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Social, Political, Economic and Health Effects of the Disi Aquifer on Jordanian Society

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Abstract

As one of the driest countries in the world, it is a challenge for Jordan to find adequate domestic and regional water resources to draw from that will provide long term, healthy solutions that are in the country's political and economic interest. The use of the Disi Aquifer as a domestic water resource has been a contested subject for several decades. With the completion of the project nearly in sight, it is important to ensure that the government provides sustainable goals for the country in order to keep up with population growth and the increasing demand for water. This paper hypothesizes that the Disi Aquifer will provide short-term benefits, but that it will harm Jordanian society in the long term. This paper uses information gathered from farmers and local households in the Disi area as well as scientists and leaders in Jordan's water policy arena who research and contribute to decisions made in regard to the country's future with water. In order for there to be long-term benefits from the use of the Disi, the government needs to provide reform within the water network and accommodate farmers currently in the Disi area with potential work alternatives. The Jordanian government must establish long term international water-sharing goals and ensure that the water of the Disi, which will provide resources to at least one third of Jordan's population, is as contaminant-free as possible in order to ensure that there is not a national health crisis in the future.

ISP Topic Codes:

Environmental Studies- 527

Hydrology- 627

Political Science- 523

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Schedule of Acronyms

ISP: Independent Study Project

JD: Jordan Dinar

MCM: Million cubic meters

MoTA: Ministry of Tourism and Antiquities

MoWI: Ministry of Water and Irrigation

GDP: Gross Domestic Product

IWA: International Water Association

WERSC: Water and Environment Research and Study Center

Introduction

Kuwait, UAE, Qatar, Saudi Arabic, Libya, Bahrain, Jordan, Yemen, West Bank and Gaza, and Oman make up the world's most water scarce countries, with Jordan as the sixth.¹ According to the authors of *Achieving Sustainable Development in Jordan: Country Environmental Analysis*, Jordan is experiencing a level of chronic water scarcity that few other countries face, "available water resources are 133 M³/ capita/year, including wastewater reuse."² Jordan is 80 percent desert and virtually landlocked.³

Jordan's water scarcity has resulted from water extraction 50 percent above safe yields,

¹ Raffaello Cervigni and Helena Naber, eds., *Achieving Sustainable Development in Jordan: Country Environmental Analysis* (Amman: The International Bank for Reconstruction and Development/The World Bank, 2010), 71.

² *Ibid.*, 3.

³ Sandra Upson, "Jordan's radioactive water problem," *Spectrum IEEE* 46, no. 8 (2009), <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5186535&isnumber=5186525> (accessed November 18, 2011)

increased pumping costs, increased salinity, and declining water table levels.⁴ Given that Jordan has few renewable resources to draw from, the prospect that the amount of water Jordan has access to might entirely become depleted in the near future is a harsh and frightening reality. In order to take pressure off of domestic use, the Jordanian government has turned to the Disi Aquifer's resources. An aquifer is defined by the Environmental Protection Agency as "a natural underground layer, often of sand or gravel, that contains water."⁵ The Disi Aquifer is approximately 30,000 years old.⁶ It is a sandstone aquifer located in southern Jordan that is 600-900 meters thick and about 320 kilometers long, and it stores about 280 km³ of water.⁷

This abundance of water would certainly help the Jordanian population as it struggles to manage the little it has. Residents of Amman currently have access to running water 36 hours a week.⁸ Amman is experiencing a population boom due to the influx of immigrants from Iraq⁹ and a population growth rate just under 2.5%.¹⁰ The daily demand for water is currently at 120 liters per person per day, significantly lower than countries that have access to an abundance of water.¹¹ With a fast-growing population and domestic renewable resources quickly becoming more polluted and less accessible, the Jordanian government is in a position where it needs to find a source of water than can be easily extracted and used as soon as possible. Annually, 100 MCM

⁴ Cervigni., *Achieving Sustainable Development in Jordan: Country Environmental Analysis*, 3.

⁵ EPA, "Drinking Water Glossary," *United States Environmental Protection Agency*, October 28, 2011, accessed November 30, 2011, <http://water.epa.gov/drink/resources/glossary.cfm>.

⁶ John Allen, "Disi Aquifer: Jordan and Saudi Arabia" (working paper University of Texas, Austin, TX, 2010) 1.

⁷ *Ibid.*

⁸ Verity, Ratcliff, "Ensuring water supply," *MEED Middle East Economic Digest* 54, no 16:40-41 (2010). EBSCOhost (00477230).

⁹ Upson, "Jordan's radioactive water problem," 3.

¹⁰ The World Bank, "Data: Population Growth (annual %)", The World Bank, 2011, accessed November 30, 2011, <http://data.worldbank.org/indicator/SP.POP.GROW/countries/JO?display=graph>.

¹¹ Upson, "Jordan's radioactive water problem," 3.

of water will travel 1300 meters uphill from Disi.¹² Sixty-four wells total will be drilled. Fifty-five of the wells will be used to generate water, “while nine will serve as a piezometer wells to measure the elevation of water.”¹³ The Disi Water Company stated that of the fifty-five wells being used for water generation, forty-six will be used for water extraction. The other nine will stay “on standby” and will be reserved for emergencies only.¹⁴ Wells being dug for water generation will be dug 600-700 meters deep. The piezometer wells are expected to be dug 400 meters deep.¹⁵ Ideally these wells will be used over the next 50 to 100 years to satisfy the needs of a country desperate to use whatever resources it can attain access to.

The Disi Aquifer will provide Amman with thirty percent of its water needs.¹⁶ However, this much-needed water only covers a periphery of the overall problem and will come with numerous costs. The project will affect the amount of water Jordan’s farmers in southern Jordan receive and the prices they will have to pay in order to sustain their agricultural output. In addition to farmers, it will also affect the amount that citizens in Amman pay for water because the project is expensive and Jordan is running out of domestic water resources. Jordan still needs to treat itself as a water scarce country and push to get an adequate amount of water from its neighbors in order to sustain the growing population and make up for disappearing renewable and non-renewable resources. Jordan shares trans-boundary water resources with Israel, Syria and Saudi Arabia; even if Jordan currently has access to an abundant domestic

¹² Upson, “Jordan’s radioactive water problem,” 1.

¹³ Hana Namrouqa, “50% of Disi project completed,” *The Jordan Times*, April 17, 2011, Local Section, Online edition.

¹⁴ Ibid.

¹⁵ Ibid.

¹⁶ Verity, Ratcliff, “Ensuring water supply.”

resource, it is imperative that the government makes sure that there is water to draw from once the Disi's resources are depleted, which requires external negotiation with neighboring countries.

The Disi Aquifer is shared between Saudi Arabia and Jordan, but a formal contract between the two countries has yet to be written and agreed to. Saudi Arabia has been using the Disi Aquifer for agricultural purposes for decades; however, a recent study conducted by a hydrologist at Duke University gave light to the fact that the radioactivity levels of Disi water are much higher than the international standards allow.¹⁷ Although the Jordanian government has acknowledged the legitimacy of this study, it is debatable whether or not the government is incorporating the correct methods in their water quality procedures to ensure that Jordanians are receiving water as radioactive-free as possible. The aquifer specifically has high levels of radium, large levels of which can cause bone cancer over time.

I chose to study the effects of the Disi Aquifer project because of its importance as a domestic resource for Jordan; I have done research earlier in my college career on water policy in Gaza and the West Bank and therefore am somewhat familiar with the topic. Water policy is related to modernization because in order for Jordan to establish a long-term water policy that is sustainable for the future of the Jordanian population, the government will have to look into modernizing its water reform policies and nation-wide conservation techniques. Using political realism, I will attempt to examine the motives behind the current policies and draw from outside opinion the potential success that will

¹⁷ Avner Vengosh et al., "High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East," *Environmental Science and Technology* 43, no. 6 (2009), <http://pubs.acs.org> (accessed November 16, 2011) 1773.

arise from said policies. I will also look at the moral consequences that will result of the monarchy's current use of the Disi's water. Jordanian society needs to treat itself as a water scarce entity in order for the Disi's resources to last as long as possible and to make sure that water is available after this resource is depleted.

