Running Dry

THE IMPACT OF SYRIAN MIGRATION ON WATER DEMAND IN NORTHERN JORDAN

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Recent Syrian migration has sharply increased water demand in northern Jordan, a region characterized by severe water scarcity. A global risk analysis conducted by Maplecroft ranked Jordan as the third most water insecure country in the world.[1] According to the Jordan Ministry of Water and Irrigation (MWI), Jordan is a resource-starved, middle income country with an insufficient water supply. Classified as a semi-arid to arid region and comprising 89,297 km^2 of land, more than 90% of Jordan is defined as either desert or rangeland. Additionally, the country receives less than 200mm of annual rainfall over 92% of the land.[2]

The MWI documented Jordan's annual renewable water resources to be less than 100m^3/capita in 2016, a number far below the global threshold of

severe water scarcity, which is 500m^3 /capita. This indicates that renewable water resources in Jordan are either unable to meet national demand or unsustainable or both. Additionally, watersheds and aquifers are becoming increasingly overused and the national water balance is facing negative impacts due to high demand, over-abstraction, and climate change.[3]

Both national and international concern is growing over the impact of refugees and associated relief plans on regional groundwater resources. Jordan's northern border towns, specifically the governates of Mafraq, Irbid and Zarqa (MIZ), have been overwhelmed by a population increase of 1.7 million[4] people since 2005, when the last official Jordan Department of Statistics (DOS) census was conducted. This population increase is due to country population growth in addition to Palestinian and Syrian refugee migration. In 2015, the MIZ governorates' population was 3.7 million, double the 2005 census population of 1.9 million.[5] Numerous compounding factors impact water usage in Jordan; therefore, it is necessary to investigate and further define the implications of the growing Syrian refugee population on the country's water sector. The result of this investigation will further clarify Jordan's water needs and assist in future water developmental plans.

A Brief History of Jordan

The sociopolitical history of Jordan is intertwined with regional water politics. Due to border changes and a history of accepting refugees, Jordan continuously encounters changing demographics and transboundary water resources, leading to changes in water use and Jordan's ability to meet this rising demand.

The 1917 British invasion of the territory comprising today's Israel, Iraq, and Jordan removed it from centuries of Ottoman control and led to the establishment of Mandatory Palestine, Mandatory Iraq, and the Emirate of Transjordan. In 1921, the Hashemites, the royal family currently ruling Jordan, established power in Transjordan in unison with the British.[6] In 1946, the Hashemite Kingdom of Transjordan gained independence. Two years later, in 1948, Jordan fought

Picture 1: The Jordan River

lands of former British-mandated Palestine, gaining control of the West Bank. The West Bank was later regained by Israel during the Six-Day War in 1967.

The creation of Israel and the later Jordanian loss of the West Bank meant the kingdom lost most of its control of the Jordan River (see picture 1). The lower portion of the Jordan River, which runs down Jordan's border with Israel, is supplied by headwaters stemming from both the Sea of Galilee and the Yarmouk River. The river basin changed dramatically as a result of increased water use following the establishment of Israel and the Six-Day War.[7]

The flow of the upper portion of the Jordan River (whose headwaters start in Lebanon) into the Sea of Galilee has remained relatively natural, but flow rates downstream have decreased sharply due to construction and reallocation in the past 50 years. Israel is now the only user of the Sea of Galilee, as well as the largest user of water from the Jordan River basin, withdrawing an estimated 640-800 million cubic meters

(MCM)[8] annually. This compares to Jordan's estimated 290 MCM annual use of the basin. The current annual water discharge into the lower portion of the Jordan River into the Dead Sea is projected at 20-200 MCM compared historically to 1,300 MCM (the Dead Sea's shoreline "bathtub rings" seen in Picture 2 offers ample evidence of this decrease in water flow). Additionally, the decrease of the water supply in the lower Jordan River has been compounded by a dramatic decline in water quality, now consisting of primarily untreated sewage and agricultural runoff.[9]

The ebb and flow of Jordanian borders plays an important part in Jordan's acceptance of refugees. Currently 2.1 million Palestinian refugees are registered in Jordan.[10] Additionally, there was an influx of Iraqi refugees after the Iraq War began in 2003. At the same time, Sudanese, Egyptians, and Yemenis also fled to Jordan, as a result of perils in their respective countries. Most significantly, Jordan has recently seen a dramatic increase in refugees from Syria.[11]

Picture 2: The shoreline of the Dead Sea

The Hashemite kingdom's stable leadership in the region has allowed for millions of refugees to flow into the country. However, Jordan is reaching its limit. In a February 2016 interview with the British Broadcasting Corporation (BBC), King Abdullah II noted that Jordanians were suffering as a result of the influx, with 25% of the state budget spent on helping refugees, public services under strain and many struggling to find jobs, going on to state:

