The impact of syrian refugees on jordan's water resources and water management planning

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Executive Summary

With the ongoing physical violence in Syria, refugees from this country have been fleeing to neighboring countries to seek refuge. Since 2011, Jordan has opened its borders to approximately 600,000 Syrian refugees who have either attempted living in the urban areas of Jordan or have adjusted to refugee camps in the northern part of the country. This number is expected to rise to 1.2 million refugees by 2014 according to Jordan's Ministry of Water and Irrigation. Without acknowledgement of a refugee capacity problem from the Jordanian government, this thesis questioned how a water resource-scarce country will plan sustainably for its future. Focusing on Jordan's water resources, this thesis evaluated what kind of impact the influx of Syrian refugees will have on the water sector. Groundwater depletion was found to be a major concern for Jordan's water resources prior to the refugee influx, since the total water extraction rates exceeded the renewable water amount. The overall water usage of 600,000 refugees was estimated to be about 2.3% of the total water consumption in Jordan. This consumption rate can increase by at least 2.2% if the number of refugees increases to the expected 1.2 million by 2014. By analyzing literature on water management planning in Jordan and case studies of refugee planning, conducting a water budget analysis prior to the refugee influx and after the influx, and carrying out interviews with water and refugee planners in Jordan, this thesis discussed recommendations to plan for the refugees in a manner which will reduce the stress on Jordan's water resources.

The recommendations provided for water and refugee planners to reduce the impact on Jordan's water resources focused on macro level solutions for governance and institutional design and also address the micro management of water resources. The site selection process for the Zaatari refugee camp required several important criteria, however the long-term impacts to the water supply were not deeply considered. The hydrologic details of what would make a "good" refugee camp site should be determined by Jordan's Ministry of Water and Irrigation in the pre-planning phase.

Areas experiencing groundwater overdraft and declining water tables prior to the Syrian refugee influx are already water-stressed and are not ideal camp sites. Also, this paper suggests that Environmental Impact Assessments should be a mandatory policy of UNHCR in order to inform the site planning process more effectively and conservatively. There needs to be a cross-sectoral ap proach in refugee and water management planning within Jordan to address the issues related to water resources.

Introduction

Water scarcity has been a planning issue for the Jordanian government for the past few decades. According to Jordan's National Water Strategy, it is one of the fourth driest countries in the world (UNESCO, 2013). Water supply does not meet the water demand for any sector (agriculture, industry, drinking water, sanitation, etc). Jordan's water withdrawal rates are about 20% above the sustainable capacity level, and approximately 70% of its water is used for agricultural purposes (Zeitoun et al., 2011). In the coming years, Jordan will also experience a high population growth rate and an unequal distribution of its resources. This will lead to Jordan not being able to support its population with freshwater by 2030 (Zeitoun et al., 2011).

Beginning in March 2011, widespread popular protests against the current government regime of President Bashar al-Assad in Syria led to violence between the protesters and the security forces, resulting in many political and economic sanctions by the international community against Syria. As a result of deteriorating safety measures and ongoing violence, Syrians fled to neighboring countries. The United Nations High Commission of Refugees (UNHCR) reported 2,241,683 refugees, of which at least 500,000 refugees are currently in Jordan. The influx of the Syrian population adds another stress to the water resources in Jordan. According to Namrouqa (2013), water demand increased 16 percent in 2013, while Jordan's water deficit will also increase by 50 percent due to the presence of Syrian refugees. With the assistance of the UNHCR and other international aid organizations, Jordan has created refugee camps near the northern border of Jordan. These camps provide refugees with water, food, and living spaces. The number of Syrian refugees has increased greatly in Jordan, and is expected to grow until the crisis stops in Syria or until Jordan reaches its capacity for refugees. Both are undetermined.

Current water management plans of Jordan do not take into account the unprecedented population growth, land use changes, waste production, and food consumption caused by the influx of refugees, and do not consider the long term consequences of refugees residing in Jordan on its scarce water resources. My research determines the impact of the Syrian refugees on Jordan's water resources, and how planning for Syrian refugees can be improved to reduce the impact on the scarce water resources. With the timeliness of the Syrian refugee humanitarian crisis, Jordan's water shortage problem, and the lack of long-term planning for Syrian refugees and their impact on water in Jordan, this thesis can contribute to addressing these important issues for water management planners in Jordan.

Background

Overview of Water Scarcity Issue in Jordan and the Region

Water management practices are decided by Jordan's Ministry of Water and Irrigation (MWI) which consists of the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA). Though these two bodies are expected to be autonomous and financially independent from the MWI, they are both linked with the MWI (Alamoush, 2011). Jordan is cited as the fourth most water-stressed country in the world (MWI, 2008). Population growth and declining freshwater availability has resulted in a decrease of per capita renewable water resources; in 1967 it was 1,857 m3/ capita/year and it reduced to 145 m3 /capita/ year in 2013 (Altz-Stamm, 2012 and MWI, 2013). This is significantly less than the world's average of 7,700 m3/year and the minimum water per capita amount recommended by the Islamic Network on Water Resources Development and Management (INWARDAM) which is 1205 m3/yr (Al-Qurashi and Husain, 2001). The INWARDM calculated this minimum per capita amount by considering the amount of water needed for domestic uses and food. Jordan has a total surface water area of 482 km2 which is made up of base flow and flood flow, with the major resources originating in the Al Yarmouk River, Zarqa River, and the Jordan River (see Figure 1) (Altz-Stamm, 2012); these sources provide Jordan with 37% of its total water supply (Palo, 2014). The Yarmouk River's source begins in Syria and flows south to the Jordan River, and its total flow is about 171 MCM per year.

Figure 1: Map of Surface Water in Jordan

Source: Altz-Stamm, 2012

The Zarqa River lies within Jordan and it receives seasonal rainfall and treated wastewater, but it experiences severe water pollution. The Jordan River starts in the Golan Heights and Lebanon and flows through the Sea of Galilee; it is shared by Lebanon, Syria, Israel, and Jordan (see Figure 2). The total flow for this river has reduced by 98% from its historical total flow, and is approximately 20 to 30 MCM per year (Altz-Stamm, 2012).

Figure 2: Surface Water Extraction from the Jordan River.

Countries	Water Used (MCM)
Lebanon	11
Syria	200-260
Israel	550-800
Jordan	290

Source: Comair, Gupta, Ingenloff, Shin, and McKinney, 2012

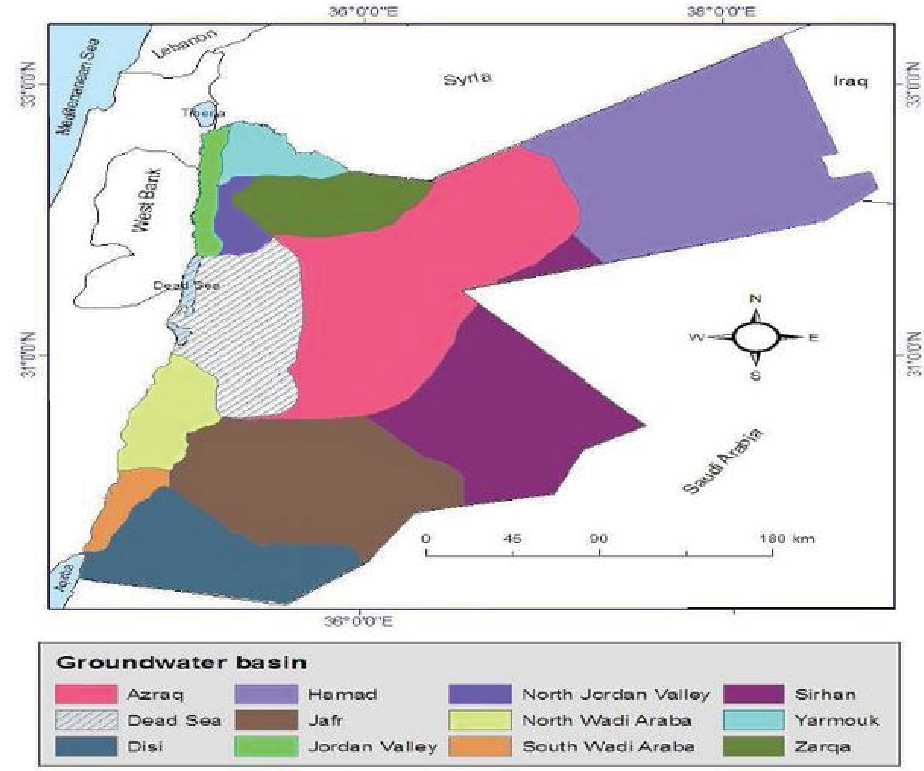
The rest of Jordan's water supply comes from the 12 groundwater basins (see Figure 3). Groundwater basins in Jordan have been facing overpumping in the past few decades, which resulted in declining groundwater levels and depletion of the aquifer.[1]

In some cases, the declining groundwater can increase the risk of saltwater intrusion which affects the water quality. The declining groundwater level can have an impact on the recharge rate, meaning that it would lengthen the duration for water infiltrating to the aquifer (Alamoush, 2011). The combination of very low precipitation rates and low recharge rates in Jordan result in a relatively low renewable groundwater supply. The safe yield[2] for the renewable groundwater basins are estimated to be 275 MCM per year, and the average abstraction rates[3] from these basins are estimated to be over 473 MCM per year (Altz-Stamm, 2012). This overpumping is indicative of the unsustainable water management practices in the country and are leading to declining freshwater resources. Non-renewable groundwater sources include the Al Disi and Al Jafr basins. The Al Jafr basin has been used by Jordan since the 1960s, but it has suffered extreme environmental damage and overdrafting has exceeded the safe yield by 267% (Barham, 2012).

The primary reason for water shortage in this country is due to its climatic and geographic profile which affects its water supply. Jordan's climate has characteristics of cool, wet winters and hot summers with most of the rainfall occurring during the winter season (Alamoush, 2011). The annual average precipitation volume measured in 2009 was 111 mm per year (Trading Economics, 2010). The annual precipitation value was also estimated in 2011, and measured to be 8,360 million cubic meter (MCM); only 10% of this rainfall volume contributes to Jordan's water budget and the rest is lost to evaporation (Alamoush, 2011). About 92% of its land area is characterized as a desert environment, which attributes to the low precipitation and high evaporation rates in Jordan (Altz-Stamm, 2012). Climate change will also have an effect on water resources. A climate vulnerability assessment conducted by the UNDP in 2009 for the Zarqa River Basin and the Yarmouk River Basin

1. Recharge rate refers to the ability of water to infiltrate the soil and reach the groundwater aquifer to replenish the water table.
2. Safe yield refers to how much water is safe to extract from the aquifer without the risk of groundwater depletion or overdrafting
3. The average abstraction rate refers to the average amount of water withdrawn from the water basin

Figure 3: Geographic locations of the groundwater water basins



Source: Alamoush, 2011

showed trends of increasing temperature patterns and decreasing annual precipitation patterns over a 45-year period from 2005 to 2050 (Alamoush, 2011).