Literature Review

USAID acting Mission Director Dana Mansouri said at the International Water Association Specialist Conference on Efficient Management Use and Management of Water: "Today's solutions to water scarcity are three: to transport freshwater in at great expense; to create freshwater from saltwater at an even greater expense and to use water more efficiently, which actually saves money."¹⁸ According to realist theory, Jordan is using the Disi Aquifer, a strategic freshwater reserve, as a rational means by which to survive as a state. The aquifer, as opposed to desalination, is viewed as the best option to alleviate pressure Jordan faces from water scarcity. It is important to examine the choices the Jordanian government has determined to be rational based on the current circumstances; I will review the opinions of academics and scientists who have conducted research on the Disi's resources and explore possible alternatives to the current policies.

For the purpose of this discussion, I looked at a study that was done recently that specifically examined how Jordan has interacted with Saudi Arabia to establish ownership of the Disi's resources and how current policy might affect the Disi in the future. Eugenia Ferragina of the Institute of Studies on Mediterranean Society and the

¹⁸ Ian Goldin, "Higher water prices could solve shortage- report," *The Jordan Times*, April 14 2011, Local section, Online edition.

Italian National Research Council in partnership with Francesca Greco of Independent Consultant, Orivo, Italy, conducted an internal and external analysis on the Disi Aquifer Project. According to Ferragina and Greco, originally Jordan withdrew water from the Disi aquifer solely for local purposes. Jordan drew significantly more water after the government gave four large agricultural companies contracts for large amounts of land in the 1980s, raising the average withdrawal rate to its current amount at 70-80 MCM annually.¹⁹ These large companies were not required to abide by any sort of withdrawal limitations and their consumption was not monitored by the government.²⁰ While it is important to look at how large commercial agricultural companies use their water, it is also imperative to look at how local farmers use water from the Disi Aquifer, and examine how they can better conserve. USAID statistics disclose that two thirds of Jordan's water goes to "low value agricultural crops."²¹ According to a study done in 2006 by Octavio A. Ramírez, Frank A. Ward, Raed Al-Tabini and Richard Phillips, "In agriculture, various water conservation measures are being scrutinized and debated, such as increased irrigation efficiency, subsidies for water-conserving measures, reduction of water-intensive crops, recycling and reuse, and water pricing reform."²² Most farmers who currently use the Disi's resources either receive water for free or for heavily subsidized prices. Currently, water-related subsidies account for 50% of total

¹⁹ Eugenia Ferragina and Francesca Greco, "The Disi Project: an internal/ external analysis" *Water International* 33, no. 4 (2008), <http://www.tandfonline.com.libproxy.unh.edu/doi/pdf/10.1080/02508060802504412> (accessed November 25, 2011) 452.

²⁰ *Ibid.*, 452.

²¹ USAID in Jordan, "Water Resources Management," *USAID*, June 12 2006, accessed December 2, 2011, <http://jordan.usaid.gov/sectors.cfm?inSector=16>.

²² O.A. Ramirez et al, "Efficient water conservation in agriculture for growing urban water demands in Jordan," *Water Policy* 13, no. 1 (2011) 103.

agricultural subsidies.²³ According to the study, “Water’s price has a significant, large, and policy-relevant effect on the depth of irrigation water applied, with a reduction in more than 360mm depth of water applied for each additional one JD added to the price per cubic meter... water’s price also has a large effect on revenue generated per unit of water, more than JD 2 per m³.”²⁴ The study showed that, by doubling the price of water, water use decreased by a little over 100mm depth and increased “revenue generated per unit of water used by over JD 0.60 per m³.”²⁵ Current subsidized water prices for farming are not sustainable in Jordan’s long-term interest to receive as much profit as possible from what is currently a low-revenue economic sector.

In combination with local farmers and large Jordanian agricultural companies drawing significant amounts of water from the Disi Aquifer, Saudi Arabia has been extracting exponentially more. In 1995 Saudi Arabia was withdrawing 1.4 billion cubic meters of water from the aquifer annually, and in 2004 the Jordanian government estimated that Saudi Arabia was withdrawing 800 MCM annually.²⁶ In 1992, Jordan accused Saudi Arabia of overexploiting the Disi Aquifer. Jordan made the same accusations again in 1999, but Saudi Arabia did not respond. The fact that Saudi Arabia is starting to use less water suggests that water degradation had already begun. It is not surprising, that, in the same year, “the Saudi government was informed of Jordan’s exploitation of the aquifer,”²⁷ but did not send a response. Ferragina and Greco termed this behavior “voluntarily silencing” and applied the term to the whole Disi issue for the

²³ Cervigni, *Achieving Sustainable Development in Jordan: Country Environmental Analysis*, 71.

²⁴ O.A. Ramirez et al, “Efficient water conservation in agriculture for growing urban water demands in Jordan,” 113.

²⁵ Ibid.

²⁶ Ferragina, “The Disi Project: an internal/ external analysis”, 452.

²⁷ Ibid., 458.

public and the media.²⁸ They argued that, “in the following years, the two parties showed by their actions that they would not cooperate and would continue taking unilateral decisions concerning the exploitation of the shared aquifer.”²⁹ Jordan cannot be sure about how international bodies and neighboring countries will react to further exploitation of the Disi Aquifer, especially when Saudi Arabia and Jordan do not have a signed contract agreeing to share the water. The lack of cooperation interfered with potential funding; the World Bank would not give Jordan a grant for the pipeline project because it required a “non-objection by Saudi Arabia under the Bank’s safeguard policy.”³⁰ As a result, Greco and Ferragina concluded, “a ‘silent’ pumping race between the two countries is going on, and that the Jordanian government began tapping the Disi aquifer in the 1990s as a preventative maneuver to be able to support its claim to water in the future.”³¹ The Jordanian government was successive in quietly establishing this claim on the Disi’s resources, especially since Saudi Arabia has yet to challenge Jordan since the pipeline project began.

In addition to keeping relations with Saudi Arabia quiet, Ferragina and Greco found that over the past few years Jordan adopted a “securitization strategy” in order to “keep (the Disi issue) within the sphere of national security and out of the political debate.”³² Saudi Arabia and Jordan are gingerly going about the situation because the Disi Aquifer is one of the last untouched groundwater sources in the area. Both countries need to use this strategic source in order to provide water to their citizens. Both have police-state qualities that give them the ability to prevent domestic disputes

²⁸

Ibid.

²⁹

Ibid.

³⁰

Ferragina, “The Disi Project: an internal/ external analysis,” 454.

³¹

Ibid., 459.

³²

Ibid., 458.

over the aquifer's usage. They have the ability to manipulate their media sources and use secret police forces as a means by which to keep political control. By keeping the pumping of the Disi a non-issue domestically, this mentality has leaked into the international sphere. Therefore, Jordan and Saudi Arabia have not been challenged by other countries or international organizations. The World Bank, while refusing to fund the pipe's construction or management, has not condemned the project. Ferragina and Greco believe that this is because "Israel has been exploiting the Mountain Aquifer of the West Bank since 1967 to grow grapefruit in the Negev desert, and Saudi Arabia, too, has used fossil water for its agriculture in the past."³³ Jordan will essentially be using what little water resources they have in the same manner as their neighbors have been for decades.