"The psyche of the Jordanian people, I think it's gotten to the boiling point. Sooner or later, I think the dam is going to burst and I think this week is going to be very important for Jordanians to see, is there is going to be help—not only for Syrian refugees, but for their own future as well.'"[12]

Recently, Syrians migrated to Jordan due to the Syrian Civil War, caused by political changes resulting from the Arab Spring, over 40 years of a Syrian police state, discontent over the vast power of the Assad regime, and a devastating drought[13] exacerbated by global warming. The conflict resulted in an estimated 10 million Syrians displaced both within their own country and globally,[14] including millions of Syrians fleeing to northern Jordan, a region already strained with limited water resources.

Population Breakdown of Syrians in Jordan

Results of selected censuses and estimates conducted by the Department of Statistics (DOS) are presented to more fully understand the impacts of the post-Arab Spring Syrian migration into Jordan. Table 1 shows the general population trend increases and establishes the pre-Arab Spring population baseline.[15] The average growth rate of the Jordanian national population is 1.94%, higher than the world average growth rate of 1.7%. Table 1 shows an annual increase of 4.5% in population, due to outlier impacts such as the Six-Day War, the Gulf War, the Syrian Civil War, and foreign migration.

Table 1: Population Statistics, includes data for all Hashemite Kingdom of Jordan censuses, as well as DOS estimates between each 10-year census				
Year	Population	Annual Increase	Annual % Increase[20]	
1952	586,200	xxx	xxx	Census
1961	900,800	34,955	4.8	Census
1965	1,028,000	31,800	3.3	Estimate
1970	1,508,200	96,040	7.6*	Estimate
1975	1,810,500	60,460	3.7	Estimate
1979	2,133,000	80,625	4.1	Census
1984	2,599,000	93,200	3.9	Estimate
1989	3,144,000	109,000	3.8	Estimate
1994	4,139,400	199,080	5.5**	Census
1999	4,738,000	119,720	2.7	Estimate
2004	5,597,000	171,800	3.3	Census
2011	6,993,000	199,429	3.1	Estimate
2015	9,531,712	634,678	7.7***	Census
Average Population Increase		**159,141**	**4.5**	

* Six-Day War (1967): Involved Israel, Egypt, Palestine, Syria, and Jordan; resulted in the Israeli annexation of the West Bank from Jordan and the Golan Heights from Syria.
** Gulf War (1990-1991): Kuwait hosted many Jordanian expatriates and refugees after Gulf War expatriates and refugees residing in Kuwait were forced to return to Jordan.
*** Syrian Civil War (2011-present): See Table 2 for breakdown
Statistics were taken from three DOS documents[21]

The UNHCR recorded 655,344 Syrians as *refugees* in Jordan in December 2016.[16] Unfortunately, this can be misleading, as there are approximately 1,265,514 *total* Syrians in Jordan (see Table 2). Syrians are often statistically under-represented in Jordan due to differences in government classification and the turbulent nature of war. There are approximately 610,170 Syrians in Jordan who not registered as refugees.[17]

The more than 1.2 million Syrians recorded in Jordan's Department of Statistics (DOS) 2015 census include registered and non-registered refugees, asylum seekers, expatriates, and others. For the purpose of water analysis, the recorded DOS number of Syrians (seen in Table 2) in Jordan will be used in calculations, and not the number of registered refugees.

Water Analysis in the North

Jordan utilizes both groundwater and surface water sources. Due to Jordan's border, there are very few water basins not shared with other countries. Jordan's only water resources contained exclusively within the nation's borders are limited to winter rainfall,[18] the Zarqa River north of Amman, seasonal *wadis* and streams, and a few, limited groundwater aquifers. Cross-border surface and groundwater sources remain Jordan's main water sources. Unfortunately, agreements between Jordan and other countries are not always honored; determining the exact amount of water that is available for use on a year to year basis is difficult.[19] Regardless of these limitations and uncertainties, water demand will be based on municipal, tourism, irrigation, and industrial uses

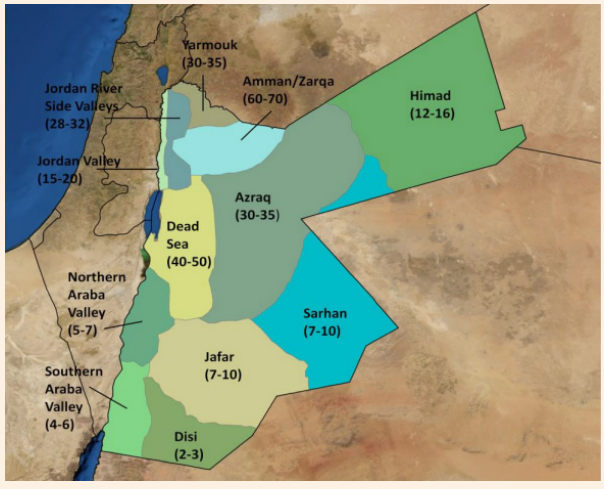
"Cross-border surface and groundwater sources remain Jordan's main water sources. Unfortunately, agreements between Jordan and other countries are not always honored."