In addition to water supply challenges, Jordan faces increasing water demand from its growing population. According to Jordan's Water Strategy 2008-2022, the water demand is expected to rise from 1,505 MCM in 2007 to 1,673 MCM by 2022. Water resources are divided among the agriculture, municipal supplies, industry, and tourism sectors. The agriculture sector uses about 60% to 70% of the total water supply; 30% of water supplies is used for municipal uses; 5% of water supplies is used for industry; 1% of water supplies is used for tourism (Altz-Stamm, 2012 and Zeitoun et al., 2012). Even though Jordan's population growth decreased from 2.5% in 1999 to 2.2% in 2010 (Alamoush, 2011), the growth rate is still higher than the average annual population growth rate of other middle income countries comparable to Jordan. The average growth rate from 1998 to 2015 estimated for middle income states was 1%, for low income states it was 1.2%, and for high income states it was 0.2% (World Bank, 2014). Jordan's population growth rate is at least 1.5% greater than the average rate.

Uncontrolled growth has taken place in Jordan in the past due to the migration of refugees from Palestine and Iraq, which affects water demand and supply (Alamoush, 2011). In 1948, approximately one million refugees from Palestine migrated to Jordan and about 1,980,000 Palestinians still reside in Jordan. Due to the Iraq War in 2003, Iraqi refugees fled to Jordan for refuge, and about 451,000 still reside in the country (Altz-Stamm, 2012).

A study conducted by Al-Bakri et al. (2013) on population growth rates, which did not include the Syrian refugees in Jordan, determined that if the population growth rate trends continue then then the expected population for 2030 and 2050 would reach 10.6 million and 17 million, respectively (Al-Bakriet al., 2013).

The Syrian political crisis, which began in 2011, is expected to add approximately 1.2 million people in Jordan, resulting in an additional stress to water resources.[4]

Overview of Syrian Refugee Crisis and Planning in Jordan

Jordan has a history of being the "safe haven" for refugees fleeing from humanitarian and political crises in neighboring countries. During the unraveling of the Arab Spring in the Middle East, the Syrian political crisis led to a humanitarian crisis which is currently ongoing. Since 2011, Jordan has absorbed at least 600,000 Syrian refugees. While two-thirds of the Syrians live integrated within cities of Jordan, the Zaatari Refugee Camp has become the largest refugee camp in the world, hosting approximately 120,000 Syrians in 2013; it has also become Jordan's fifth largest city (UNHCR, 2013). As of May 2014, the Zaatari camp hosts 101,402 individuals (UNHCR, 2014). The Jordanian government has yet to announce its capacity for refugees, and is providing them with free healthcare and education.

Due to an increasing demand, UNHCR had been planning for another refugee camp in the Azraq region, about 80 kilometers east of Amman, Jordan. The new site is going to be the "most planned" refugee camp in the world.

This is a result of it having been under construction since April 2013; while the Zaatari Camp was "set up in a manner of days" according to the United Nations Integrated Regional Information Networks (IRIN). The Zaatari Camp has improved living conditions now, but until recently, many people at the camp site did not have access to running water and not enough squat toilets existed. And, services were only available on one side of the camp, which was not planned very efficiently (IRIN, October 2013). According to aid workers, mitigating violence among refugees because of living provisions has become a daily occurrence, a consequence of ignoring the Syrians during the project development for the camps from the beginning. Deputy camp manager Iris Blom at Zaatari stated that they "had not given the necessary priority to community mobilization [and] it's something [they] are now improving" (IRIN, July 2013). Furthermore, IRIN mentions that more organization by UNHCR is needed to respond to the issues of refugees in a fair and equitable manner.

Although some aspects of the site are planned, its layout changes very often because refugees are able to pick up their tents or caravans (which are similar to trailers and are donated by the Gulf countries) and move wherever they want (see Figure 4) (IRIN, July 2013)[5]. Other challenges of managing the refugee camp include overcrowding, violence, poor sanitation, and crime.

Figure 4: A layout of site plan changes for Zaatari from November 2012 to February 2013

4. Ali Subah and Nisreen Hadaddin, personal communication, January 14, 2014.
5. According to IRIN, almost half of the population has received caravans, and it continuing to be distributed (IRIN, July 2013).

Jordan's Minister of Environment Taher Shakhshir said that the ministry is currently working with international agencies to address the issue of environment pollution in the area of the Zaatari camp (Namrouqa, 2013). A recent study by the Ministry of Water and Irrigation (MWI) warned that the main aquifer lying beneath the Zaatari camp is at risk to become polluted soon due to wastewater leakage in the Zaatari refugee camp. Additionally, over-pumping of the Amman-Zarqa aquifer is another risk facing water resources in this region. The influx of Syrian refugees is placing pressure on the local sewage network, causing it to overflow frequently, according to officials and residents of Mafraq. The study indicated that over 34.164 million cubic metres (MCM) of wastewater are generated annually by Syrian refugees in Jordan. In addition, the Ministry of Water and Irrigation will soon install portable wastewater treatment units at the Zaatari and Mreijeb Al Fhoud camps to prevent sewage from leaking into underground water (Namrouqa, 2013). This study shows that planning for water and environmental pollution is necessary for the sustainability of the resources near these refugee sites.

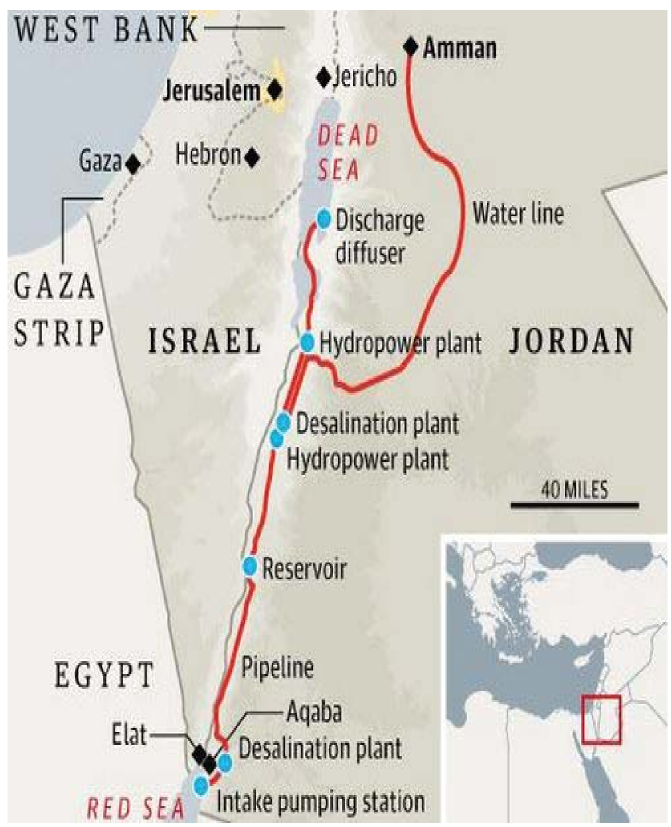
The new refugee site which is under construction in Azraq is said to have been planned while keeping the mistakes of Zaatari Camp in mind (IRIN, October 2013). The housing structures will be metal-framed instead of tents and caravans, and it will include amenities such as schools, playgrounds, child-friendly spaces, food warehouses, an arrival and registration area, health posts and a fully-equipped hospital. The plan, which is shown in the Appendix section, is to set up 5,000 shelters to provide housing for 50,000 people in four villages. This site was previously used in the early 1990s to house fleeing nationals from Kuwait.

LITERATURE REVIEW

Water Management in Jordan

According to Zeitoun et al. (2012) power asymmetry among water stakeholders in Jordan has been the primary hindrance to implementing water conservation practices. The position of the Prime Minister in Jordan determines the type of water management policy implemented; currently most of the water policies focus on meeting the water demand (which is an example of water supply management) rather than on water demand management. The International Development Research Centre defined water demand management as "any practice or policy implemented which results in water being used in a more efficient, equitable and sustainable way" (Zeitoun et al., 2012, p. 55). Even though water stakeholders are experiencing water shortage, through droughts and depletion of groundwater aquifers, water supply management type projects hold more advocates in the country. For example, the pursuit of funding and support for the Red Sea-Dead Sea Canal has been prioritized among other water policies, which aims to bring seawater from Aqaba at the Red Sea in the south of Jordan up north about 230m and then down to 420m below sea level to the Dead Sea (see Figure 5). This will be used to yield hydropower which will be able to produce energy for desalination and provide drinking water, with an additional 850 MCM per year of freshwater resources for Jordan (Altz-Stamm, 2012).

Figure 5: Red Sea-Dead Sea Canal



Source: http://www.theguardian.com

In early 2013, the Disi Water Conveyance Project was initiated in order to bring 80 to 100 MCM of additional water per year to Amman for at least the next 50 years, an example of another supply-side management policy. This project aimed to pump water from the Disi groundwater aquifer located in the south and transport it about 200 miles north to Amman (Altz-Stamm, 2012). Engineer Ali Subah, Assistant Secretary General of Technical Affairs at the MWI, mentioned that the Disi project was not a successful water supply initiative because the influx of Syrian refugees since 2011 in Jordan has not allowed the project to reduce the gap between water demand and supply in the capital.[6]

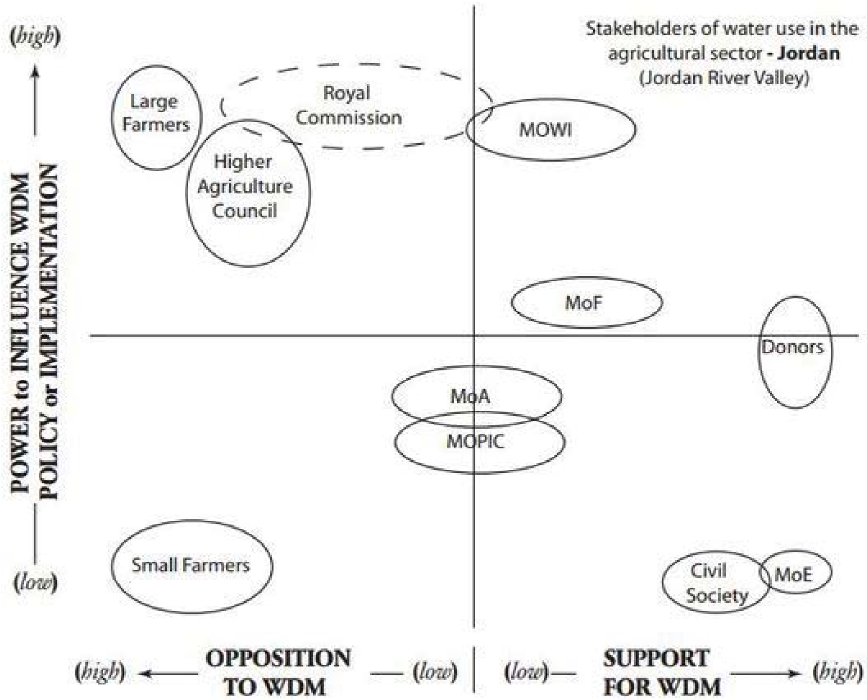
One of the most powerful entities in the water sector is the Royal Commission for Water, consisting of academics and technocrats, and this sector relies upon the advice given by the MWI. In 2008, the Commission produced Jordan's Water Strategy 2008-2022. The Higher Agricultural Council, which is headed by the Prime Minister, holds a parliamentary role and is considered to have greater influence on water management policies than the Royal Commission. The Council tends to be against implementing the water demand management policies, and instead it responds more to the powerful farmers and stakeholders of the Jordan River Valley. The Jordan River Valley is the "bread basket" for Jordan's agricultural sector; the agricultural sector consumes approximately 70% of the country's resources, but only contributes 3% to the overall economy. Many of the large farms are controlled by people associated with several tribes in Jordan, and the interests of these stakeholders hold a great amount of influence which resulted in tariffs and subsidies to protect the banana production industry. The policies in favor of the local banana production was in contradiction with MWI's policy which shows how power asymmetry has affected water policies in Jordan (Zeitoun et al., 2012). Power asymmetry in the water sector in Jordan is depicted in Figure 6 which is adopted for this research to understand the roles and decision making power of various water stakeholders.