While the Jordanian government has, to a degree, successfully silenced the negative issues associated with the Disi Aquifer in the domestic and international sphere into order to maintain control and prevent public outcry over the long term effects of the aquifer's use, it has simultaneously promoted the benefits of drawing from the aquifer for mass domestic consumption. From the government's point of view, the Disi aquifer is an ideal source because it contains an abundance of quality water. Jordan does not foresee extraneous negotiations with other political entities in its way of exploiting the water and no other countries would burden Jordan with a political veto.³⁴ In addition to being able to avoid external conflict, the project will also provide labor

³³ Ferragina, "The Disi Project: an internal/ external analysis," 457.

³⁴ Ibid., 453.

opportunities for Jordanian society, and more water will be provided for villages located in close proximity to the pipe.³⁵

However, Ferragina and Greco pointed out that, “at the same time, the government let very little technical information leak through, thus depriving the population of objective data to evaluate the real impact of the project on their living conditions.”³⁶ The former minister of MoWI, Dr. Munther Haddahin, brought to light several economic issues that would arise as a result of the Disi Aquifer Project, including the fact that the combined costs from collection and treatment of Disi water would be “five times higher than the affordable threshold for the Jordanian population.”³⁷ It would be feasible to have Jordanian citizens contribute 2% of the annual per capita income (annually \$37.5 per capita). The project would raise the affordable 2% to 13.3% (\$198.70 per year).³⁸ If the Jordanian government does not find a way to balance out these costs, it could result in potential protest from Jordanian society. In the current region-wide delicate political situation, it is in Jordan’s interest to avoid national outcry over what is considered to be a vital necessity.

It was inevitable that energy costs would also be significantly impacted from the project with a 250-meter difference in altitude between Amman and the pipe’s origin in southern Jordan. El Nasser, another former minister from the MoWI, warned that oil prices would increase sharply due to international market activity.³⁹ Out of economic necessity, the Jordanian government sought a build-operate-transfer plan where a company would plan, build, and manage the Disi Aquifer pipeline for forty years and

³⁵

Ibid.

³⁶

Ibid., 457.

³⁷

Ferragina, “The Disi Project: an internal/ external analysis,”454.

³⁸

Ibid.

³⁹

Ibid., 455.

then hand the project over to the government.⁴⁰ The government also offered a \$200 million non-refundable grant in order to offset the costs for the Jordanian population. GAMA, a Turkish company, won the bid and Jordan officially invested \$1 billion into the project under the agreement that responsibility would be transferred from GAMA after twenty-five years.⁴¹

Along with economic impacts, numerous scientists have stated other foreseeable issues that would arise as a result of the pipeline project. In 2002, Professor Elias Salameh assessed that the aquifer could last at a 100 MCM extraction rate for forty years, and an annual extraction rate of 70 MCM for 100 years.⁴² These numbers are very different from the numbers the Ministry gave to the public with 100 MCM annually extracted over the course of 100 years.⁴³ Salameh also stated that the Disi's usage for irrigation had to stop in order to preserve the quality and quantity of water.⁴⁴ Salameh's suggestions have been heard in the Royal Committee on Water, and recently the Jordanian government decided that water from the Disi Aquifer and its allocation must be re-evaluated. Officially, as of 2012 when the large agricultural companies in the south have their contracts expire, they will not be renewed. From now on, only small local farmers will be able to use Disi water for irrigation.⁴⁵ This has caused an issue since the agricultural business owners used to be former government officials, but the government so far has kept its stance on the matter.⁴⁶

40 Ibid., 454.

41 Ibid., 455.

42 Ferragina, "The Disi Project: an internal/ external analysis,"456.

43 Ibid.

44 Ibid.

45 Ibid., 457.

46 Ibid.

While the government has affirmed the need to reallocate the use of Disi Aquifer in order to make best use of this resource, there are numerous other issues related to sustainability that need to be examined. Friends of the Earth Middle East expressed concern over the “risk that the high percentage of water losses in the Amman distribution network would eventually invalidate the benefits from the Disi”⁴⁷ and the fact that the project would have an unsustainable environmental impact on Jordan. Many believe that the aquifer should be preserved as a capital asset “in the view of the uncertain future of the country’s water resources, which were being undermined by climatic changes and high demographic pressure.”⁴⁸ Along with environmental problems, health concerns have recently arisen as a result of a study conducted on the Disi Aquifer related to radioactivity levels.

In 2007, Avner Vengosh, a hydrologist from Duke University, and a team funded by USAID conducted various studies on water resources in Israel, Palestine, and Jordan to test how salinity related to radioactivity. Their original hypothesis predicted that if a groundwater source had high levels of salinity, then it would also have high radioactivity levels.⁴⁹ The team began their research in the Negev in Israel before moving onto water sources in Palestine and in Jordan. Contrary to their original hypothesis, they discovered that low saline groundwater in the Negev in Israel had high amounts of radioactivity.⁵⁰ Vengosh’s team decided to test their theory again on the Disi Aquifer since it had the lowest level of salinity. When they received the results back from an independent laboratory in Chicago, they were yet again puzzled: there were

⁴⁷ Ibid., 456.

⁴⁸ Ferragina, “The Disi Project: an internal/ external analysis,”454.

⁴⁹ Vengosh et al., “High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East,”1773.

⁵⁰ Ibid.

extremely high levels of radioactivity in a low saline-level body of water.⁵¹ They repeatedly took more samples and the lab came out with the same results. Low saline sources from the Banariya Oasis and the Arava Valley also had high radioactivity levels.⁵² Results showed that groundwater from the Khreim Group cluster in the Disi with high salinity had much lower radium activity than the other groundwater clusters in the aquifer.⁵³ The scientists looked at a study conducted by the New Jersey Department of Health and Senior Services conducted in 2003 on radioactivity in water and its relation to bone cancer to compare to the results they found in this region. The groundwater used in central and southern New Jersey all had levels of radium that were deemed to increase the bone cancer incidence rate by 90%.⁵⁴ It is important to note that the radioactivity levels in the Disi's Rum Group were found to be between nine and eighteen times higher than the radioactivity levels found in the New Jersey sources.⁵⁵ The study showed an "association between radium in drinking water and increased rate of osteosarcoma (a type of bone cancer) in males but not in females."⁵⁶ However, studies done from as early as the 1920s and 1930s show that female watch dial painters who ingested large amounts of radium from paint by licking their brushes to make them pointed also developed bone sarcomas.⁵⁷ New Jersey took care of the problem by having the state's water procedures examine levels of short-lived radium-224 and installed treatment systems. New Jersey found that maintaining water

⁵¹ Avner Vengosh. Personal Interview. November 22nd, 2011.

⁵² Vengosh et al., "High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East," 1773.

⁵³ Ibid., 1771.

⁵⁴ Vengosh, "High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East," 1773.

⁵⁵ Ibid.

⁵⁶ (P Cohn 2007)

⁵⁷ New Jersey Drinking Water Quality Institute, "Maximum Contaminant Level Recommendations for Radium in Drinking Water" (state recommendation, Drinking Water Quality Institute, 2002), 18.

softeners is an easy way to remove radium⁵⁸ and relieve society's health concerns over radioactive water and its effects. Jordan needs to examine the actions other governments have taken in order to successfully lower the radioactivity levels in their water resources and how they worked it out economically.

Jordan will continue to build the Disi Aquifer pipeline project despite the fact that there is significant potential for health problems to arise as a result of the aquifer's usage because there are few water resources left. Along with potential health issues, half of the country's drinking water is currently being lost in the network. While fixing the network might take a significant amount of time and it might take awhile to see results, the aquifer's usage will have immediate effects that will relieve water scarcity problems in the north and immediately provide clean water for the capital. The fact that Jordanian government will be able to provide so much water to the capital and villages close to the pipeline will give the Jordanian monarchy another way to legitimize itself by proving that it can provide a plethora of water to one of the world's most water scarce countries. Jordan's use of Francesco and Greco's term "voluntarily silencing" has put the government in a position where it appears their decision to use the aquifer will bring nothing but good for the Hashmite Kingdom.