The overall water demand in Jordan, according to 2015 figures, was 1,401 MCM. The Jordan Ministry of Water and Irrigation (MWI) provides a water demand calculation that was used to determine the Syrian water demand in Jordan, estimating it to account for a total of 3.3% demand increase on all water usage. The water demand calculation was then used to analyze the Syrian water demand in the MIZ governorates (1.7% demand increase on total country use). A further breakdown looked into the impact Syrians have had on municipal water demand in the MIZ governorates (19.8% demand increase on MIZ municipal use). It is important to note that municipal demand is under the umbrella of the previously listed percent increases. While this number seems large, it is a breakdown of a category (municipal use) within the total country water demand.

Jordan's Ministry of Water and Irrigation sets standards for municipal use of water share per person per day (liter/p/d) based on available water resources in order to estimate per capita consumption.[22] The water demand is separated into three different categories:

- 80 liters/p/d in rural areas,
- 100 liters/p/d in urban areas,
- 120 liters/p/d in the capital, Amman.

Table 2: Breakdown of Syrians in Jordan	
Registered Syrian refugees (as of UNHCR's Dec. 31, 2016 report)	655,344
Syrians not registered as refugees, residing in Jordan	610,170
2015 DOS census: recorded Syrians in Jordan	**1,265,514**
Discrepancies are due to the varying definitions of "refugee," "registered refugee," "unregistered refugee," and "guest."	



Picture 3: Jordan aquifers and safe yield estimates

In Table 3, I provide a breakdown of Jordan's municipal water share in liters/p/d, highlighting the populations' use in the northern governorates of Mafraq,

Irbid and Zarqa (MIZ). Water demand in Amman, where roughly 40% of the population resides, was used only for the estimated total. Daily water consumption is provided in liters per day and converted to million cubic meters (MCM) when addressing yearly consumption.

The MWI estimated that 2015 water demand across all sectors (industrial, irrigation, municipal, and tourism) was approximately 1,401 MCM. The ministry provided a breakdown of demand as listed below.[23]

- Municipal, industrial and tourism: 701 MCM[24]
- Irrigation: 700 MCM

Table 4 shows that almost 20% of the MIZ municipal water demand is attributed to the Syrian population. Total increase in Syrian MIZ water demand is less than 4% in the country, which highlights the uneven

population distribution and resulting stress on the water resource. These figures are based on the water demand indicated in Table 4 and the total country demand noted by the MWI.[25]

Confounding Variables

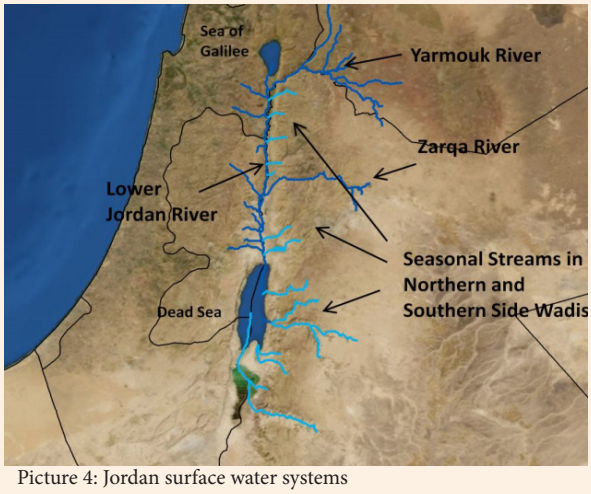
Twelve groundwater basins account for 60.6% of Jordan's total water supply.[26] According to the MWI report, six basins are over-extracted, four are utilized at capacity, and two are underexploited. The Jordanian government estimates that the twelve water basins have a combined safe yield of 275 MCM/yr (see picture 3 for breakdown).[27] In 2014, a total of 589 MCM/yr of ground water was utilized to satisfy country demands; this resulted in nearly 314 MCM/yr of over abstraction of Jordan's ground waters. The country water strategy for the 2016-2025 period aims to cut over abstraction of groundwater to 118 MCM/yr by 2025. Unfortunately, due to limited options, the current plan could not eliminate completely the need for unsustainable extraction.

