May 2011. http://www.spiegel.de/international/world/0,1518,764877,00.html. Accessed 1 June 2011.

8. Policy Recommendations for Future Sustainable Water and Energy Development in the Jordan River Basin

In light of the many social, environmental, and political benefits that can be realized through sustainable development in the Jordan River Basin, this report concludes with three broad policy recommendations for future development in the region. This section is not meant to be an exhaustive list of all necessary policies, but rather a starting point for future discussions to achieve more complementary, equitable, and sustainable management of limited water and energy resources within the Jordan River Basin.

- **Establish robust regional management structures to enhance cooperation over water and energy resources.**

Strengthening the institutional capacity of regional management structures is inevitably the key to achieving sustainability of shared water resources and energy supplies in the Jordan River Basin. Strong regional institutions are important because they allow for cooperation and exchange of knowledge over shared natural resources that simply cannot be managed through unilateral action. Strong institutions can also new open channels of communication between typically hostile states that can help build trust and cooperation on other issues.[176] Within the Jordan River Basin, new regional institutions and regimes may need to be created, and existing structures will certainly need to be improved.

In an ideal world, it would be useful to establish a single, regional committee that could coordinate all sustainable water and energy management within the Jordan River Basin. Understanding that current political realities are likely to inhibit the creation of such an institution, improving existing agreements and institutions can still be effective in achieving sustainable management of water and energy. For example, adjusting existing inequities within the Joint Water Committee (JWC) between Israel and the Palestinian territories will be necessary to achieve sustainable water use in the Jordan River Basin. The existing structure of the JWC should be modified to give Palestinians greater input on water management and must include measures to hold Israel accountable for overdrawing the region's renewable water supplies. If these efforts are successful, the JWC has the potential to become a model for success in managing limited resources between hostile states.

On the renewable energy side, regional institutions are needed to attract investment, coordinate energy sector integration, and to share knowledge and best practices for the Jordan River Basin. One option could be strengthening the management committees of the EIJLLPST grid interconnection project, which could broaden their current mandate to become a driver of regional energy policy. The steering committees already set policies, strategies, and general rules to develop and improve the EIJLLPST interconnection project. The committees could expand to include efforts to incorporate renewable energy sources into the power grid and to improve Palestinian access to electricity. The EIJLLPST project should also assess the possibility of eventually connecting Israel to the grid, which is admittedly difficult under current political circumstances, but would help foster increased regional integration and cooperation.

[176] Wolf, A. et al. "Chapter 5: Managing Water Conflict and Cooperation." *State of the World: Redefining Global Security*, 2005. Page 91.

In addition, the international community could and should help develop coordinated regional management structures in the Jordan River Basin through existing international institutions, such as the Euro-Mediterranean Partnership (Euro-Med),[177] the European Neighborhood Policy,[178] and the Desertec Initiative. These institutions could help the Jordan River Basin attract investment, set policy goals, and even arbitrate disputes over water and energy resources when they arise.

- **Look for ways to improve water conservation and energy efficiency as opposed to building new, large-scale infrastructure projects.**

In many cases, water and energy shortages in the Jordan River Basin can and should be addressed purely through enhanced measures of conservation and efficiency. Water scarcity in particular is exacerbated by inefficient water use and water losses due to ageing infrastructure. In Jordan, for example, as much as 50% of water supplies are lost through inefficiencies.[179] In addition, as much as 85% of available water in the Jordan River Basin is used for agriculture, which is an unnecessarily large quantity in a region that struggles to meet the water demands of its municipal and industrial sectors.[180] Limited water supplies are also further constrained by high levels of water contamination from untreated sewage, agricultural pollution, and saltwater intrusion in groundwater aquifers. Therefore, increasing water use efficiency by repairing ageing infrastructure, implementing more water-efficient irrigation methods, and improving wastewater treatment systems would have the net effect of increasing water supplies and would be much less costly and energy-intensive than large-scale infrastructure projects.