My research will offer an in-depth analysis of how the Jordanian government has gone about setting up the use of the Disi Aquifer and how it will directly affect both people in the capital and people in the south who have been using the Disi's resources for agricultural and domestic purposes. I will look into how the distribution of water from the Disi has been allocated in the past and examine professional opinions to see how both domestic and international politics will be affected in the future. I will also examine

⁵⁸ (P Cohn 2007)

professional opinions to find out if the government has conducted their own study on the Disi's radioactivity levels, the results, and what they are doing to treat it.

Methodology

After spending the past semester focused on modernization in Jordan, it seemed that modernization and water scarcity were intricately linked to one another. In order to ensure economic viability and political stability, it is in Jordan's best interest to modernize its water policy in order to avoid a national water crisis. Originally, I was specifically interested in the health effects of the Disi Aquifer, but knowing that it would be difficult to get enough information on the Disi's radioactivity levels, I decided that it would be more manageable to do a general study on the social, economic, health, and political effects of the Disi Aquifer on Jordanian society. My most effective method of gathering research was through interviews. I decided that I would interview farmers and local households who currently draw their water for domestic and agricultural purposes in the Wadi Rum area in order to gain perspective on the social and economic aspects of my research. The ages of those interviewed ranged from twenty-seven to sixty-three. My academic advisor was extremely helpful and made sure that I could go to Wadi Rum at the beginning of the ISP period to survey how water is used and ask for local opinions on the Disi Aquifer pipe's construction. I had a translator and a person who worked in the local area take me around to various interviewees. I believe that having two individuals who spoke Arabic fluently and one person who lived in the area established a degree of trust between my interviewees and myself. Each interview took between half an hour and an hour to administer. The reason for the time variability was due to introductions and initial conversation to get my interviewees to feel that they were

in a low-stress environment and therefore comfortable enough to answer my questions. I had to take into account the fact that I was a female researcher conducting interviews with males who potentially had conservative views on what women should and should not do; that, in combination with the fact that I was an unfamiliar foreigner, might have prevented some of my interviewees from giving me more detailed and emotional answers to my questions.

While collecting data in Wadi Rum, there was occasionally a language barrier even with a translator. In order to prevent miscommunication, if there was a point where I did not understand the answer, I would try to rephrase the answer in English until the translator and I agreed that we found the best English equivalent of the answer.

Along with interviewing local people in Wadi Rum, I also wanted to interview experts who specialized in numerous fields in relation to water scarcity. Specifically, I sought the advice of those who were involved in establishing water policy and its political and economic effects, and scientists who were familiar with the long-term effects of the aquifer's usage and the radioactivity levels. Since I started setting up interviews and researched experts in these fields ahead of time, I was fortunate to have the chance to interview people in numerous areas of expertise and get a wide range of opinions. My main struggle was creating an opportunity to talk to somebody in the MoWI. I waited to get in contact with the Ministry until the second week of the ISP period; I feel that getting an interview with somebody involved in overseeing the Disi Aquifer Project would have made my paper stronger. I tried numerous times to reach somebody who currently works at the MoWI; I went into the Ministry personally to try to set up an appointment with people I thought would be familiar with this project.

Unfortunately, I was not able to set up an interview, probably due to the sensitivity of this issue. It would have been beneficial to get an interview with somebody currently in the MoWI to add to the amount of information I would have had on political and economic outcomes. It would have also been helpful to get a verbal answer on the exact methods that will be used to take care of the Disi's radioactivity issue and find out whether or not the Ministry rationally believes that it will provide what is necessary to treat the water. However, even though I could not get an interview with a member of the Ministry, my other interviewees provided me with enough depth and scope for this paper.

Apart from not being able to access an individual currently working in the MoWI, I was able to get in contact with everybody else I felt was necessary to include in my research by making phone calls and working around my interviewees' schedules. My other interviews were with professors, scientists, and people who have worked with Jordanian water policy. I found these people by reading articles about the Disi Aquifer and then contacting those interviewed in the articles.

I contacted individuals from Jordan University by e-mail and phone. I was able to successfully set up and execute interviews with geologist Dr. Elias Salameh, hydrologist Dr. Marwan Alraggad, researcher Abbas Al-Omari, and former minister of the Ministry of Water and Irrigation, Muhammad Shatanawi. I had the opportunity to interview with Dureid Mahasneh, a former Secretary General of the Jordan Valley Authority. I also talked with Munqeth Mehyar, Director of Friends of the Earth Middle East, and Avner Vengosh, the hydrologist who originally conducted the study on the Disi's radioactivity levels. These individuals spoke English fluently and therefore it was easy to clarify

whenever I felt that I did not understand the answer to a question perfectly. I felt that my role as a woman did not affect how these individuals responded to me; I felt that my questions and presence were respected in all cases, and therefore I was able to comfortably attain a great deal of information.

I will only use the names of participants who signed their consent forms saying that they permit me to use their identities. Several of my interviewees asked that I send them the material I use in this paper to them first before sending in my final product; I obliged and made sure that my interview notes matched up with what they gave me. I tried to keep my bias out of the questions I asked of my interviewees by carefully phrasing my questions. I will, to the best of my ability, keep my biases out of the data analysis.

Findings

My findings indicate that while the Disi Aquifer seems to offer a plethora of short-term benefits for Jordanian society, the long-term effects will hurt Jordanian society more than help.

Social and Economic Effects

Amman currently receives water from several sources. When the Disi pipeline construction is complete, water that is usually taken from various governates and transferred to Amman will ideally be able to stay in its original areas and serve those communities.⁵⁹ Unfortunately, Jordan is already facing problems that will make use of the Disi Aquifer lose its full effectiveness. According to Munqeth Mehyar, director of

⁵⁹ Muhammad Shatanawi, interview with Ryan D. Greenwood, November 17, 2011.

Friends of the Earth Middle East, Jordan is currently losing forty-eight percent of its water in the network.⁶⁰ These statistics are even worse than numbers taken in 2005, when forty-five percent of Jordan's drinking water was unaccounted for due to leaking networks. He stressed: "We need to reform the water sector. We are really pushing for reform in the legislation."⁶¹ Completely rehabilitating the leaking networks would cost about thirty percent of the overall average investments made in Jordan's drinking water supply over the last decade.⁶² In an interview with Dureid Mahasneh, former Secretary General of the Jordan Valley Authority, he stated that if the government "did a proper water management for Jordan and mended the pipes and the network, we would be able to bring up 100 MCM of water instead of using the Disi's resources. Desalination is much better than the Disi."⁶³ Mehyar also stated that desalination would be the country's only viable option to bring in water once the Disi's resources ran out: "Desalination is the only way out with population growth. We need to treat ourselves as a water scarce country and address reform."⁶⁴ The Disi project, even though it is technically a short-term solution to a long-term problem, will be very expensive. All citizens in Jordan will see water price increases because Jordan does not currently have enough money set aside to fund the project. Desalination, although it would also be an expensive and complicated solution, would last much longer than using the fossil aquifer and therefore be a better use of Jordanian money.

In an interview, Dr. Raed al-Tabini shared that he heard the government was planning on raising the price of water household pay to as much as JD 6 per cubic

⁶⁰ Munqeth Mehyar, interview with Ryan D. Greenwood, November 14, 2011.

⁶¹ Ibid.

⁶² Cervigni, *Achieving Sustainable Development in Jordan: Country Environmental Analysis*, 116.