Surface water (26.6%) and treated wastewater (12.8%) make up the remaining amount of Jordan's water supply.[28] Historically, the Yarmouk river, when combined with the upper Jordan River, provided a major source of surface water to Jordanians. Before the 1960s, flow into the Dead Sea was estimated at around 1,300

Table 3: Residential Water Share Breakdown

MIZ Governorates	Population	% Total Population (Jordan)	Water Share in liters/person/day			Average liters/person/day*	Million Cubic Meters MCM/day	MCM/Year
Syrian MIZ Population			80 liters	100 liters	120 liters			
Mafraq	207,903	2.18	16,632,240	20,790,300	xxx	18,711,270	0.018	6.329
Irbid	343,479	3.6	27,478,320	34,347,900	xxx	30,913,110	0.030	11.283
Zarqa	175,280	1.84	14,022,400	17,528,000	xxx	15,775,200	0.015	5.757
Sub-Total	726,662	7.62				65,399,580	0.065	23.870
Total MIZ Population								
Mafraq	549,948	5.77	43,995,840	54,994,800	xxx	49,495,320	0.049	18.065
Irbid	1,770,158	18.57	141,612,640	177,015,800	xxx	159,314,220	0.159	58.149
Zarqa	1,364,878	14.32	109,190,240	136,487,800	xxx	122,839,020	0.122	44.836
Sub-Total	3,684,984	38.66				331,648,560	0.331	121.051
Total Pop								
Syrian (Total)	1,265,514	13.28	101,241,120	126,551,400	151,861,680	126,551,400	0.126	46.191
Jordan (Total)	9,531,712	100	762,536,960	953,171,200	1,143,805,440	953,171,200	0.953	347.907

* Assume equal distribution of Syrians in rural and urban categories.
All data taken from 2015 Jordan Housing and Population Census unless otherwise noted (Hashemite Kingdom of Jordan 2016)



Picture 4: Jordan surface water systems

MCM/yr. Construction of large water diversion projects such as Syrian dams (1980s) on the Yarmouk River and the Israeli National Water Carrier (1950s), which transferred water from the upper Jordan River and the Sea of Galilee to Israel's population centers and arid south, have decreased the inflow into the Dead Sea, with the current flow estimated to be around 20-200 MCM/yr.[29]

The Zarqa River is the only major river completely contained within Jordan's borders. Unfortunately, the river is highly contaminated as it runs through metropolitan Amman, Jordan's main industrial area. The only remaining water sources contained nationally in Jordan include seasonal rivers, intercepted winter precipitation, and treated wastewater (12.8%).

Jordan receives only an estimated one-third of its proposed share of surface water as specified by treaties and agreements of distributed water among neighboring countries. Additionally, rainfall is seasonal and localized, occurring mainly between November and March with high evaporation rates quickly diminishing the available water supply. Furthermore, the MWI notes the need to further develop wastewater collection and treatment in order to further draw from that potential water source.[30] This leaves Jordan chronically dependent on transboundary water sources susceptible to the shaky geopolitical environment and negotiations.

The Jordan River is 223 kilometers long and flows from the northern slopes of Mount Hermon through the borders of Israel, Lebanon, and Syria to the Dead Sea in the south. The largest part of the Jordan River basin is located in Jordan (40%) and Syria (37%) with the remaining basin spread between Israel (10%), Palestine (9%) and Lebanon (4%). The basin had an estimated 2012 population of more than seven million with the majority (71%) residing in Jordan, 18% in Syria, and the remaining in Israel, Palestine, and Lebanon.[32] Note that the water consumption per basin country is not proportional to their respective populations.

Approximate riparian water usage of Jordan River Basin:
Israel: 640-800 MCM/y
Syria: <450 MCM/y
Jordan: 290 MCM/y
Lebanon: 9-10 MCM/y

Table 4: Water demand breakdown: Total water demand in country, total Syrian residential water demand in country, total Syrian MIZ residential water demand

Population Group	Water Demand (MCM)	% Water Demand of Total (Jordan)	% Municipal Water Demand of Total (MIZ)
Jordan (Total)*	**1401**	**100%**	**8.6%**
Syrian (Total)**	46.2	3.3%	xxx
MIZ (Total)**	121	8.6% (municipal demand)	xxx
Syrian (MIZ)**	24	1.7%	19.8%

* (Ministry of Water and Irrigation (MWI) 2016) reported 2015 water demand
**Residential water use based on MWI water consumption formula: 80 liters/p/d in rural, 100 liters/p/d in urban, and 120 liters/p/d in the capital, Amman.[31]