The MWI has some support for water demand management practices and it created a department dedicated to implementing these types of policies in 2002. Within the MWI, the Jordan Valley Authority holds significant legitimacy among farmers, and the MWI has been able to increase its power among water stakeholders due to the developing awareness of the water scarcity issue in Jordan and in the region. The MWI has more influence with the Agricultural Council than it does with the Royal Commission. However, because of a lack of donor funding and unilateral support for water demand management among the various ministries, the department was suspended in 2005 (Zeitoun et al., 2012). Figure 6 represents the various water stakeholders in Jordan, and it summarizes their positions in regards to water demand management and their power to influence the implementation of the policy. The trend shows that the least influential actors are usually the most in favor of promoting water demand management in Jordan.

Zeitoun et al. (2012) and Barham (2012) suggested that improving the water management decision making structure relied on the ability to address the inequities of power among the stakeholders and encouraging cooperation and shared decision making among the private, civil society, and NGO groups. The current involvement of local communities and NGOs in regards to water conservation lacks a judicial framework (Barham, 2012). For the entities which overlap in Figure 6, such as the Royal Committee, the MWI, and the Ministry of Planning and International Cooperation, a common platform should be formed to induce consensus on water policies among the groups. Also, other demand management strategies for the agricultural sector should include enhanced irrigation design and management, such as drip irrigation and wastewater reuse. According to Comair et al. (2012) Jordan could decrease its annual water loss by 100 MCM if it implements policies to use drip irrigation and micro-sprinklers. Treated wastewater currently provides water for irrigation purposes to approximately 50 percent of the farmlands in the Jordan Valley.

6. Ali Subah and Nisreen Haddadin, personal communication, January 14, 2014.

Figure 6: Water Stakeholders in Jordan



Source: Zeitoun et al., 2012, p.60
The dashed line circled around the Royal Commission represents uncertainty on its position regarding WDM.
JRV: Jordan River Valley; MOWI: Ministry of Water and Irrigation; MoF: Ministry of Finance; MoA: Ministry of Agriculture; MOPIC: Ministry of Planning and International Cooperation; MOE: Ministry of Environment

If this practice continues and becomes more widespread, the supply of treated wastewater can reach 256 MCM per year by 2022 (Altz-Stamm, 2012). If Jordan is able to supply treated wastewater to at least 80 percent of its population it will be able to increase its water resources by 100 MCM/year (Comair et al., 2012). Additionally better water pricing mechanisms should be used to accurately account for the water demand and supply; even though the majority of the water is consumed by the agriculture industry, farmers in the Jordan Valley pay only 10% of the total costs whereas the households pay 50% of the total water costs (Barham, 2012).

Environmental Planning of Refugee Camps

Planning for refugee camps in emergency situations usually occurs on an ad hoc basis, and there is rarely adequate time to plan for environmental conservation measures, which was the case in Zaatari. In areas with particularly scarce natural resources, it is important to consider the long term ramifications of hosting an influx of population for an undetermined period of time. Jordan is one of the most water poor countries in the world, due to its physical and climate conditions. While planning for Syrian refugees residing either in the Zaatari Refugee Camp or in cities, this thesis argues that it is necessary to simultaneously consider water conservation planning techniques for current and future water demands. Literature related to refugee site planning in general has shown a lack of focus on the detriment on water resources, among other natural resources.

Academics and planners have mentioned that Environmental Impact Assessments (EIAs) should have a larger role in influencing site planning decisions, since according to Shepherd (1995), refugee settlements often occur in environmentally sensitive areas and refugee influxes intensify existing environmental problems of the host country.

Materials needed for basic living conditions, such as supplies for construction, fuel, and food, have price increases in local markets. Also, host communities often bear most of the burden because they have to adjust to using scarcer resources, and this can result in conflicts or negative perceptions against refugees. For example, Nielsen (2011) stated that host communities in Kenya had mixed feelings for the Somali refugees, because they felt anger that the refugees would receive new schools, free food, and there was a significant stress on the natural resources. Shepherd (1995) argued that there is a need for more effective environmental planning for refugee camps and it should be a priority for UNHCR and host governments. Also, both refugees and local populations should be participating in the planning process.

The UNHCR has prepared Environmental Guidelines which give a summary of its operational policies and principles, however it does not explain the implementation strategies of the environmental policies for the planning process of refugee camps sites (UNHCR, 2001). The UNHCR Environmental Guidelines do acknowledge that issues related with refugee sites include deforestation, soil erosion, and depletion and pollution of water resources. However there are no specific design guidelines mentioned to reduce the impacts on these resources. According to the UNHCR website, an important lesson learned about environmental impacts of refugee camps include that "there is a need for clearer and more systematic approaches to environmental assessments, monitoring and evaluation, as part of overall project and programme management" (UNHCR, 2014). Madanat (2013) also agrees that environmental impacts of refugee camps, such as deforestation and firewood depletion, land degradation, unsustainable groundwater extraction, and water pollution, affect the long term livelihoods of both refugees and the host country. An example is provided by a United Nations Environment Protection study on the environmental impacts of the refugees in Guinea (UNEP, 2000). In this study, UNEP discussed the lack of planning for waste disposal and collection on camp sites, and mentioned that the national water management plans in Guinea were not prepared for the influx of refugees.

The result of this lack of planning for infrastructure and long term water resources, resulted in a situation where water demand was much greater than water supply (UNEP, 2000). Thus far, planning for Syrian refugees in Jordan have not sufficiently considered the impact of waste collection and disposal on water resources, and similarly, the national water plan in Jordan lacks infrastructure to implement long term water solutions for the unexpected influx of population.

A handbook on lessons learned from the field from the UNHCR, discussed how to better plan for environmental externalities of refugee site planning, and it stated that if the baseline environmental situation prior to a refugee influx is known, a realistic assessment can be made of the refugees' impacts on natural resources, or the effect of mitigative measures. Remote sensing techniques can be useful for sourcing this information (UNHCR, 2002). It is important to note that many studies related to the refugees' impact on environmental conditions in host communities lacks sufficient focus on the effect on local water supplies, and these studies are usually completed after the camp has been established.

Nielsen (2011) discussed that Dr. Kennedy studied the building and planning process of refugee camps, and he concluded that usually the "long term perspective is missing." Borton (1993) concurs and stated that refugees are considered "temporary" by governments and international aid agencies which ensures that there is no long-term planning. While working for the Norwegian Refugee Council, Kennedy supervised the building of camps, which was planned by UNHCR, in Daadab, Kenya for Somali refugees in 2007. Initially, the camps which were built in 1999 were supposed to last only six months, however they still exist with a population of approximately 70,000. New camps were needed in 2007 because the planners had not prioritized the concern that the camps were located in a flood zone, thus the sites were flooded every two years. To improve the way current refugee site planning is conducted, Kennedy proposed the "cycle of intervention." This "cycle of intervention" process demands planners to design the camp one step at a time with constant re-evaluation , by observing how the people use various aspects of the site so that the layout remains efficient and safe. Although Kennedy's proposal addresses the issues of long term sustainability, he does not address how feasible it is to constantly re-assess refugee camps and plan in an adaptive manner. The "cycle of intervention" would require more costs and resources (Nielsen, 2011). In Jordan, the Zaatari Camp is responding to the needs of the refugees as they come up on a daily basis, but perhaps more adaptive management and planning would be beneficial.

Water Resource Assessment for Refugee Camps in Jordan

As stated earlier, Jordan has opened it borders for refugee populations in the past. After the U.S. led invasion in Iraq in 2003, Iraqis fled to Jordan for refuge, and upto 451,700 still reside in the country (Altz-Stamm, 2012). Past studies on planning for camps and environmental assessments have explained that there were significant stresses on Jordan's water resources, however the stress on these resources were not quantified in the studies (Harper, 2008). Allaf (2011) discussed how resources such as water and electricity were spread thin among Jordanians and Iraqis, and citizens had blamed the refugees for the rising prices of real estate, rent and food, and for overcrowded schools and health facilities. Al-Bakri et al. (2013) studied the land use/cover map for Jordan in 2010 to evaluate the total rainfed and irrigated area in areas with large Iraqi refugee populations. Reduction of irrigated areas in Irbed and the Amman-Zarqa basin was observed, from 9.4 percent to 7.6 percent at a rate of 125 ha per year, as a result of a decline in irrigation water quality because of over-pumping (to provide water resources for extra persons) and the increasing salinity of soils. Land use changes are attributed to population growth, lack of land use laws, and changing climate conditions (Al-Bakri et al., 2013). Future land use in Jordan was predicted by Al-Bakri et al. (2013) based on population growth trends, climate change predictions, and Jordan's water strategies; the study showed reductions of irrigated areas by 20 percent in the highlands, rainfed areas by 11-18 percent, and forests by 30-50 percent.

An assessment on water resources at the Zaatari Camp was conducted a year after it was opened by UNHCR and OXFAM. A survey of water sources used by refugees residing in the north of the country found that 12 of the 15 sources assessed were contaminated (UNHCR, 2013). Syrian refugees interviewed during an Oxfam/Abaad assessment indicated a lack of access to appropriate water and sanitation facilities. The lack of adequate water and sanitation facilities is a major concern for refugee site planners. An Oxfam GB assessment found that the main factors affecting access to water among informal settlements in Balqa and Amman are purchasing power, water storage capacity and geographic location. The assessment also concluded that poorer households generally pay more for water due to the lack of adequate storage tanks, and makeshift latrines with no sewage disposal or treatment was common (UNHCR, 2013 and Maden, 2013). Also, according to OXFAM, Syrian immigration has led to drying up of wells. About 65 percent of water transported to the Mafraq province is lost through the pipelines and as a result of people illegally tapping into the pipelines (Maden, 2013). These factors will impact the long term planning of water management for the host communities in Jordan.