⁶³ Dureid Mahasneh, interview with Ryan D. Greenwood, November 22, 2011.

⁶⁴ Mehyar, interview, November 14, 2011.

meter, a 600 percent increase from its original value at the current JD 1.⁶⁵ In addition to the construction of the pipe itself and water extraction, pumping the water to Amman will use a significant amount of the country's energy. According to Othman Kurdi, the engineer in charge of the Disi Water Conveyance Project, the project will use four percent of Jordan's electricity production.⁶⁶ According to numbers acquired from the MoWI by Dr. Abbas Al-Omari, associate researcher at the WERSC of the University of Jordan, "sixteen percent of electric use is for water pumping in the capital now... I estimate it will go up to twenty percent in Amman according to current energy sources."⁶⁷ Dr Alraggad concurred: "Energy consumption will rise. This is a problem with the current situation in Egypt. Due to vandalism, they cut off energy and we face energy crises."⁶⁸ With the current instability in the region, it is hard to predict exactly how much energy prices will increase.

In addition to growing costs, my interviewees addressed how water, in their opinion, should be redistributed. According to Mehyaar, "We need to be more realistic when looking at the agricultural sector and the fact that it provides a low amount of GDP for the country. It needs to be looked at as a sector that does not provide a large amount of jobs or growth. Tourism is 40 times more efficient than agriculture. If we use one cubic meter of water in agriculture, the profit is JD .32. If we apply that to industry, the profit is JD 4.3. With tourism, the profit is JD 12."⁶⁹ According to the MoTA, seven million people visited Jordan in 2009 and about half remained in Jordan for longer than

⁶⁵ Dr. Raed al-Tabini, interview with Ryan D. Greenwood, October 25, 2011.

⁶⁶ Upson, "Jordan's radioactive water problem," 1-2.

⁶⁷ Abbas Al-Omari, interview with Ryan D. Greenwood, November 22, 2011.

⁶⁸ Marwan Alraggad, interview with Ryan D. Greenwood, November 22nd, 2011.

⁶⁹ Mehyaar, interview, November 14, 2011.

one day. Tourism in 2009 contributed JD 2.1 billion to Jordan's economy.⁷⁰ Agriculture, on the other hand, has historically offered much less profit. The IWA reported that "irrigated agriculture consumes 75% of [Jordan's] water, while contributing to only 4% of national income."⁷¹ Irrigation efficiency can be improved thirty to forty percent, as proved by various ongoing projects.⁷² In 2005, for every 1 JD spent on agricultural subsidies, agriculture would return JD .81.⁷³ The current output is JD .60, and data suggests that higher outputs around JD 4 are possible. This goal can be reached through efforts to educate farmers on efficient irrigation techniques⁷⁴, or by moving farmers up north where water can be used more sustainably since evaporation rates are lower. Fortunately, since the large agricultural companies will no longer have access to the Disi after 2012, water that would have originally been allocated towards water intensive agriculture will instead be distributed for domestic use. While local farmers will most likely be able to remain in the south even though their use of water is not optimal, more water should go towards tourism since this industry brings in a large amount of profit for Jordan.

In addition to interviewing local farmers, I also interviewed the heads of four domestic households in Wadi Rum. All of these individuals owned their land and received water for free even though water is a scarce and valuable resource. Two household owners were in favor of raising the price of water for the purpose of making the Disi's resources last as long as possible, and two were not in favor of raised water

⁷⁰ Verity, "Ensuring Water Supply."

⁷¹ Goldin, "Higher water prices could solve shortage- report."

⁷² Cervigni, *Achieving Sustainable Development in Jordan: Country Environmental Analysis*, 116.

⁷³ *Ibid.*, 71.

⁷⁴ *Ibid.*, 116.

prices.⁷⁵ Domestic Household #2 stated that he believed that the Disi Aquifer was renewable.⁷⁶ This answer suggests that there is not a need to conserve water since its source will not entirely deplete. For the most part, none of the households use methods in their homes to conserve water, save for one individual who used drip irrigation for the small group of olive trees in his yard and Domestic Household #1 where the family uses some type of filter in the tap water “that doesn’t allow a lot of the water to flow out at once.”⁷⁷ According to the IWA, low water prices in rural Jordan prevent water conservation.⁷⁸ The people living in rural Jordan pay low prices for water because, as explained in an interview with the former Minister of Water and Irrigation Muhammad Shatanawi, Bedouins were originally given free water and land as part of a settlement project put in motion by the Jordanian government in the 1970’s.⁷⁹ The Badu people were encouraged by the government to develop in southern Jordan so that they would end their nomadic ways of living.⁸⁰ However, the former Minister stressed, “You cannot irrigate agriculture in a desert. Maybe bring in water for drinking purposes, but not agricultural.”⁸¹ Seven out of the eight farmers interviewed used the Disi’s resources for water intensive crops such as tomatoes and melons. None of the farmers used outside expert advice on crop selection or irrigation methods, although half of them use professional advice for pesticide use. Some of the farmers said that they did not necessarily regulate the amount of water they used on their plants; Farmer #8 said that

⁷⁵ Domestic Households, interview with Ryan D. Greenwood, November 12, 2011.

⁷⁶ Domestic Household #2, interview with Ryan D. Greenwood, November 12, 2011.

⁷⁷ Domestic Households, interview, November 12, 2011.

⁷⁸ Goldin, “Higher Water prices could solve shortage- report.”

⁷⁹ Shatanawi, interview, November 17, 2011.

⁸⁰ Ibid.

⁸¹ Ibid.

he lets the water run until it is visibly deemed the plants have had enough.⁸² Over-irrigation is an inefficient use of water since it can lead to disease and pesticide use.⁸³ However, because the farmers do not pay by a meter, they feel there is no need to regulate exactly how much water they use for plants.

Half of the farmers interviewed pay a lump sum to rent their land and are provided with water. Seven out of the eight farmers were not in favor of raising water prices in order to conserve the Disi's resources; four of them said raising prices did not make sense because they currently get their water for free. However, seven out of the eight farmers do not believe that there will be an alternative source of water to use once the Disi is depleted. Only Farmer #1 brought up desalination as a potential future step, while the majority of the other responses went along the lines of with Farmer #2's answer: "There is no alternative- the farms will be destroyed."⁸⁴ Half of the farmers interviewed said that they would be fine if people in Amman paid the same price for water as people in the Disi region. All of the farmers use drip irrigation and three of the eight also used milsh (a black plastic put on the ground around the plants to maintain moisture) in order to make the best use out of the water delivered to them by the government. Farmer #4 stated, "I feel that deep irrigation (applying water directly to the roots) would be more effective in saving agriculture and money, but this system [drip irrigation] definitely saves money because otherwise the water would evaporate and I would lose agriculture."⁸⁵ When asked about the possibility of raised water prices, Farmer #6 stated, "In the case of [a price] increase, people will still consume the same

⁸² Farmer #8, interview with Ryan D. Greenwood, November 11, 2011.

⁸³ Raed al-Tabini, in discussion with the author, December 1, 2011.

⁸⁴ Farmer #2, interview with Ryan D. Greenwood, November 11, 2011.