Transboundary Groundwater Systems:				
	Saq-Ram Aquifer System (West)	Tawil Quaternary Aquifer System - Wadi Sirhan Basin	Basalt Aquifer System (West) -Yarmouk Basin	Basalt Aquifer System (South) -Azraq Dhuleil Basin
Riparian Countries	Jordan, Saudi Arabia	Jordan, Saudi Arabia	Jordan, Syria	Jordan, Syria
Total Recharge	3-10 MCM/yr	~30 MCM/yr	Thought to be significant amount; information is unavailable.	~ 37.3 MCM/yr
Surface Area		~44,000 km^2	6,900 km^2	8,500 km^2
Renewability Strength	Low	Very low (0-2 mm/yr)	High	South: Medium, North: High
Storage	Jordan: 4-10 BCM Saudi Arabia: ~740 BCM	22 BCM	Information not available.	Information not available.
Population/ Location	750,000 (500,000 in Tabuk Province in Saudi Arabia, 250,000 in Jordan - 133,000 in Aqaba Governorate 116,000 in Ma'an Governorate)	440,000 - Saudi Arabia. The aquifer is situated on the Jordanian border and there was no population record available.	1.6 million (1.2 million Syrians in the governorates of Dar'a, As Suwayda and Quneytra, and 443,000 Jordanians where the basin extends over parts of the governorates of Irbid and Mafraq)	126,900 (43,600 Syrians within a small part of As-Suwayda governorate and 83,300 Jordanians in parts of the Mafraq and Zarqa governorates)
Amount Abstracted MCM/yr	Jordan: 90 MCM Saudi Arabia: >1,000 MCM	1984: 100 MCM 2004: 3,500 MCM	~ 244MCM/yr - 50-57, Jordan, 189 MCM, Syria	~51.16 MCM Jordan. No information available on Syrian extraction.
Based on last known Groundwater Study	Saudi Arabian Ministry of Agriculture and Water in Saudi Arabia, 1984; Haiste Kirkpatrick International and Scott Wilson Kirkpatrick, 1995; Christian, 2000; Abunayyan Trading Corporation and BRGM, 2008; and Barthelemy *et al.*, 2010.	ACSAD, 1983a; UN-ESCWA, 1990; ACSAD, 1983b. Abunayyan Trading Corporation and BRGM, 2008; Barthelemy *et al.*, 2010.	UN-ESCWA, BGR, Ministry of Water and Irrigation in Jordan and Ministry of Irrigation in the Syrian Arab Republic (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 1996	UN-ESCWA, BGR, Ministry of Water and Irrigation in Jordan and Ministry of Irrigation in the Syrian Arab Republic (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 1996

Mean Annual Flow Volume:
Natural conditions (1950s)

- Upper Jordan River: 605 MCM
- Yarmouk River: 450-500 MCM
- Lower Jordan River: 1,300 MCM

Current conditions

- Upper Jordan River: 616 MCM
- Yarmouk River: 83-99 MCM
- Lower Jordan River: 20-200 MCM

Development of a realistic water budget is complicated by the county's infrastructure problems. For example, "lost" water, or water that is not billed, is caused by leaks in the system due to poor-quality equipment and pipes or inadequate maintenance. Additionally, non-operational meters, as well as unauthorized connections such as illegal groundwater wells, contribute significantly to water loss. According to the MWI, up to 51% of water sent into the Jordanian water distribution system remains unaccounted due to physical and administrative losses

This creates an information gap in water data accounting and budgeting as the government is unable to account for more than half of its revenue water. Additionally, monitoring water escaping the ministry's system through either unauthorized groundwater abstraction or illegal service connections is very difficult to detect. Stolen water is often used for irrigation or sold through water tankers to businesses or municipal services. It is unclear how this impacts the MWI reported water use numbers, since estimates do not exist.

As stated in the MWI's National Water Strategy, the government aims to reduce non-revenue water by 3-6% per year and up to 25% nationally by 2025. The two-part plan includes, (1) improving infrastructure quality and maintenance, effectively cutting technical losses down to less than 15%, and (2) strengthening the criminalization of both water theft and the use of unauthorized wells with the hope of cutting down unauthorized connections.[33]

Jordan underwent significant population increases between the 2004 (5,103,639) and 2015 (9,531,712)

Picture 5: The Jordan River Basin

censuses. 1.2 million of this increase was accounted for by the Syrian, Palestinian and Egyptian populations, which collectively quadrupled. The 2015 combined Palestinian and Egyptian population amounts to 1,270,452, a number slightly greater than the total Syrian population increase in Jordan.[34]