Research Design

To evaluate the impact of Syrian refugees on Jordan's water resources and management planning, this paper conducted an analysis through a literature review, water budget calculations, and interviews with water and refugee planning experts. The literature review consisted of studies related to refugee camp planning, UNHCR case studies, environmental assessments in refugee camps, and Jordan's water management planning. This literature review provided the background necessary to address the gaps present in current research and planning in Jordan. Case studies of other UNHCR refugee camps and water management will provide best practices and lessons learned for the ongoing situation in Jordan with Syrian refugees. A water budget analysis was used to account for the water inflows and outflows from Jordan and to understand the overall existing water supply. The water budget calculation before the refugee influx in 2011, and after the influx until 2013 was evaluated to determine refugee impacts on water resources. was evaluated to determine refugee impacts on water resources. Data sources for the water budget calculations were gathered from interviews with the UNHCR and Jordan's Ministry of Water, and the Food and Agriculture (FAO) online database. According to the Land and Water Management Division of the State of Michigan, the following equation should generally be used for the water budget:

$\Delta S = P - E - ET \pm SRO \pm GF$ + Other source inputs/outputs

Independent Variables: Precipitation (P), Evaporation (E), Evapotranspiration (ET), Surface runoff (SRO), Groundwater flow (GF), Other source inputs/outputs (e.g. water withdrawal from groundwater and surface waters)

Dependent Variable: Change in storage (ΔS)

The interviews with water and refugee planning experts provided anecdotal information for planning processes of refugee camps in Jordan to respond to the question how can planning for Syrian refugees be improved to reduce impact on the scarce water resources. These interviews supplemented the water budget calculations to show how refugees are impacting the water resources in Jordan.

Questions for Refugee Camp Planners (International Aid Organizations) included:
-How deep are you drilling wells? Are these wells drying up, and if so, how quickly?
-Which aquifer are you using as the local water source for refugee camps?
-How is waste being disposed? Are there health concerns for waste/sanitation on camp sites?
-Do you know how deep the groundwater is before pumping for wells?
-What are living conditions at camps?
-How do host residents view the refugees?
-How long are refugees expected to live in camps?
-Moving to urban areas?
-How is wastewater used by refugees?
-How does UNHCR and the Jordanian government choose site locations for refugee camps?
-Are impacts on water considered?
-What were the planning processes for the refugee camps, who was involved?
-Any lessons learned on ways to conserve water resources at refugee camps?

Questions for Ministry of Water and Irrigation included:
-How are the national water plans including the refugee situation?
-Does the planning framework treat environmental factors such as water as an integral part of overall contingency plans for refugee emergency operations?
-What are long term planning provisions for refugees? How temporary are the camps?
-Have the Water Plan and Master Plan been changed since the influx of refugees? Who is involved?
-How do refugees obtain water for drinking and personal use? Assess infrastructure.
-Is water service delivery in large, urban areas such as Amman impacted by water practices in refugee camps?
-Was there an official Environmental Impact Statement during pre-planning phase?
-Was the Jordanian Government involved in project development and environmental planning for refugee areas?
-What were the planning processes for the refugee camps, who was involved?

Findings

UNHCR Draft Environmental Impact Assessment
The purpose of analyzing the UNHCR Draft Environmental Impact Assessment (EIA) for the Zaatari Refugee Camp (Palo, 2014) was to: determine the role of environmental management in the planning process for Syrian refugees, understand the baseline conditions of water resources in the Zaatari camp area, and identify gaps within the refugee planning process in regards to prioritizing the threats to water shortage and quality in Jordan.

The Draft EIA was conducted from September 2013 to December 2013, approximately one year after the establishment of the Zaatari camp due to the recommendation of the environmental scoping mission carried out in September 2012. The EIA used the Rapid Impact Assessment Matrix (RIAM) methodology for the assessment to determine the magnitude of impact on environmental conditions (see Appendix for RIAM results for the Zaatari refugee camp). The purpose of this EIA was to collect and analyze baseline data and determine the environmental conditions in the camp.

The Zaatari camp is located in an area with rangeland with surrounding agricultural land uses, some of which showed effects of land degradation prior to planning the refugee camp. The ground surface is covered with gravel. There is a dried out olive plantation located north of the camp. There is soil bund several meters high which encourages infiltration of water into the soil, reduces runoff, and obstructs drainage water from entering the Amman-Zarqa aquifer (Palo, 2014).

The EIA concluded that the establishment of the camp had an overall significant negative impact on the change of the environment when compared to conditions prior to the Syrian refugee influx in Jordan, which are shown in Figure 7. Most of the indicators exemplified reversible conditions which can be improved with appropriate mitigation efforts. Although there seems to be an overall significant negative effect on the environment, the environmental management of Zaatari by UNHCR has had slight negative to negative impacts on the environmental conditions. This means that the agencies in control of the Zaatari camp, such as UNHCR, are only partially responsible for the negative impacts to the environment. Since the camp was built in an area with degraded agricultural land, the location of Zaatari has had a moderate negative effect on the baseline environmental conditions. Water use by the refugee camp has shown to have a significant negative impact on baseline environmental conditions due to the existing water shortage in the region and the increase of non-revenue losses. Non-revenue losses resulted from transporting water via trucks and leakages from poor water infrastructure. The aquifer near the Zaatari camp has been of concern to the Government of Jordan, however the EIA concluded that the risk of contamination of the groundwater supply is small. In contrast, the EIA concluded that the waste water management and solid waste management at the camp site has had a significant negative impact on baseline conditions. Appropriately managing waste water and solid waste is integral to protecting the water quality of the aquifer. Therefore, there is a high amount of responsibility for UNHCR to handle the waste water and solid waste effectively.

Figure 7: UNHCR Baseline Conditions

SECTOR	DESCRIPTION
Water Resources	Significant Negative Impact
Environmental Health	Significant Negative Impact
Wastewater	Significant Negative Impact
Solid Waste	Significant Negative Impact
Energy	Significant Negative Impact
Site	Moderate Negative Impact
Environmental Management	Negative Impact
Chemicals	Slight Negative Impact

Source: Palo (2014)

The assessment of baseline water and hydrological conditions explain that there is significant over pumping of the deep wells in the Zaatari site area. Interviews with Dr. Al-Raggad and Ghassan Hazboun of Mercy Corps supported this claim, and concluded that the water table decreased by 1.5 meters to 2 meters in the last year and a half, and there is no more continuous recharge.[7,8] Also, the lack of a sewage system at the camp site has induced the vulnerability of the aquifer. Furthermore, non-revenue losses result from damaged water tanks. Approximately 40% of the water storage tanks are leaking and about 60% of the waste water transported out of the camp is also leaking, which contributes to the non-revenue losses. The most significant effects on water use is determined to be the size of the refugee population.

7. Dr. Marwan Al-Raggad, personal communication, January 15, 2014.
8. Ghassan Hazboun, personal communication, January 15, 2014.

Refugee and Water Policy Planning

The purpose of obtaining anecdotal data from water management and refugee planning specialists in Jordan was to supplement the quantitative data received from the Ministry of Water and Irrigation (MWI) and the completed assessments conducted by organizations working in the field. To understand the overall water policies implemented in Jordan, interviews were conducted with experts working with the MWI, the Royal Water Committee, and researchers at the University of Jordan. According to Engineer Maysoon Zoubi, former Secretary General of the Ministry of Water, short term water planning is very prominent in Jordan, and the primary reason that the environmental externalities of water practices are not highly prioritized is because of the high need for water for basic purposes such as industry use, drinking water use, sanitation, and agriculture use.[9] The National Water Plan is updated every five years, and the most recent plan is progressive because of its participatory approach in involving a majority of the water stakeholders such as the Royal Committee, donors, and the civil society.

Engineer Ali Subah, Assistant Secretary General of Technical Affairs at the MWI, stated that the most important lessons learned from planning for refugee populations in the past, specifically for the Palestinian refugees and Iraqi refugees, are that the Ministry needs to include a risk assessment for water resources in the national plan and include the count and projection of the refugee population as "unexpected growth" to be more prepared for the stress on water supply. [10] In the 2013 water assessment conducted by the Ministry, these two issues were included to have a more informed discussion of water needs and priorities within Jordan.[10]

Zoubi (2014) recommended that the marginal cost[11] of water supply should be further considered and explored by water managers in Jordan.[9] Because of low rainfall, scarce surface water availability, and the high risk of groundwater depletion, other water supply sources such as desalinated water can be useful in Jordan.[9] However, much of the literature regarding desalination projects in Jordan state that the primary reason this is not a widespread practice is because of the high energy and technological costs for these type of projects (Denny et al., 2008). Also, long-term wastewater treatment plants are needed in the Mafraq, Azraq, and Ramtha regions which have experienced a high influx of unplanned growth. Existing plants are not able to sustain the needs of the population, and according to Ali Subah there have been cases of the Al-Akeider plant experiencing problems due to overuse, which has resulted in sewer overflow.[10] Azraq, a region with about 5% of its population consisting of Syrian refugees, is planned to open a refugee camp with a capacity for 50,000 refugees in 2014. It is expected to have a wastewater treatment plant by 2015.[10] Theoretically, this plant should reduce the demands from the existing wastewater plants in the northern region.

Water Distribution at Refugee Camps- Zaatari and Azraq

Other expert interviews were conducted with specialists working with non-governmental support on water issues in Jordan such as UNHCR, UNICEF, ACTED (Agency for Technical Cooperation and Development), and Mercy Corps. These interviews provided specific information on water management practices at the Zaatari refugee camp. Although UNHCR is in charge of overall refugee operations, UNICEF is carrying out plans for water and sanitation needs of the refugees. UNICEF has led the WASH (water and sanitation and hygiene) sector group which focuses on providing water, sanitation, and hygiene services for all Syrian refugees at the camp. Supporting UNICEF in this sector are ACTED and Mercy Corps, among other international organizations at Zaatari. The MWI has been the decision maker for general issues related to water and has been responsible for giving permission regarding drilling and distribution. The Yarmouk Water Authority is the local governing body for water in the Mafraq region, and has been responsible for general water allocation at the Zaatari pumping station (Al-Qadi et al., 2013).