⁸⁵ Farmer #4, interview with Ryan D. Greenwood, November 11th, 2011.

amount of water. People should be trained on how to properly use and conserve water. The training should be provided by the specialists in the Water Authority. They should train people and then regulate them.”⁸⁶ However, Munqeth Mehyar believes that this type of action would be insufficient:

To use any kind of groundwater for agriculture is a crime. High quality water in a water scarce region should not be used for farming. Wadi Rum was not built for farming. It is very expensive to harm over there when we consider the real price of water. The cost-benefit is very inefficient when we look at the heavy subsidies provided by the government.⁸⁷

This contradicts with the feelings of farmers in the south. Farmer #6 stated,

If you came here 20 years ago, the situation for people was very bad. People still stayed here. They have the right to cheaper prices because they have endured difficulties. People in Amman sell their houses for a lot, whereas here, not very much. If they change the price in Amman, it would not affect them as much as it would affect people here. If they raise the price here, people will face hunger.⁸⁸

Farmer #6 feels that people in Amman are better prepared to handle water price increases than farmers in rural areas; he placed more importance stress on the morality of raising water prices for those already facing a degree of economic hardship rather than addressing the nation’s need to conserve its resources by reconfiguring prices. Agriculture is a field that does not bring in much profit even though it takes in a

⁸⁶ Farmer #6, interview with Ryan D. Greenwood, November 12th, 2011.

⁸⁷ Mehyar, interview, November 14th, 2011.

⁸⁸ Farmer #6, interview, November 12th, 2011.

significant amount of Jordan's precious water. Morally, however, the farmers living in the south need a way to survive and the Jordanian government set the precedent by encouraging them to settle in the south. The government gave the farmers and domestic households either highly subsidized prices or water for free in order to encourage the people to stay, and it would be very difficult to uproot an entire body of people and either move them or force them to change their professions when they will feel direct social and economic short term impacts as opposed to the long term economic benefits the entire country would receive in the future.

In an interview at Jordan University with Professor Elias Salameh, it was made clear that he believes agricultural practices in the south were not a sustainable way to use the Disi's resources. He stated, "Agriculture does not bring much profit because of the high evaporation rates."⁸⁹ Salameh, who has been doing research on the Disi Aquifer since the 1980s, believes that agricultural activities in Disi should end. He explained that if 1000 square meters of land is used in the north for agricultural purposes, 500 M³ of water is needed to irrigate the land. By contrast, in the south 1,200 M³ of water on average is needed for the same amount of land. "One can irrigate double the amount in the north using the same amount of water. Water should be used for drinking water now and then for irrigation to double its use."⁹⁰ Salameh, along with other individuals interviewed, also discussed how moving people to the Disi instead of moving water up north would help the country economically. In 2007 the government made plans to build an industrial zone in Mufraq and a housing project in Zarqa; the northern

⁸⁹ Elias Salameh, interview with Ryan D. Greenwood, November 22, 2011.

⁹⁰ Ibid.

projects combined would use sixty MCM of water annually.⁹¹ Salameh proposed to the Royal Committee to instead move the projects down south close to the Disi in order to save energy and water. Moving the projects down south would relieve Zarqa of stress from traffic and the local environment.⁹² To Salameh's disappointment, the government went along with both projects, and now it is too late to make changes. Hydrologist Dr. Marwan Alraggad, who worked for the Ministry of Water and Irrigation for five years, also felt that moving people down south instead of moving the Disi's resources up north would be good for the country. He stated that decentralization would be good for the country; "Amman is too concentrated; we should make an urban center near Disi to save money."⁹³ Mahasneh also shared this point of view: "We should create other urban centers near Disi to save water and energy consumption,"⁹⁴ he said. However, since the likelihood of the Jordanian government adopting this mindset is low, my interviewees suggested other methods of conserving Jordan's water on a smaller scale. Mehyar argued: "The Ministry of Water should educate people and communicate more. People should be encouraged to use double flush toilets because they use less water. Thirty percent of water [in domestic households] is used for flushing toilets. People should be encouraged to use grey water for flushing."⁹⁵ Local water conservation both in city and rural households combined with mending the network, relocating agricultural to the north to produce more and new urban centers to the south, and educating the public on water conservation methods appear to be the best economic ways to manage and use Jordan's water sources.

⁹¹ Ibid.

⁹² Ibid.

⁹³ Alraggad, interview, November 22, 2011.

⁹⁴ Mahasneh, interview, November 22, 2011.

⁹⁵ Mehyar, interview, November 14, 2011.

Political Effects

As Jordan figures out how to manage the Disi's resources domestically, it also needs to negotiate with its neighbors in order to get water from both the Disi and other resources. The Disi Aquifer is a non-renewable fossil aquifer shared with Saudi Arabia. As both countries use it up, it is necessary that the Jordanian government find a viable long-term solution to the country's water scarcity once this strategic reserve runs out. Along with the Disi Aquifer, Jordan has access to the Jordan River and the Yarmouk. The Hashemite Kingdom's "total renewable water resources sum up to "900 MCM/year."⁹⁶ Saudi Arabia currently withdraws over 1000 MCM from the Disi Aquifer alone.⁹⁷ Jordan plans on extracting 100 MCM annually.

According to the Mehyar, "Saudi Arabia is accepting the fact that Jordan is using the water. The fight is over. Saudi Arabia originally blocked the financing, but they realized we need it."⁹⁸ When asked about how having the Disi as a domestic water resource would affect how we conducted hydropolitical relationships with our neighbors, Mehyar stated "The Disi has no impact on our relationship with Israel. Our treaty needs to be re-negotiated because the current treaty is because on numbers that are twenty years old. Jordan needs to negotiate with Israel to get our rightful share. We will always need more water."⁹⁹ Mahasneh shared this sentiment: "We will still push for our fair share of water. We have signed agreements."¹⁰⁰ However, while it might not change how we negotiate with our neighbors for water, Mehyar consented that there is a

⁹⁶ John Allen, "Disi Aquifer: Jordan and Saudi Arabia" (working paper, University of Texas, Austin, TX, 2010) 2.

⁹⁷ Ibid.

⁹⁸ Mehyar, interview, November 14th, 2011.

⁹⁹ Ibid.

¹⁰⁰ Dureid Mahasneh, interview, November 22, 2011.

definite potential for internal politics to harm long term sustainability goals: “It will cause Jordan to relax and prevent us from pushing for reform. We will think ‘I have water, so why should I change?’”¹⁰¹ Salameh discussed another domestic political issue: how water will be distributed between classes if a water shortage occurs after the aquifer’s resources are depleted. “Poor areas get less water. If a rich man does not have water, it is easier for him to get water than a poor person without water because he can afford it. Water shortages will impact poor people more severely than rich people.”¹⁰²

However, even though Salameh does not believe that the Disi Aquifer Project is an optimal solution, he believes there will be short-term benefits, “Suffering in the north will be satisfied. There is a problem in the mindsets of Jordanians: it’s always a constant worry for Jordanians on whether their tanks have enough water. Farmers in the Jordan Valley are suffering. Their water will be pumped to Amman. Water effluence from the north will go to farmers and they will get more water.”¹⁰³ Dr. Alraggad also agreed that there would be short-term benefits: “It will enhance our human security and per capita supply. It will help the environmental area around Amman. We will reduce the use of the Azraq basin and let it recover. We currently take water from Madaba and Kerak- they will be able to keep their water.”¹⁰⁴ According to Dr. Abbas Al- Omari, based off of information provided by the Ministry of Water and Irrigation: “It will help satisfy some of the water supply for ten years. After ten years the deficit will come up again in Amman because of population growth and high per capita revenues (people use more water as their economic status gets better) and more immigrants will come into Jordan and use

¹⁰¹ Mehyar, interview, November 14, 2011.

¹⁰² Salameh, interview, November 14, 2011.

¹⁰³ Salameh, interview, November 22, 2011.

¹⁰⁴ Alraggad, interview, November 22, 2011.

more water.”¹⁰⁵ It is clear that the aquifer’s usage will provide short-term benefits for Jordan. However, because of the lack of a long-term solution or a contract with Saudi Arabia on how the Disi’s resources should be officially split, this could lead to both domestic and international disagreements.