Roughly 1.5 million (50%) of non-Jordanians live within the capital of Amman. Additionally, almost three million foreigners reside inside the nation's borders, marking an annual increase of 59% relative to the 392,273 non-Jordanian population of 2004. Furthermore, the Jordanian national population is only 6,613,587, meaning that a little over two-thirds of the nation's population are Jordanian nationals. The initially small 2004 country population has nearly doubled in a little over 10 years. Meanwhile, adjusting infrastructure built for a much smaller population—including that for water—has been met

Table 5: Non-Jordanian 2004, 2015 Census Data								
	Total number of Non-Jordanian	Palestinians	Syrians	Egyptians	Iraqis	Yemenis	Lebanese	Others
2004 (Official Census Data)	**392,273**	115,190	38,130	112,392	40,084	2,585	1,995	81,897
2015 (Official Census Data)	**2,918,125**	634,182	1,265,514	636,270	130,911	31,163	22,700	197,385
Annual Increase	**229,623**	47,181	111,580	47,625	8,257	2,598	1,882	10,499
Annual % Increase	**59**	41	293	42	21	101	94	13
All data from: (Department of Statistics 2004) (Hashemite Kingdom of Jordan 2016)								

with complications including high costs and limited resource capacity.[35]

Information Gaps

The majority of water basin information described in this analysis was obtained through a search of relevant documents and reports. Many of these reports were produced in partnership with the Ministry of Water and Irrigation, United Nations Economic and Social Commission for Western Asia (UN-ESCWA), and Bundesanstalt für Geowissenschaften und Rohstoffe (BGR). See footnote for a full list of reports used.[36]

All available research unanimously described the difficulties of obtaining relevant data due to the lack of updated information. Margane *et. al* (2015) listed the following as reasons for information gaps:

- No defined procedure for water level measurements
- No entity feels responsible for water management tasks
- Lack of adequate monitoring equipment due to:
  - broken instruments
  - cable lengths too short
  - no instruments
  - lack of budget

Margane *et. al* (2015) further urges the need to implement, standardize, and create consistent procedures for water level measurements. These measurements should be taken yearly and coordinated among all monitoring agencies including improvement in unit measurements, procedures and information sharing.

The report also stated that static water level reports are a prerequisite for hydrological studies (currently these reports are unavailable or outdated) since groundwater models and assessments cannot be conducted without these data prerequisites. For example, many groundwater models are nearly obsolete and outdated in Jordan since current studies reference old assessments (many dating back to the 1990s) that are based on outdated or wrong information and lack geological descriptions. Margane *et. al* (2015) concluded that, due to information gaps, "the impact of the Syrian refugee crisis on the groundwater system cannot be assessed." This statement stresses monitoring agencies' frustration with the lack of data and highlights the importance of increasing studies and assessments of water availability in Jordan.

It is important to note the distinction between the impact of Syrian migration on water demand in Jordan, which is what this report focuses on, and the impact of Syrian use of Jordan's groundwater, which

BGR states cannot currently be assessed. The key differences are listed below:

- The impact of Syrian migration on water demand in Jordan can be assessed as it looks into the percent increase on water demand in Jordan. Water demand is based on reported water usage, which the Jordanian government is able to track since Jordan runs on a water delivery system and requires wells and irrigation to be both reported to and approved by the government. This number is flexible as it is dependent on year-to-year water demand changes; therefore, assessments need to be conducted on an annual basis.
- The impact of the Syrian refugee crisis on the groundwater system cannot be assessed with the current data available. There needs to be a comprehensive analysis of the groundwater systems in Jordan before the impact of a population increase on the groundwater system in Jordan can be assessed. Until the water quantity in Jordan is known, it is impossible to assess the actual impact that populations are having on groundwater resources. Any studies that claim otherwise are basing their research on speculation.

All agencies expressed the desire to update current groundwater maps and water basin information. MWI (2016) called upon donors and technical experts to assist in expanding the current capacity of the water sector. The National Water Strategy 2015-2016 states that addressing knowledge gaps and building the capacity of monitoring plans will be a priority.

In addition to the above problems, there are notable discrepancies in the available published data, including inconsistent reporting within the same document as seen with the MWI (2016) report mentioned above, which references different total values for municipal demands. This discrepancy might be due to a number of things including but not limited to: inaccurate census population reports, lost water, and illegal abstraction. However, without further information it is impossible to conclude why there is such a large reporting difference.

Without further clarification of water usage and allocation it is difficult to draw accurate conclusions. An increase in data sharing and transparency would benefit further research. As mentioned above, outdated information creates large knowledge gaps. If information in the future continues to be based on inaccurate data, then finding appropriate water management solutions will become increasingly difficult.