9. Maysoon Zoubi, personal communication, January 13, 2014.
10. Ali Subah and Nisreen Haddadin, personal communication, January 14, 2014.
11. Marginal cost is an estimate of the per unit change in cost caused by changes in future water supply

The World Health Organization's (WHO) standard for basic water provision is approximately 20 liters/per/day (l/p/d), thus it is also the minimum standard used in Jordan for water provision for refugees.[12] Refugees at the camp are receiving 35 l/p/d on average.[12] According to the REACH July 2013 survey, refugees who have stayed at Zaatari longer have been able to purchase private water tanks to store additional water. There are on average 61 water collection facilities in each of the twelve districts with about 162 persons per water collection facility. For sanitation purposes, the WASH sector has been able to provide Zaatari with a total of 2,340 public toilets (approximately 51 persons per toilet). There are very few cases where the refugees at Zaatari live further than 150 meters from the nearest toilet; most refugees reside within 50-100 meters from the nearest toilet.

Water sources for the Zaatari camp consist of 80% coming from groundwater wells (which is delivered via trucks) and 20 percent coming from one agricultural private farm well located near the camp (which is delivered via pipeline) (Al-Qadi et al., 2013). At Zaatari, there are two boreholes which are drilled by Mercy Corps approximately 137 meters deep, and the groundwater table is between -137.16 meters to -106.68 meters below the ground surface.[12] These boreholes provide water at the rate of 100 cubic meters per hour. Ghassan Hazboun, Water and Infrastructure Programs Director at Mercy Corps in Jordan, stated that drilling for water in the Amman-Zarqa basin can safely be between 91.44 meters to 152.4 meters. Outside water sources for the camp, which are purchased by ACTED, consist of five boreholes located about 500 meters from the camp site. Outside water sources for the camp, which are purchased by ACTED, consist of five boreholes located about 500 meters from the camp site. According to Gian Melloni, WASH Technical Coordinator for ACTED in Jordan, on average the groundwater decreases 1 meter annually, and it is projected to decrease to 1.5 meters annually at the current and projected pumping rate. Hazboun estimated up to a 2 meter drop in the groundwater level.[12] These five boreholes provide water at the rate of 50 to 60 cubic meters per hour. The water from these sources are trucked to communal WASH blocks where there are 2m^3 water tanks that supply the blocks throughout the Zaatari camp.[13]

Hazboun and Sherwood stated that Mercy Corps and UNHCR are discussing a project to build an additional well on-site at Zaatari so that the water in the tanks for each tent/caravan would have continuous access to water.[12,13] A piped water supply network could also decrease operating costs and dependence on water trucking, which is expected to be functional near the end of the 2014 year.[13]

Wastewater has been a challenging issue for refugee camp managers, since the Ministry of Water and Irrigation has required UNICEF to transport the wastewater outside of Zaatari to the Al-Akeider Wastewater Treatment Plant, which is located about 32 kilometers (or 19.8 miles) from the site.13 This is demanded because of the risk of polluting the Azraq-Zarqa basin and the lack of on-site wastewater treatment facilities. According to Hazboun, the sewer sludge is transported to the treatment plant via trucks on a daily basis.[13] Currently, there is no objective to reuse the wastewater, but there is potential to recycle the water for small agricultural uses. Also according to Catherine Sherwood, UNHCR WASH Officer at Zaatari Camp, there is a plan to develop on-site wastewater treatment facilities for Zaatari in the form of membrane bioreactor (MBR) systems, which can be used for industrial and municipal wastewater treatment.[13] According to the February 2014 WASH sector group report, there will be two on-site containerized wastewater treatment plants functional in September 2014 (UNHCR, 2014).

Furthermore, sanitation has affected the water network and supply system at Zaatari. ACTED stated that the UNHCR implements similar strategies for camp planning without regards to the context and needs of the population.[14] Consequently, they have installed 400 WASH blocks for sanitation purposes within Zaatari, which was successful in Darfur refugee camps but have not worked as expected at Zaatari. Subah mentioned that these WASH blocks remain unused because women and children feel at

12. Ghassan Hazboun, personal communication, January 15, 2014.
13. Catherine Sherwood, personal communication, January 3, 2014.
14. Vicente Palacios, personal communication, January 16, 2014.

risk when using the community sanitation facilities, especially at night.[15] As a result, 70 percent of the households in Zaatari have constructed their own sanitation facilities, which was an unauthorized activity.[16]

Another issue with the water infrastructure of the Zaatari camp is the extent of the non-revenue water losses, which range from 35 percent to 75 percent.[17] These losses are due to the transportation of drinking water and wastewater through trucks, and the inefficient infrastructure which has resulted in 60% of water loss from leakage (Palo, 2014). According to Palo (2014), there are 100 trucks which transport water per day, with a total of 250 roundtrips from Zaatari.

UNICEF and the WASH sector were planning the water infrastructure for the new refugee camp which opened in Azraq in April 2014. This camp has the capacity to hold up to 130,000 refugees (UNHCR, 2014). Hazboun stated that there is no long-term water network or sewage infrastructure planned for the Azraq camp.[17] According to a joint assessment conducted by UNHCR, UNICEF, and the UN World Food Programme (2014), a few lessons learned from Zaatari are being applied at the Azraq camp. Melloni stated that the water source and infrastructure layout would be similar to Zaatari, however there were some considerations of implementing a land use plan and planning for water conservation efforts for the host communities.[18] Due to the safety concerns for women and children at the communal latrines provided in the WASH blocks at Zaatari, site planners for the Azraq camp will develop WASH facilities for up to six shelter units to reduce the distance to the facility and the number of people using the facility (Joint Assessment Review of the Syrian Refugee Response in Jordan, 2014).

Long-term refugee planning is a controversial issue because refugee planning is meant for a short term, and camp planners have been declaring that these areas are not cities, but refugee camps. However, Hazboun (2014) mentioned that the average life of a UNHCR camp is 17 years.[17]

Within the context of the Syrian civil war case, there is no expectation from the refugees, the Jordanian government, or the international aid organizations that these camps will close within the next year. So why is there no long-term planning?

Summary of Water Conditions in Jordan

Data on available surface water and groundwater sources was obtained from a report by the MWI for the purpose of evaluating existing water conditions and management in Jordan. As stated earlier, Jordan receives about 37% of its water resources from surface waters (Palo, 2014); these sources include the Jordan Rift Valley, Springs, and base and flood flows. Treated wastewater is another water source for Jordan, and this was included with the calculation of surface water supply because it is often mixed with freshwater (Raddad, 2005). The annual total supply of surface water used in 2009 was 388.2 MCM (see Figure 8). A majority of the surface water was diverted for irrigation purposes, with a volume of about 283.3 MCM (about 73% of the total surface water use), which is mostly used for agriculture in the Jordan Valley. The municipal sector, which includes households and several service activities, was the second highest consumer of water sources in 2009, with a volume of 93.8 MCM (about 24% of the total surface water use).

The annual total supply of surface water used in 2012 decreased to 340.7 MCM (see Figure 9). There was a decrease of water supply from the Jordan Rift Valley of about 10 MCM from 2009 to 2012, and this can be due to variability in climate conditions. In 2012, the municipal sector used 122 MCM (about 35% of the total surface water use), whereas in 2009 it had used 24% of the total surface water. Although the agricultural sector consumed the majority of surface water supply in 2012, it seemed that a change in water management policies may have affected the decrease in water used by the agricultural sector; Figure 8 and Figure 9 show there was a reduction in 23% of total surface water use by this sector.

15. Ali Subah and Nisreen Haddadin, personal communication, January 14, 2014.
16. Thomas Palo, personal communication, January 14, 2014.
17. Ghassan Hazboun, personal communication, January 15, 2014.
18. Gian Melloni, personal communication, January 14, 2014.

Figure 8: Jordan's Surface Water Use in 2009

Surface Water Supply (2009) MCM					
Source	**Livestock**	**Irrigation**	**Industrial**	**Municipal**	**Total**
Jordan Rift Valley	0	104.8	2.0	49.6	156.4
Springs	0	39.1	0.9	44.2	84.2
Base & Flood	7	38.3	0	0	45.3
Registered Treated Wastewater	0	101.1	1.2	0	102.3
Non Registered Treated Wastewater	0	-	-	-	
Total	7	283.3	4.1	93.8	388.2

Source: MWI (2014)

Figure 9: Jordan's Surface Water Use in 2012

Surface Water Supply (2012) MCM					
Source	**Livestock**	**Irrigation**	**Industrial**	**Municipal**	**Total**
Jordan Rift Valley	0	36.5	5.1	105	146.6
Springs	0	31	0	17	49
Base & Flood	7	37.7	0	0	44.7
Registered Treated Wastewater	0	100	1.4	0	101.4
Non Registered Treated Wastewater	0	-	-	-	
Total	7	205.2	6.5	122	340.7

Source: MWI (2014)

The surface water sources and uses explained in Figure 8 and Figure 9 are important for this research because it depicts how water is managed and distributed in Jordan. These values will be used for the water budget calculation to determine the impact of refugees on the water sector. Although surface water use decreased from 2009 to 2012, there needs to be further evaluation on how much water was used from the groundwater sources.

The groundwater sources in Jordan come from 12 aquifers, and Figure 10 and Figure 11 explain how this water source was distributed in 2009 and 2012. Jordan receives approximately 63% of its water sources from groundwater aquifers (Palo, 2014). The total supply of groundwater used increased from 484.1 MCM in 2009 (see Figure 10) to 494.1 MCM in 2012 (see Figure 11). All of the basins are renewable sources, except for the Al Disi and Al Jafr basins (Barham, 2012). From the 10 renewable sources of groundwater a total volume of 410.1 MCM was used in 2009, which increased to 433.1 MCM in 2012. Approximately 74 MCM of groundwater was consumed from the two non-renewable aquifers in 2009, which decreased to 61 MCM in 2012. Non-renewable groundwater basins usually take a longer period of time for replenishment or recharge, thus these basins should be used cautiously for sustainable management. As is the case for the surface water supply, the groundwater use is mostly allocated between the irrigation and municipal sectors. In 2009, the agricultural sector consumed 245.7 MCM of the total groundwater supply (about 50% of the total groundwater use), and the municipal sector used 204.4 MCM (about 42% of total groundwater use). In 2012, water allocated for the agricultural sector increased from 2009 by 5.2 MCM, and water used by the municipal sector increased by 12.6 MCM.

The groundwater uses explained in Figure 10 and Figure 11 can be compared with the surface water uses in Figure 8 and Figure 9. Although surface water use decreased from 2009 to 2012, the total groundwater use increased from 2009 to 2012. This change in water management practice could be a result of a decrease in water availability from one of the sources, or it can be due to policy changes made by the MWI.