Health Effects

Avner Vengosh and his team were funded by USAID in 2004 to study the effects of salinity and the age of groundwater in Israel, Jordan and the West Bank. According to the published study:

“Thirty-seven groundwater samples were collected from pumping wells in the Cambro-Ordovician sandstone Disi (Rum Group) aquifer and the overlying Khreim Group in the Disi-Mudawwara and Dead Sea areas in southern and central Jordan. Groundwater samples were measured for major and trace elements and for the four Ra isotopes. In addition, sandstone rocks from the Cambro-Ordovician sandstone in Disi, Jordan, and Lower Cretaceous Nubian sandstone rocks in the Negev, Israel, were measured for their ²²⁸Ra and ²²⁶Ra contents.”¹⁰⁶

The wells studied from the Disi were all in use at the time for drinking water and agriculture, and they were found with exceedingly high radioactivity levels.¹⁰⁷ According to S. Upson in an article from Spectrum IEEE,

“Vengosh theorizes that the isotopes entered the water from the surrounding sandstone through a physical process known as recoil. Thorium-232 and thorium-230,

¹⁰⁵ Al-Omari, interview, November 22, 2011.

¹⁰⁶ Vengosh et al., “High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East,” 1769.

¹⁰⁷ Vengosh, interview, November 22, 2011.

the parents of radium-228 and radium-226, respectively, exist naturally in the porous sandstone that holds the Disi water. When one of those thorium atoms radioactively decays to emit an alpha particle (two protons and two neutrons bound together) some energy is also released that causes the new atom to move in the opposite direction of the ejected particle. In some cases, the recoil can cause this new atom to get pushed out of its host material into a surrounding medium- in this case, from the sandstone into water.”¹⁰⁸

Overtime, a significant amount of thorium radioactivity decayed into radium and, through the recoil process, was pushed from the sandstone into the water. Dr. Alraggad explained that since the aquifer is made of sandstone, that meant that its origin is granite and naturally carries radioactivity.¹⁰⁹ Vengosh’s team cited a study conducted by the New Jersey Department of Health and Senior Services; the study’s purpose was to discover if there was an increased risk of developing osteosarcoma in areas that contained water sources with high levels of radium.¹¹⁰ The MoWI has acknowledged the radioactivity issue and stated that the pipeline’s water will be sent to two large reservoirs outside of the capital.¹¹¹ 100 million cubic meters of the Disi’s water will be blended with 105 million cubic meters of Amman’s current supply of treated surface water.¹¹² However, according to Vengosh’s research, a 1:1 ratio will not be enough to bring radioactivity levels below international standard. A 2:1 ratio is needed in order to bring the radium levels down to the World Health Organization’s standards.

¹⁰⁸ Upson, “Jordan’s radioactive water problem,”2.

¹⁰⁹ Alraggad, interview, November 22, 2011.

¹¹⁰ (P Cohn 2007)

¹¹¹ Upson, “Jordan’s radioactive water problem,”2.

¹¹² Ibid.

Since Vengosh is an Israeli, it has proven to be difficult to establish that his study is legitimate. Many people living in surrounding Middle Eastern countries tend to not have a positive opinion of Israel because of the Palestine-Israel issue. As a result, few Jordanian professionals are willing to give Vengosh's study validity. The Jordanian government has recognized that the Disi's water is contaminated with radiation, but some Jordanian academics and scientists questions Vengosh's motives behind the study and therefore whether or not the study is valid.

Dr. Alraggad discussed how the government's general water quality procedures include testing salinity levels, NO_3 , and for pathogens (E. coli). However, in reference to radioactivity, he stated "The government has not carried out their own study."¹¹³ The MoWI is monitoring some of the wells, but "they have not published a study on radioactivity levels."¹¹⁴ Alraggad's reasoning for the lack of a published study was: "If the monitoring process is going well, there is no need to publish a report. A report will be published if a problem comes up."¹¹⁵ If a problem did occur, then "[a] simple treatment will be enough to treat it."¹¹⁶ When Munqeth Mehyar was asked about the legitimacy of the study, his response was "We've been using water from the Disi Aquifer for over 30 years. As far as I know, it has the best quality water. I personally do not have proof or disproof. My feelings are that it's not true. The government did testing on it. Would GAMA take on this project if it were that polluted? The same water has been used by Saudi Arabia."¹¹⁷ When I asked Dr. Abbas Al-Omari the same question, he responded "The radioactivity concentration is different from well to well. I think it might

¹¹³ Alraggad, interview, November 22, 2011.

¹¹⁴ Ibid.

¹¹⁵ Ibid.

¹¹⁶ Alraggad, interview, November 22nd, 2011.

¹¹⁷ Mehyar, interview, November 14, 2011.

be politically motivated, and the radium levels are unknown. Some of the wells tested in the study might be abandoned. Radioactivity levels are different well to well.”¹¹⁸ Political prejudices that exist between Israel and Jordan are interfering with Jordan’s academic individuals from pushing the government to find out the exact radium levels and how to go about solving the issue. When I asked Dr. Elias Salameh about Vengosh’s study, he replied:

Any deep ground water source has radioactivity. It is not something that can be dealt with easily technically or scientifically. The main portion of the work was done by Israelis. It was one short sampling. You have to analyze each source several times to see each well. Some have radioactivity, others not. The time of publishing the paper was critical. It looked like they wanted to create panic. It is not a big problem to solve; the big question is where to put the radioactive waste. The big problem is that the Israelis took samples and wrote reports and included Jordanian names. Why didn’t they protest against other projects where water was being used for drinking purposes? There is no such thing as an international standard for water- Canada’s limits are ten times that of Australia’s. European standards are stricter. How much [radioactivity] is removed by pumping and irrigation?¹¹⁹

If it is so obvious that radioactivity naturally occurs in deep ground water sources, then the Jordanian government needs to find out for itself what the levels are and work with the academic community to find the best way to treat the radioactivity levels.

¹¹⁸ Al-Omari, interview, November 22, 2011.

¹¹⁹ Salameh, interview, November 22, 2011.

Vengosh's response to these accusations was, "People would use this water without any protection. Since this would be the major source of drinking water in Amman, we thought that printing out this paper would be looked at as serving the people. I was naïve and the government was very defensive and in denial. Public perception that will tell us one thing- it's only conspiracy."¹²⁰

While it might be considered rational from a Jordanian's point of view to question the motives behind Vengosh's study, it is even more crucial that the Jordanian government conduct its own study on the water from the Disi to see what the radioactivity levels in individual wells. It is difficult to "make up" science; the potential results from having the majority of Jordan's population drinking from contaminated water as a result of not doing proper testing are far worse than conducting a study and possibly finding out that the radioactivity levels of these particular wells are fine for domestic consumption.

Conclusion

As one of the world's driest countries, Jordan is backed into a wall. Treaties for the country's current renewable resources are not enough to provide enough water for Jordan's needs. This research proved my hypothesis. While the Disi Aquifer Project will provide numerous short-term benefits for Jordan, in the long-term there will be more negative effects than positive. Short term, Jordan will have access to a new water source and it will bring labor opportunities for domestic workers. As Abbas Al-Omari stated, it will fulfill the deficit for ten years before population growth and economics re-create the gap. Short-term, the majority of Jordan will have access to water. With the

¹²⁰ Vengosh, interview, November 22, 2011.

big agricultural companies having their contracts end in 2011, this will also add to the amount of drinking water available for citizens.

Long-term, even though half the farmers interviewed were okay with Amman paying the same amount for drinking water as those living in the Disi area, their opinion might change once the Disi Aquifer's depletion starts to affect them. The government might have to consider moving people around in order to make best use of Jordan's water so that the country as a whole can survive, specifically those who work in agriculture. Agriculture in the south clearly is not a sustainable way to use water, while farming in the north would be a much better use of water. However, even though this might be an economically savvy solution to Jordan's lack of profit from agriculture, it would cause social issues because this process would mean that the government would have to uproot people in the south, which would inevitably cause degree of internal strife.