Conclusion

The Syrian population increases water demand in Jordan by 3.3% according this study's analysis using the MWI water demand calculation. However, this number can be misleading in two ways:

1. The number is relatively small and ignores that most of the Syrian population is concentrated in northern Jordan. For example, Syrians in the MIZ governorates increase Jordan's total water demand by just 1.7%. However, there is a 19.8% increase in municipal water demand in the MIZ governates due to this same population. This indicates that the concentrated population increase has a significant impact on local municipal usage and service.
2. The percent water use, regardless of being either for the total country or only for the MIZ governates, does not allow for unknowns or compounding uncertainties (i.e., wasted water, outdated data, illegal connections, or cross-border water resources). This highlights the difficulties of quantifying an accurate account of the Syrian demand. Of course, accurately quantifying a continuously increasing and migrating refugee population only exacerbates this problem. It is necessary that these issues be considered and data be updated prior to attempting an assessment like this again. It should also be noted that these estimates do not consider the increased stress a population increase of almost 15% may exert upon infrastructure and water services, or how it may effect water demand related to tourism and irrigation. Without better data, the water demand of the Syrian population can only be quantified through yearly assessments of the municipal water use and census estimates, such as the one done in this report.

In conclusion, the numbers given for Syrian impact on water demand in northern Jordan (3.3% water demand increase overall, and 19.8% increase on specifically municipal use in the MIZ governorates) provide baseline data useful for future assessments and inquiries into the Syrian impact in Jordan. However, as these numbers are dependent on fluctuations in populations, total water available, and sociopolitical environments, they must be treated as such and updated regularly. Precise assessments are only possible through increasing information in databases and continuous updating of previous studies. This work will serve as useful baseline for future studies on the impact of the Syrian migration on water demand in Jordan. ◆

Endnotes

1. Verisk Maplecroft. 2011. Maplecroft. 3 22.
2. (RJGC), Royal Jordanian Geographic Centre. 2012. Royal Jordanian Geographic Centre, About Jordan: Fast Facts.
3. Ministry of Water and Irrigation (MWI). 2016. National Water Strategy 2016-2025. Amman: Hashemite Kingdom of Jordan.
4. 726,662 of which are Syrians that presumably migrated after the civil war began in 2011
5. Hashemite Kingdom of Jordan. 2016. King Hussein: History - The Tragedy of Palestine.
6. The Hashemite Kingdom's rule was strongest in areas of modern day Jordan, Palestine and Israel. For further information see (Hashemite Kingdom of Jordan 2016) or Review: Jordanian History: Studies in the History of Transjordan, 1920-1949: The Making of a State. by Uriel Dann, or The Modern History of Jordan by Kamal Salibi

Picture 1: http://www.bluebird-electric.net/oceanography/Rivers/River_Jordan.htm

Picture 2: Jordan Looking South - May 17, 2014 (Michael Beaulac)

7. (Hashemite Kingdom of Jordan 2016)
8. 640MCM is the number recorded in ESCWA-BGR (2013) water inventory for estimated Israeli abstraction from the Jordan River Basin. The journal Water Alternatives, released an article criticizing the ESCWA-BGR Jordan River Basin chapter, stating that it misrepresented and falsely portrayed Israel's water abstraction of the Basin. The article states that a closer estimated yearly abstraction is ~ 800 MCM/year. Messerschmid, C. and Selby, J. 2015. "Misrepresenting the Jordan River Basin." Water Alternatives 8(2): 258-279.
9. UN Economic and Social Commission for West Asia-Bundesanstalt für Geowissenschaften und Rohstoffe (ESCWA-BGR). 2013. Inventory of shared water resources in Western Asia. New York: United Nations.
10. Due to the nature of the conflict and close relationship with Palestine, most Palestinians who entered Jordan between 1948 and 1967 have become fully naturalized as Jordanians. United Nations Relief and Works Agency (UNRWA). 2015. Jordan: Where We Work. December 1.
11. The DOS noted in 2011, a pre-war , 2011 population , of 6.25 million residents in Jordan, marking the migration of approximately 1.263 million Syrians into Jordan after 2011 between 2011-2012. Department of Statistics. 2016. Methodology of Annual Population Estimation At The Department of Statistics. Statistical Explanation of Methods, Amman: Hashimite Kingdom of Jordan.
12. British Broadcasting Corporation. 2016. Syria conflict: Jordanians 'at boiling point' over refugees. February 2.
13. In 2006, the worst drought in Syrian history began. Shahrzad Mohtadi, an advisor to the White House and expert in the field, stated that Syria may have experienced a phenomenon with the "most severe set of crop failures since agricultural civilizations began in the Fertile Crescent many millennia ago." Furthermore, geographer Dr. Jessica Barnes argues that water scarcity in Syria was constructed as a direct product of the Syrian government's promotion of agriculture since the Ba'ath Party came to power in 1963.
14. Syrian Refugees. 2016. Syrian Refugees - A snapshot of the crisis – in the middle east and europe
15. (Department of Statistics 2016)
16. The Syrians registered as refugees are defined as the following: "A refugee is someone who has been forced to flee his or her country because of persecution, war, or violence." UNHCR. 2017.