Figure 10: Jordan's Groundwater Use in 2009

Ground Water Supply (2009) MCM					
Source	Livestock	Irrigation	Industrial	Municipal	Total
Renewable	0.83	203.4	18.6	187.2	410.1
Non-Renewable	0.05	42.3	14.3	17.2	74
Total	0.85	245.7	32.9	204.4	484.1

Source: MWI (2014)

Figure 11: Jordan's Groundwater Use in 2012

Ground Water Supply (2012) MCM					
Source	Livestock	Irrigation	Industrial	Municipal	Total
Renewable	0.1	217	19	197	433.1
Non-Renewable	0	34	7	20	61
Total	0.1	251	26	217	494.1

Source: MWI (2014)

These values will be used for the water budget calculation to determine the impact of refugees on the water sector.

As mentioned in the literature review, the rate of groundwater abstraction often exceeds the safe yield for most aquifers, signifying an unsustainable reliance on this source of water and exploitation of groundwater sources. Figure 12 shows the groundwater availability and abstraction rates from each aquifer in 2004. According to Zoubi (2014), the percent of safe yield in the tables should be below 100% to depict safe and sustainable use of the groundwater aquifer. Most of the water balances were negative and the percent of safe yields were greater than 100, meaning that the ground water was abstracted more than the safe yield value, which resulted in overdrafting. If the abstraction of the water levels remain above the safe yield there is a high risk of permanent damage and depletion of the groundwater aquifer (Todd 1959). The aquifers which were experiencing the most overpumping in 2004 (when analyzing the percent safe yield values) consist of the Side Valleys (172%), Amman-Zarqa (158%), Dead Sea (157%), North Araba Valley (193%), Red Sea (316%), Jafer (276%), and Azraq (247%).

It is important to note that in 2004, prior to the Syrian refugee influx in Jordan, the use of groundwater already exceeded the safe yield in most of the basins.

Figures 13 and 14 show the groundwater abstraction rates and recharge rates of the 12 aquifers in 2009 (prior to the Syrian refugee influx) and in 2012 (during the Syrian refugee influx). Theoretically a higher value for an aquifer's recharge rate is ideal since this value explains the amount of water that is able to infiltrate through the soil to reach the groundwater source. The average groundwater recharge rate in Jordan for 2009 was 3.98% and the average recharge volume was 16.0 MCM. In 2009, the Yarmouk, Jordan Valley, Amman-Zarqa, Dead Sea, and Azraq groundwater basins had a recharge rate above the average recharge rate. The Yarmouk, Amman-Zarqa, and Azraq basins had a recharge volume above the average recharge volume. The average groundwater recharge rate in Jordan for 2012 was 4.72% and the average recharge volume was 20.3 MCM. The Yarmouk, Jordan Valley, Amman-Zarqa, Southern Desert, and the North Wadi Araba groundwater basins had a recharge rate above the average rate. The Yarmouk, Amman-Zarqa, and the Southern Desert basins had a recharge volume greater than the average recharge volume.

Figure 12: Groundwater Use by Basin 2004

Groundwater Use (2004)				
Groundwater Basin	**Safe Yield (MCM)**	**Abstraction (MCM)**	**Balance**	**% Safe Yield**
Yarmouk	40	43.3	-3.3	108
Side Valleys	15	25.9	-10.9	172
Jordan Valley	21	27.9	-6.9	133
Amman-Zarqa	87.5	138.7	-51.2	158
Dead Sea	57	89.3	-32.3	157
Desi and Mudawrah	125	82.1	42.9	66
North Araba Valley	3.5	6.7	-3.2	193
Red Sea/South Araba Valley	5.5	17.4	-11.9	316
Jafer	9	24.8	-15.8	276
Azraq	24	59.3	-35.3	247
Serhan	5	3.8	1.2	76
Hammad	8	0.9	7.1	11
Total	275.5	520.1	-170.8	

Source: Raddad (2005)

Figure 13: Groundwater Use by Basin 2009

2009 Groundwater Use					
Groundwater Basin	**Safe Yield MCM**	**Abstraction**	**% Safe Yield**	**Recharge rate % of Rain**	**Recharge MCM**
Yarmouk	40	50.1	125	6.3	26
Side Wadis	15	22.7	151		
Jordan Valley	21	25.3	120	6.4	12
Amman-Zarqa	87.5	154.2	176	9.3	58
Dead Sea	57	80.7	141	4.4	10
Southern Desert	125	63.8	51	1.8	0.9
North Wadi Araba	3.5	5.5	159	3.8	7
South Wadi Araba	5.5	7.3	133	1.6	1
Jafer	9	30.6	340	0.9	4
Azraq	24	51.5	214	5.7	33
Sarhan	5	1.3	26	1.6	8
Hammad	8	0.8	10	1.5	11

Source: MWI (2014)

These values will be used for the water budget calculation to determine the impact of refugees on the water sector.

As mentioned in the literature review, the rate of groundwater abstraction often exceeds the safe yield for most aquifers, signifying an unsustainable reliance on this source of water and exploitation of groundwater sources. Figure 12 shows the groundwater availability and abstraction rates from each aquifer in 2004. According to Zoubi (2014), the percent of safe yield in the tables should be below 100% to depict safe and sustainable use of the groundwater aquifer. Most of the water balances were negative and the percent of safe yields were greater than 100, meaning that the ground water was abstracted more than the safe yield value, which resulted in overdrafting. If the abstraction of the water levels remain above the safe yield there is a high risk of permanent damage and depletion of the groundwater aquifer (Todd 1959). The aquifers which were experiencing the most overpumping in 2004 (when analyzing the percent safe yield values) consist of the Side Valleys (172%), Amman-Zarqa (158%), Dead Sea (157%), North Araba Valley (193%), Red Sea (316%),

Figure 14: Groundwater Use by Basin 2012

2012 Groundwater Use					
Groundwater Basin	Safe Yield MCM	Abstraction	% Safe Yield	Recharge rate % of Rain	Recharge MCM
Yarmouk	40	49.8	124	8.9	44
Side Wadis	15	23.2	154		
Jordan Valley	21	32.5	154	6.1	8
Amman-Zarqa	87.5	162.8	186	8.3	56
Dead Sea	57	80.5	141	4.3	14
Southern Desert	125	52.8	42	8.2	63
North Wadi Araba	3.5	6.1	174	4.8	8
South Wadi Araba	5.5	8.4	152	2.5	5
Jafer	9	36.6	406	1.4	5

Source: MWI (2014)

Jafer (276%), and Azraq (247%). It is important to note that in 2004, prior to the Syrian refugee influx in Jordan, the use of groundwater already exceeded the safe yield in most of the basins.

Figures 13 and 14 show the groundwater abstraction rates and recharge rates of the 12 aquifers in 2009 (prior to the Syrian refugee influx) and in 2012 (during the Syrian refugee influx). Theoretically a higher value for an aquifer's recharge rate is ideal since this value explains the amount of water that is able to infiltrate through the soil to reach the groundwater source. The average groundwater recharge rate in Jordan for 2009 was 3.98% and the average recharge volume was 16.0 MCM. In 2009, the Yarmouk, Jordan Valley, Amman-Zarqa, Dead Sea, and Azraq groundwater basins had a recharge rate above the average recharge rate. The Yarmouk, Amman-Zarqa, and Azraq basins had a recharge volume above the average recharge volume. The average groundwater recharge rate in Jordan for 2012 was 4.72% and the average recharge volume was 20.3 MCM. The Yarmouk, Jordan Valley, Amman-Zarqa, Southern Desert, and the North Wadi Araba groundwater basins had a recharge rate above the average rate. The Yarmouk, Amman-Zarqa, and the Southern Desert basins had a recharge volume greater than the average recharge volume. The average groundwater recharge rate and volume increased from 2009 to 2012, although individual basins show variations in the increase or decrease during this time period. Recharge rates are mostly affected by the rainfall and climate conditions, permeability of water to the basin, and evaporation rates (MIT, 2012).

Refugee Influx and Water Costs

The purpose of evaluating the population influx in this study is to determine a relationship between the increase in population and the resulting water usage characteristics and overall water budget changes. The following data on population for each governorate in Jordan was received by the MWI in January 2014 (see Figure 15). The total registered Syrian refugees by UNHCR equaled 549,575 in October 2013 (but it is estimated to be 600,000 as of May 2014); approximately 76 percent of the refugees lived among the host communities and 23 percent of the refugees lived in refugee camps. This value does not include unregistered refugees thus it is an underestimate of the Syrian population in Jordan. The Mafraq governorate, which hosts the Zaatari refugee camp, hosted the largest influx of refugees, with 60.5 percent of the population identifying as Syrian refugees. According to Hazboun (2014), the Yarmouk Water Company which is managing water resources in the Mafraq region stated that the increased stress on water has been a result of the refugee population. The population in the Mafraq region was 289,309 before the influx of Syrian refugees in 2012, and grew to 300,300 by 2013. Other governorates which also hosted large populations of refugees were Irbid (10.83 percent of the population identified as Syrian refugees), Ajloun (6.64 percent of the population identified as Syrian refugees), Amman (5.39 percent of the population identified as Syrian refugees), Jerash (5.44 percent of the population identified as Syrian refugees), and Zarqa (5.03 percent of the population identified as Syrian refugees). The UN WASH sector group in

Figure 15: Population of Syrian Refugees- 2013

Population of Syrian Refugees					
Governorate	Total Registered Refugees	Host Communities/Registered	Camps/Registered	Total Population of Governorate (2012)	Percent of Refugees/Governorate
Ajloun	9752	9752		146900	6.64%
Amman	133373	133373		2473400	5.39%
Aqaba	2040	2040		139200	1.47%
Balqa	14145	14145		428000	3.30%
Irbid	123099	121657	1442	1137100	10.83%
Jerash	10420	10420		191700	5.44%
Karak	8505	8505		249100	3.41%
Maan	5454	5454		121400	4.49%
Madaba	7343	7343		159700	4.60%
Mafraq	181683	59146	122537	300300	60.50%
Tafleh	2114	2114		89400	2.36%
Zarqa	47849	43983	3886	951800	5.03%
Dispersed in Jordan	3796	3796		-	-
Total	549575	421730	127845	6388000	8.60%

Source: MWI (2014)

Jordan expect the total number of registered refugees to increase to 800,000 in 2014, and the MWI is preparing for about 1.2 million refugees in 2014.

The overall water demand of the Syrian refugees was calculated by the MWI in 2013 and it was estimated to be approximately 20.65 MCM per year with a total refugee population of 600,000 (if the average water usage of the refugees is 90 l/c/d).[19] Specifically within the Zaatari refugee camp the water demand was estimated to be 1.2 MCM per year (if the average water usage of the refugees is 35 l/c/d). The water demand for the Azraq refugee camp with its full capacity of 130,000 refugees is estimated to be 1.6 MCM per year (if the average water usage of the refugees is 35 l/c/d). To evaluate the impact of the refugees on the water sector, the estimated water usage of the refugees was compared to the total amount of water extracted for domestic use. The overall water usage of 600,000 refugees was about 2.3% of the total water consumption in Jordan; and the overall water usage of an overestimate of 1.2 million refugees would be about 4.5% of the total water consumption in Jordan. The Syrian refugees at the Zaatari camp used about 0.8% of the total water extracted from the Amman-Zarqa aquifer in 2012.