The fact that Saudi Arabia and Jordan do not have a treaty over how the Disi Aquifer is used is also a problem. While in the short term it might be fine, once the Disi starts to run out of water there might be conflict between the two countries on how to distribute the remainder of the water. The "silencing" policy, while it might temporarily give Saudi Arabia and Jordan the freedom use the water the way they want, might lead the Tragedy of the Commons theory to come into play; Jordan and Saudi Arabia, while they are rationally extracting water from a resource in order to satisfy their countries' needs, they are each acting in their own self interest without consulting the other, and thus the Disi's resources could potentially run out before either country comes up with an alternative resource.

While Jordan uses the Disi Aquifer, the issue of radioactivity is being addressed as quietly as possible. I was unable to get numerical, hard information from any of my interviewees on the aquifer's radioactivity levels, with the exception of the one scientist who has actually conducted a study, Avner Vengosh. The Jordanian government has acknowledged that at least some of the Disi's wells contain radioactivity, but they have yet to publish any studies of their own on the exact levels of radioactivity. Since the government has recognized that there is a radioactivity problem in the Disi's water, the best solution would be have an independent group either copy Vengosh's study or conduct a more in-depth study on the wells that are being drilled for drinking purposes to find the exact amount of radioactivity in each well; even though treatment will be expensive, surely it is better to be preventative and take care of the problem now as opposed to going along with the Disi project without proper treatment and facing a country-wide bone cancer increase in the future; this might result with disciplinary action from international bodies such as the UN where government officials could be brought forth on counts of genocide for knowing that a problem existed with the radium levels and they knowingly failed to take proper action.

Limitations

My findings would have more scope and depth if I was given the opportunity to interview somebody from the MoWI. Such an interview would have added another perspective on the economic and political effects of the Disi Aquifer. It might have been difficult to find out more about the radioactivity issue because it is a sensitive topic, but it would have been worth trying to find out. I feel that if I had more time to conduct my research and was able to make connections with more people who knew those who

worked at the Ministry, I might have had a better chance of successfully setting up an interview.

Language was a barrier in my interviews with farmers and local households in the Disi area; if I were able to speak Arabic to a degree of fluency, it would have been easier to develop a better understanding of my interviewees' responses and thus reduce my dependence on a translator and allow less room for misinterpretation. I also might have received more in-depth answers from farmers if I were male; I oftentimes felt that my legitimacy as a researcher was silently questioned by some of my interviewees; I might have received more emotional and honest answers if I was a local male that my interviewees felt they could absolutely trust.

Recommendations

This research has led me to the conclusion that the Jordanian government needs to involve scientists and academics more in their policy decisions; it seems that the government is carrying through a project that contradicts the opinions of those who have done extensive research on the Disi and have rational alternatives. When the water from the Disi runs out, the Jordanian water network will still lose up to half of its water before it reaches citizens. Taking action now could prevent a great deal of water from being lost and will help make Jordan's already scarce resources last as long as possible.

While moving farmers to the north might be a difficult endeavor and might result in temporary discontent amongst the Badu people in the south, it might be one of the few options Jordan can take in order to make optimal use out of its agricultural production. The government should involve the Badu people in the decision process so

as to avoid as much controversy as possible; it would be economically sound to keep people in the south for tourism purposes, and those who want to continue with agriculture can do so in the north in alternative villages. As for developing new urban centers in the south, It would only make sense to do so if the government were to invest in a long term water solution in the area, such as a desalination plant.

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Appendices

A. Questions for farmers and domestic households in the Wadi Rum area.

1. How old are you?
2. What is the extent of your education?
3. What products do you grow on your farm?
4. Do you use outside expert advice for crop selection?
5. Do you use outside expert advice for irrigation?
6. What do you currently pay for water?
7. Do you own a well or rent?
8. What are the main sources your water comes from?
9. What are methods you currently use to conserve your water usage, if any?
10. Do you believe there are economic gains in conserving water from the Disi Aquifer?
11. Does it make sense, in your opinion, to raise water prices in order to conserve water and make the Disi's resources last longer? Why or why not?
12. What do you think will be a main source of water to use once the Disi Aquifer's resources are depleted?
13. How do you feel about the Disi Aquifer's construction? How will it affect local citizens?
14. How do you feel about citizens in Amman paying the same price for water as citizens here?

15. What, in your opinion, are the negative aspects of building the Disi Aquifer?
16. Is there anything else you would like to share with me?

B. Combined questions asked to scientists and academics.

1. What is your background with the Disi Aquifer?
2. What are short term and long term benefits?
3. What are the short term and long term negative consequences?
4. How will the Disi Project affect Jordan's relationships with other countries we currently negotiate for water with now?
5. How will the aquifer's usage help Jordan gain status as a regional power?
6. What, if any problems, have arisen with Saudi Arabia?
7. What are the social effects of the Disi Aquifer Project on Jordanian society?
8. How do you feel the Disi Aquifer will affect farmers and other local citizens in the Disi area economically?
9. What are your thoughts on how the Disi's resources are being used for water now?
10. How will the project affect prices in Amman and in the Disi area?
11. What do you foresee Jordan using as a main source of water once the Disi's resources are depleted?
12. What steps do you believe the government should take to make the best use of the Disi's resources?
13. What are your thoughts on the legitimacy of the study done in 2007 on radioactivity? Do you think the government is taking the proper steps to take care of radioactivity levels?

C. Questions for Avner Vengosh.

1. Your paper discusses how the radioactivity levels you found were higher than international standards for water, but I've heard through another interview with (name) that international standards do not exist. Would you mind explaining this to me?
2. Why did you decide to conduct a study on the Disi Aquifer's radioactivity levels when you did?
3. What was the response you received after your study was published?
4. What are the consequences of ingesting too much radium?

D. Consent Form

Effects of the Disi Aquifer on Jordanian Society

Ryan D. Greenwood, University of New Hampshire, New Hampshire, United States
School for International Training—Jordan: Modernization and Social Change

Instructions:

Please read the following statements carefully and mark your preferences where indicated. Signing below indicates your agreement with all statements and your voluntary participation in

the study. Signing below while failing to mark a preference where indicated will be interpreted as an affirmative preference. Please ask the researcher if you have any questions regarding this consent form.

I am aware that this interview is conducted by an independent undergraduate researcher with the goal of producing a descriptive case study on the social, economic, political and health effects of the Disi Aquifer on Jordanian society.

I am aware that the information I provide is for research purposes only. I understand that my responses will be confidential and that my name will not be associated with any results of this study.

I am aware that I have the right to full anonymity upon request, and that upon request the researcher will omit all identifying information from both notes and drafts.

I am aware that I have the right to refuse to answer any question and to terminate my participation at any time, and that the researcher will answer any questions I have about the study.

I am aware of and take full responsibility for any risk, physical, psychological, legal, or social, associated with participation in this study.

I am aware that I will not receive monetary compensation for participation in this study, but a copy of the final study will be made available to me upon request.

I [do / do not] give the researcher permission to use my name and position in the final study.

I [do / do not] give the researcher permission to use my organizational affiliation in the final study.

I [do / do not] give the researcher permission to use data collected in this interview in a later study.

Date:

Participant's Signature:

Participant's Printed Name:

Researcher's Signature:

Thank you for participating!

Questions, comments, complaints, and requests for the final written study can be directed to:

Dr. Raed Al-Tabini, SIT Jordan Academic Director

Telephone (962) 0777463348

Email: raed.altabini@sit.edu