The United Nations Refugee Agency (UNHCR). http://www.unrefugees.org/what-is-a-refugee/.

17. This number includes both unregistered refugees and Syrians who were living in Jordan before the war. In practice, Jordan avoids the official recognition of refugees under its domestic law and prefers to refer to Syrian refugees as 'visitors,' 'irregular guests,' 'Arab brothers' or simply 'guests,' all of which have no legal meaning under domestic laws. (ARDD-Legal Aid (Arab Renaissance for Democracy and Development): Refugees in Jordan: FAQ)
18. Abdulla, Fayez A., and A. W. Al-Shareef. 2009. "Roof rainwater harvesting systems for household water supply in jordan." Desalination 243 (1): 195-207.
19. (Ministry of Water and Irrigation (MWI) 2016)
20. Percent annual increase was produced using the following formula rate=1/(time in years between last census) Ln(Population size of following census)/ Population size of previous census) or r=1/tLn(P0/P1)
21. (Department of Statistics 2016), (Hashemite Kingdom of Jordan 2016), Department of Statistics. 2004. Department of Statistics: Official results of the 2004 Population and Housing Census. Amman: Hashemite Kingdom of Jordan.
22. (Ministry of Water and Irrigation (MWI) 2016)
23. (Ministry of Water and Irrigation (MWI) 2016)
24. Unfortunately, information available to further divide municipal, industrial and tourism use is conflicting. For example, the MWI national water strategy indicated municipal demanded to be 429 MCM, industrial, 37 MCM and tourism 4 MCM. In the same document the ministry described the three sectors as using a combined total of 701 MCM. There is no indication in either the MWI document or other relevant resources as to why these numbers do not agree.
25. (Ministry of Water and Irrigation (MWI) 2016)
26. (Ministry of Water and Irrigation (MWI) 2016)
27. Amelia, Altz-Stamm. 2012. GIS for Water Resources Jordan's Water Resource Challenges and the Prospects for Sustainability. University of Texas.
28. (Ministry of Water and Irrigation (MWI) 2016)
29. (UN Economic and Social Commission for West Asia-Bundesanstalt für Geowissenschaften und Rohstoffe (ESCWA-BGR) 2013)

Pictures 3 and 4: https://water.fanack.com/jordan/water-resources/surface-and-groundwater/

30. (Ministry of Water and Irrigation (MWI) 2016)
31. It is important to note that the MWI calculation does not compute with the recorded numbers MWI (2016) stated for the 2014 municipal water usage, 136.5 MCM, in 2014. However, without knowing where the 15MCM discrepancy between the 121MCM number calculated with the MWI calculation compared to their reported number, 136MCM, it is more accurate to use their calculation for this reports statistical analysis than guess on the reason behind said discrepancy.
32. (UN Economic and Social Commission for West Asia-Bundesanstalt für Geowissenschaften und Rohstoffe (ESCWA-BGR) 2013) All data is from ESCWA-BGR report unless otherwise indicated

Picture 5: Ibid.

33. (Ministry of Water and Irrigation (MWI) 2016) All data from National Water Strategy unless otherwise indicated
34. (Department of Statistics 2004) (Hashemite Kingdom of Jordan 2016)
35. (Hashemite Kingdom of Jordan 2016)
36. (Amelia 2012). (Ministry of Water and Irrigation (MWI) 2016). Margane, A., Al-Qadi, M. & Al-Kurdi. 2015. Updating the Groundwater Contour Map of the A7/B2 Aquifer in North0 Jordan. - Technical Cooperation Project 'Syrian Refugee Response'. Technical Report No. 1, Amman: BGR & MWI. (UN Economic and Social Commission for West Asia-Bundesanstalt für Geowissenschaften und Rohstoffe (ESCWA-BGR) 2013). (UN-ESCWA, BGR, Ministry of Water and Irrigation in Jordan and Ministry of Irrigation in the Syrian Arab Republic (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe 1996). (UN-ESCWA (United Nations Economic and Social Commission for Western Asia) 1990).