While some large infrastructure projects will admittedly be necessary in the Jordan River Basin, achieving energy efficiency should still be a primary goal in their development. For example, new desalination plants should be powered by solar energy instead of fossil fuels, and research by the German Aerospace Center (DLR) shows that solar desalination plants are both technically and economically feasible.[181] In addition, wastewater treatment plants could be built or retrofitted to use recycled biomass for power, thus saving huge amounts of energy in treating sewage.[182]

Finally, the most important goal is to increase public awareness about water and energy efficiency within the Jordan River Basin. Individual efforts to conserve water and energy are an essential component of sustainability, but changing existing patterns of behavior is difficult. The

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[177] The Euro-Mediterranean Partnership (also known as the Union for the Mediterranean or the Barcelona Process) is the European Union's comprehensive policy for the European-Mediterranean region. In 2008, six priority areas were established: depollution of the Mediterranean Sea; investing in maritime and land highways; protecting civil and human rights; promoting alternative energies; investing in higher education and research; and establishing business and financial partnerships. http://www.ufmsecretariat.org/en/who-we-are/.

[178] The European Neighborhood Policy (ENP) is the European Union's external policy that emphasizes bilateral relations between the EU and each neighboring country to improve economic integration, increase mobility, and enhance cultural exchange. http://ec.europa.eu/world/enp/policy_en.htm.

[179] Mahsaneh, D. "Bring the People to Disi not Disi to the People." Jordan Business Magazine, 2007.

[180] Bou-Zeid, E. and El-Fadel, M. "Climate change and water resources in Lebanon and the Middle East," *Journal of Water Resources Planning and Management*. September/ October 2002.

[181] Trieb, F. et al. "Concentrating Solar Power for Seawater Desalination," page 2. Study by German Aerospace Center (DLR). 2007.

[182] "Bioenergy in Oregon: Biogas Technology." Oregon Department of Energy. http://www.oregon.gov/ENERGY/RENEW/Biomass/biogas.shtml#Wastewater. Accessed 2 June 2011.

governments of the Jordan River Basin should implement public awareness campaigns, support educational programs in public schools, and incentivize small-scale efficiency efforts, such as domestic rainwater harvesting and domestic solar panels, in order to achieve this goal.

- **Focus on building local capacity for sustainable development of the energy and water sectors.**

As future efforts to achieve sustainability get underway, it will also be extremely important to focus on building up local capacity and supporting local industry in the Jordan River Basin. As new water and energy projects are started, there should be an emphasis on investing in local manufacturing and providing technological training so that the Jordan River Basin remains the primary economic beneficiary of the investments. In this respect, the Jordan River Basin probably has the most to gain in the field of renewable energy: a study by the World Bank predicts that as demand for solar energy increases, the Middle East and North Africa could add as many as 80,000 new manufacturing jobs and $14.3 billion in economic gain from new concentrating solar thermal power plants in the next ten to fifteen years.[183] The countries in the Jordan River Basin should therefore work to develop their local renewable energy industries and create investment-friendly policies to tap into this potential.

In addition to building up local businesses, policies should also be implemented to enhance the local capacity for research and development. Investments in schools and universities should be made to train local engineers with a focus on sustainability and integrated energy and water management. Some progress has been made on this front: the Arava Institute for Renewable Energy and Energy Conservation at Ben Gurion University in Israel[184] and the Energy Center at the Jordan University of Science and Technology in Jordan[185] are both engaged in cutting edge research in the region. Investing in additional research institutions and encouraging greater exchange among the scientific communities could help position the Jordan River Basin as a regional hub for water and energy technological innovation.

Finally, the international community should encourage the governments of the Jordan River Basin to each develop more robust national strategies for water and energy development and should work to coordinate them at the regional level. These strategies should define clear commitments for complementary and sustainable water and energy sector development and should also incorporate policies for emissions reductions, climate change adaptation, and future urban growth. Such broad strategies would help frame the discussion for water and energy development in the Jordan River Basin and would reaffirm the region's overall commitment to sustainability. Ultimately, it will be up to the people and the governments of the Jordan River Basin to direct their own plans for development, which will allow them to realize both economic and social benefits of more coordinated, sustainable, and peaceful development of their water and energy resources.

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[183] "Middle East and North Africa Region Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP) Projects: Forward." The World Bank, January 2011.

[184] More information on the Arava Institute for Renewable Energy and Energy Conservation available here: http://www.arava.org/cat.asp?catid=1&subcatid=19

[185] More information on the Energy Center at the Jordan University of Science and Technology available here: http://www.just.edu.jo/CENTERS/ENERGYCENTER/Pages/default.aspx

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