If the Azraq refugee camp is at its full capacity of 130,000 refugees, the camp would consume about 2.9% of the total water usage in Jordan. To compare the water consumption of the refugees and the Jordanians in each of the governorates, data about the average water consumption of Jordanians for each governorate would be needed.

In 2014, with existing resources, the UN WASH group expects to meet the water and sanitation demand of 600,000 refugees and 180,000 Jordanian residents (those that are hosting refugees in the northern governorates) (UNHCR, February 2014). In a 2013 MWI report, the direct short term costs of hosting refugees and the indirect long term costs of hosting refugees on the water sector were calculated. The direct short term costs show that Jordan would need to invest about 370,827,232 USD for an estimated 1.2 million refugees per year. This cost accounted for capital costs and operational costs for water and wastewater. The long term indirect costs on the water sector show that Jordan would need to invest about 353,498,714 USD for an estimated 1.2 million refugees per year. This number considered factors such as the environmental overpumping of the GW, costs of crisis management, and the cost of opportunity loss.

19. Refer to the Appendix for water demand information of refugees per governorate (Figure 17)

Jordan's Water Budget Analysis

The following data on Jordan's water use, supply, demand, and projections were obtained from the MWI and online datasets from the Food and Agriculture Organization (FAO) in January 2014 to comprehensively analyze the water situation in Jordan and the direct and indirect impacts the Syrian refugees have had in the past few years on the water budget, and the projected impact for future water resources. According to Kumar (2012), a water balance is used to determine the ways in which the water supply is used; usually it is used to account for the water in the hydrological cycle for a period of time by evaluating water inputs and outputs. This is simplified in the following equation:

$\Delta S = P - E - ET \pm SRO \pm GF +$ Other source inputs/outputs (LWMD, 2010). The independent variables include: Precipitation (P), Evaporation (E), Evapotranspiration (ET), Surface runoff (SRO), Groundwater flow (GF), Other source inputs/outputs (e.g. surface water withdrawal and groundwater withdrawal). The dependent variable is the is the change in storage (ΔS).

This paper used a variation of the water budget equation provided by the Land and Water Management Division of Michigan (LWMD, 2010). This analysis accounted for the excess available water budget of Jordan for the years 2004, 2009, and 2012. The budget for the years 2004 and 2009 can be used to analyze the water supply and management prior to the Syrian refugee influx in Jordan, and the budget for the year 2012 can be compared with the previous years' budgets to analyze the impact of Syrian refugees on the water supply and use.

The excess available water budget included the amount of water that could be captured from all sources of rainwater, surface inflows, and groundwater inflows. This analysis assumed that the impacts on the water budget from the surface water runoff and evapotranspiration components were minor, and thus were not computed.

thus were not computed. The precipitation data should be calculated by month when conducting an evaluation of an annual water budget such as in this study. Due to data access limitations, the annual average precipitation value and evaporation value used for the water budget analysis for the year 2012 came from the literature provided by Alamoush (2011); the annual average precipitation volume is 8,360 MCM and the evaporation volume is 7,524 MCM (which is 90% of the rainfall volume). The evaporation rates for the years 2004 and 2009, which were 6,255.9 MCM and 5,738.4 MCM respectively, were calculated by determining 90% of the rainfall volume. The groundwater recharge volume is included within the precipitation value. The total surface water inflow and total groundwater inflow data were obtained from the Food and Agriculture Organization; total surface water inflow is 130 MCM, and total groundwater inflow is 90 MCM. The equation assumed that all rainfall which did not evaporate remained within Jordan and it contributed to Jordan's groundwater and surface water sources. There is a lack of information on the amount of groundwater and surface water which flows out of the country, thus this analysis is a liberal estimate and the water balance is probably lower than it is stated here. Regardless of these data limitations, the excess available water budget values for 2004, 2009, and 2012 provided an overall/comprehensive estimate on water supply in Jordan.

The equation used for the analysis:

Excess available water budget = Annual Average Precipitation + Total Surface Inflow + Total Groundwater Inflow - Evaporation - Surface water and Groundwater Outflow - Water Withdrawal from Surface water Supply - Water Withdrawal from Groundwater Supply

Water Budget (2004)= 8,360 MCM + 130 MCM + 90 MCM - 7,524 MCM - 0 (unknown) - 289.0 MCM - 520.1 MCM = 246.8 MCM

Water Budget (2009) = 8,360MCM + 130 MCM + 90 MCM - 7,524 MCM - 0 (unknown) - 340.7 MCM - 484.1 MCM = 231.1MCM

Water Budget (2012) = 8,360 MCM + 130 MCM + 90 MCM - 7,524 MCM - 0 (unknown) - 340.7 MCM - 494.1 MCM = 221.1 MCM

In addition, a groundwater budget was calculated to understand the concepts of safe yield and sustainable yield. The groundwater budget value would indicate whether more water is being extracted from the aquifer than is replenished. The renewable groundwater value is calculated from data provided by the MWI and the FAO. The total groundwater outflow is unknown and is assumed to be zero, thus the actual groundwater budget is lower than the values given for 2009 and 2012.

The groundwater budget is represented below for the years 2004, 2009, and 2012:

Groundwater budget = Total Groundwater Inflow + [weighted average groundwater recharge rate x Precipitation] - Groundwater Outflow - Water Withdrawal from Groundwater Supply

Groundwater budget (2004) = 90 MCM + [334.4 MCM] - 0 (unknown) - 520.1 MCM = -95.7 MCM[20]

Groundwater budget (2009) = 90 MCM + [214.4 MCM] - 0 (unknown) - 484.1 MCM = -179.7 MCM

Groundwater budget (2012) = 90 MCM + [315.4 MCM] - 0 (unknown) - 494.1 MCM = -88.7 MCM

The input and output terms of the groundwater budget unrelated to human consumption represent the quantity of renewable groundwater. The total groundwater outflow is unknown and is assumed to be zero, thus, similar to the total groundwater balance, the actual renewable groundwater amount is lower than the values calculated for 2009 and 2012. The renewable groundwater is shown below for 2004, 2009, and 2012:

Renewable Groundwater = Total Groundwater Inflow + [weighted average groundwater recharge rate x Precipitation] - Groundwater Outflow

Renewable Groundwater (2004) = 90 MCM + [334.4 MCM] - 0 (unknown) = 424.4 MCM

Renewable Groundwater (2009) = 90 MCM + [214.4 MCM] - 0 (unknown) = 304.4 MCM

Renewable Groundwater (2012) = 90 MCM + [315.4 MCM] - 0 (unknown) = 405.4 MCM

Discussion

UNHCR Draft EIA

Since the UNHCR was responsible for consulting the Jordanian government about refugee planning, and it is usually the most important organization providing refugee and emergency management in other countries, it is necessary to address its responsibilities towards the environmental management of the refugee camp. UNHCR claims that environmental management is a policy priority during all phases of their work, and there is a need to improve its approach towards environmental assessments and monitoring and evaluation (UNHCR, 2001). The literature review showed that there are vague UNHCR guidelines related to water management on refugee camp sites, and the interviews indicated that the Syrian refugee planning process was lacking a focus on the impact on water resources. The UNHCR environmental guidelines solely consider the availability of water sources for the provision of water and sanitation for the refugees. It does not consider the impact of using the land or water sources on the broader availability of water in the host country. An Environmental Impact Assessment (EIA) should be done prior to opening the refugee camp, but this assessment was conducted one year after the Zaatari camp was established. It is important for the UNHCR planning process, which has been planning refugee camps since 1950, to realize its long term impacts on the host population and to encourage host governments to prioritize the protection of its natural resources. Shepherd (1995) and Nielsen (2011) agree that EIAs are needed for the refugee planning process. They

20. The groundwater recharge values for 2004 for each basin were not available, thus the weighted average was not used. The average recharge rate of 4% was used in the calculations for the groundwater budget and the renewable groundwater.

also agreed that the long term perspective for refugee planning and context-specific guidelines related to the impact on the environment are lacking within this planning arena. This thesis suggests that EIAs should be a mandatory policy of UNHCR in order to inform the site planning process more effectively and conservatively, and it should be adopted immediately. This will allow the UNHCR guidelines to be implemented in a country-specific context, and it would mitigate the overall negative impacts of refugees on the host country.

Also, by requiring EIAs, UNHCR would set an example for other institutions working in this field. It should encourage the MWI and other stakeholders to adhere to the recommendations of the EIA and plan accordingly. Although there is a strong argument against making refugee planning a long-term effort (for example calling the Zaatari camp a "city" is still considered taboo), the process can be reformed so that it would include more stakeholders in the site planning process, and measures can be taken to reduce the overall negative effects of the refugee crisis.

Refugee and Water Policy Planning

It is concerning that the new Azraq refugee camp, expecting to host up to 130,000 people, is planned for a location on top of a groundwater basin already experiencing overdraft for the past decade. Prior to the field interviews, it was hypothesized that the refugee planning process in Jordan had not considered the impact on Jordan's water resources, because of past case studies of emergency planning. According to the UNHCR Draft EIA for Zaatari (Palo, 2014) and the interview with Subah (2014) at the MWI, the site selection process for the Zaatari refugee camp required several important criteria, however the long-term impacts to the water supply were not deeply considered. There is a criteria defined by Jordan's Ministry of Interior's Policy Council and the UNHCR refugee planning guidelines. Both agencies were involved in the site selection process, with the majority of the decision making power in favor of the Government of Jordan. The priorities of the Government of Jordan included: proximity to the Syrian border, proximity to dense urban areas, proximity to natural resources, existing land availability and surrounding land uses, population capacity, and national security concerns. The Zaatari camp in the Mafraq region fit the criteria of the Jordanian government and the UNHCR. It is located about 30 km from the Syrian border, and is in an area with rangeland and surrounding agricultural land uses. Some of this area showed effects of land degradation prior to planning the refugee camp (Palo, 2014). The hydrologic details of what would make a "good" refugee camp site should be determined by the MWI in the pre-planning phase. A "good" refugee camp site from the perspective of the MWI could be defined after evaluating the water availability and constraints of the surface and groundwater aquifers; and asking questions such as: how deep is the aquifer, how much energy will it require to extract the water, is the water quality safe for human use, what is the safe yield, and what is the vulnerability of contaminating the aquifer. Also, along with the assessment of water availability for human consumption, there needs to be a focus on building treatment facilities simultaneously to account for water quality and wastewater. Areas experiencing groundwater overdraft and declining water tables prior to the Syrian refugee influx are already water-stressed and are not ideal camp sites.

Also, according to Subah (2014) at the MWI, the MWI was not included in the planning process for the Zaatari refugee camp, even though the Zaatari camp resides on top of the Amman-Zarqa aquifer. This is concerning since a national priority of the Jordanian Government is the threat of water shortage. There needs to be a more holistic and cross-sectoral approach in refugee planning within Jordan to address the issues related to water resources. In addition to the MWI being involved in the site planning process, the Jordanian government should include land use planning perspectives to enhance regulations related to water resources and land development. An integrated water resource management approach would be beneficial for this situation.

Coupled with reforms to the refugee planning process, Jordan's MWI should consider other initiatives to improve the water management techniques used, especially in the northern regions that are heavily populated with refugees. Currently, the MWI and UNHCR are planning a water supply network to replace the water trucking in the Zaatari refugee camp, which will reduce transportation costs of the water and non-revenue losses (UNHCR, 2014). This is a step in the direction of long term planning for the population in this region.

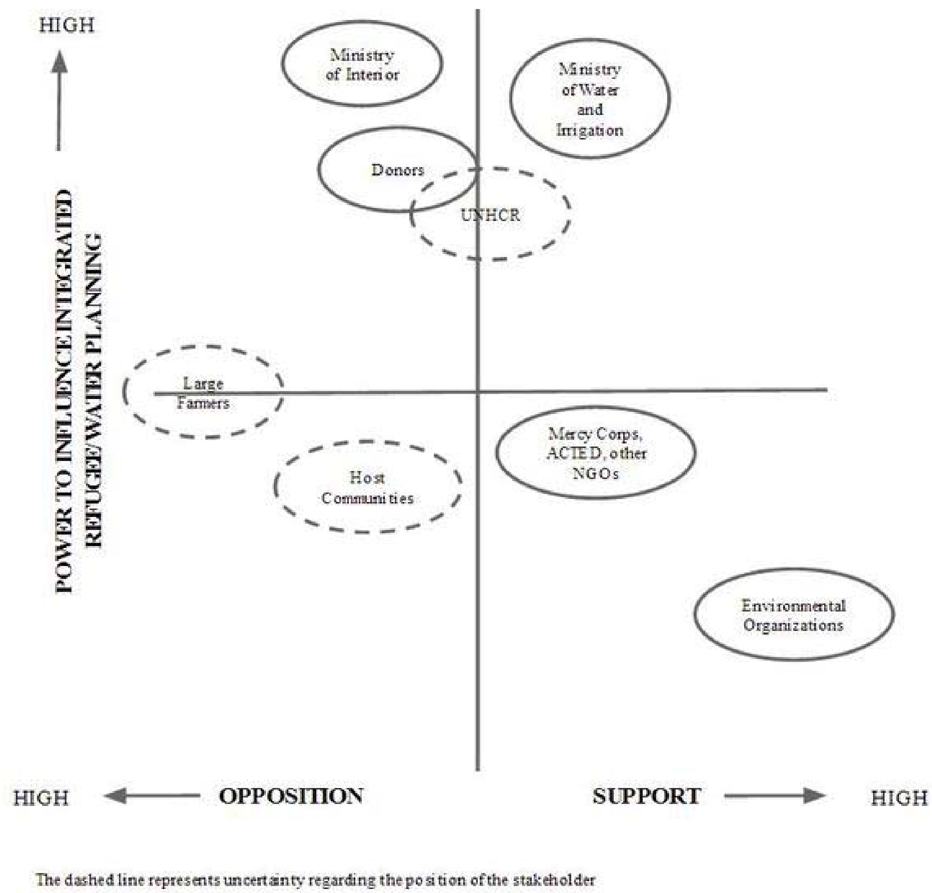
Also, as mentioned in the literature review, water demand management needs to be a higher priority among other water planning objectives. Altering the existing policies and convincing stakeholders to adopt demand management principles would need to be a long term objective for Jordan. Demand management strategies for agriculture include enhanced irrigation design through drip irrigation or wastewater reuse. The data showed that most of the surface and groundwater sources are allocated for this sector, even though it contributes to 3 percent of Jordan's overall GDP. Drip irrigation would assist Jordan to reduce its water loss by 100 MCM (Comair et al., 2012). The containerized wastewater treatment plants planned for Zaatari will reduce the stress on the Al-Akeider plant, but this is a temporary solution. Zoubi (2014) believed that constructing permanent plants would be more beneficial for the overall Mafraq region, even after the refugee camp is closed. Namrouqa (2013) indicated that over 34 MCM of wastewater is generated annually by Syrian refugees in Jordan, and according to Hazboun (2014) there is currently no plan for wastewater reuse at the Zaatari or Azraq refugee camps. Treated wastewater is currently used for 50 percent of the agriculture land in Jordan for irrigation purposes; if Jordan increases wastewater reuse to supply at least 80 percent of its population, then it can increase water supply by at least 100 MCM per year (Comair et al., 2012). Investment in wastewater recycling at the camp scale and on a national scale could offer more water supply per year in the long term. Farmers in the Jordan Valley pay only 10 percent of the total water costs, whereas the households pay 50 percent of the total water costs (Barham, 2012). Reformed water pricing mechanisms which reflect demand and use is another water demand management principle that should be addressed at a national scale.

Additionally, more investment should be allocated for large scale educational campaigns to reduce water losses and encourage water conservation. UNICEF has been working on water conservation awareness efforts at the Zaatari camp, by providing ways to conserve water at the household level while washing dishes, cleaning clothes, and for drinking water and sanitation uses. This needs to be replicated at a larger scale in Jordan.

Although these water demand management strategies are recommended in Jordan's National Water Plan, the implementation of these policies have not been successful due to powerful stakeholder groups against demand management policies. This is one reason for why large scale projects such as the Red-Dead Sea Canal and the Disi Water Conveyance projects are campaigned for on a larger scale. The issue with increasing water supply projects is that it is more costly and it may not be as effective if inefficiencies in water management exist. Investing in reforming water mismanagement would be the ideal long term solution for Jordan. Zeitoun et al. (2012) described the tensions between the water stakeholders and the power structure in Figure 6. A long term solution to water mismanagement can include implementing stakeholder cooperation initiatives and open dialogue with groups that have less political clout (such as the civil society or Jordan's Ministry of Environment). Furthermore, refugee planning needs to be more integrated with water management planning to reduce the impacts on the water sector. Since the Syrian conflict has been ongoing for the past few years, long term refugee planning should be adopted.

Similar to the stakeholder map of Zeitoun et al. (2012), a stakeholder map was created to depict opposition, support, and power in decision making for integrated water resource and refugee planning (see Figure 16). The site selection process can be reformed so that it would include more stakeholders in the site planning process, and measures can be taken to reduce the overall negative effects of the refugee crisis. The stakeholders chosen for this diagram were based off of the literature review and field interviews conducted for this thesis.

Figure 16: Integrated Water and Refugee Planning Stakeholder Map



The Ministry of Interior and UNHCR are the prominent decision makers for refugee planning. The Ministry of Interior is concerned about national security and is at risk of experiencing backlash from host communities, thus it is less likely to formally implement long term refugee planning unless it garners more support from other stakeholders. The UNHCR actor shows uncertainty regarding long term refugee and water planning. Although this organization has been crucial for water management at the refugee camp level and in initiating water conservation efforts, the ideology of the UNHCR and other refugee aid organizations has been more focused on emergency and short term planning. Institutional policy change would be needed for UNHCR to take a more proactive approach at long term planning. The actors which would be more opposed to this policy include the large farmers and host communities in Jordan. The former group has substantial political clout in shaping water management policies which are not aligned with water demand management; therefore it was categorized as having some power to influence the integrated policy, but it would be most likely opposed to the policy (Zeitoun et al., 2012). The latter group consisting of host communities is more likely to be opposed to the policy, since there are several case studies that show rising tensions between host communities and refugees over scarce resources. The Ministry of Water and Irrigation is at a high position to influence water management policies geared towards an integrated approach, which covers the issue of Syrian refugees. The MWI should work with the Ministry of Interior to implement this policy. Other non-governmental organizations, and specifically environmental organizations, seem to have less political clout in water and refugee decision making in Jordan, and they usually rely on the UNCHR for coordination efforts in refugee planning. In the current situation where Jordan is at a risk of being unable to support its population with freshwater by 2030 (Zeitoun et al., 2011), the threat of water scarcity should be the incentive for most stakeholders to agree on investing in long term water conservation and refugee planning.

Water Conditions

A volume of 162.9 MCM was extracted from the Amman-Zarqa basin in 2012, which experienced a surplus of about 181,683 people after the Syrian crisis. Prior to the refugee influx, this basin was already experiencing overdraft. This was an increase in the groundwater extraction of 8.6 MCM since 2009, which increased the percent safe yield value of the basin. Additionally, the recharge volume of the aquifer decreased to 56.3 MCM in 2012 (a reduction in about 2 MCM), which is still relatively high when compared to other basins (see Figure 14). The decrease in recharge volume could be a result of land use change and high evaporation rates (MIT, 2012).

In 2012, a volume of 53.5 MCM was abstracted from the Azraq basin; the basin had a safe yield of 24 MCM, meaning that it experienced overdrafting prior to the Syrian refugee influx. The Azraq basin experienced a surplus of 47,849 people due to the refugee influx, and consequently about 2 MCM more was extracted from the aquifer since 2009. This value does not yet include the additional 130,000 refugees expected for the new refugee camp which will also use this basin which will most likely increase the volume withdrawn from the aquifer.

Even though the refugees in the Zaatari camp (receive on average 35 l/p/d) and many communities within the north receive less water than Jordanians, the water supply will still be impacted. Overall, the groundwater abstractions rates, particularly for the regions experiencing the refugee influx, showed higher rates in 2012 than the precedent years. As mentioned in the Findings section, the overall water usage of 600,000 refugees was about 2.3% of the total water consumption in Jordan; and the overall water usage of 1.2 million refugees would be about 4.5% of the total water consumption in Jordan. The Syrian refugees at the Zaatari camp used about 0.8% of the total water extracted from the Amman-Zarqa aquifer in 2012. If the Azraq refugee camp is at its full capacity of 130,000 refugees, the camp would consume about 2.9% of the total water usage in Jordan.

Water Budget Analysis

This analysis accounted for the excess available water budget of Jordan for the years 2004, 2009, and 2012. The budget for the years 2004 and 2009 can be used to analyze the water supply and management prior to the Syrian refugee influx in Jordan, and the budget for the year 2012 can be compared with the previous years' budgets to analyze the impact of Syrian refugees on the water supply and use. As shown in the Findings section, the water budget showed a decline from 2004 to 2009 to 2012; it was respectively 246.8 MCM, 231.1 MCM, and then 221.1 MCM. The decline in the water budget can be due to various factors such as population growth, changes in water usage by sector, changes in precipitation and stream flow, and unplanned impacts to the water supply. This paper argues that the influx of Syrian refugees played a role in the declining water budget, and the growing number of refugees in Jordan will continue to impact the overall water budget. The influx of 600,000 refugees has increased the total water consumption by at least 2.3%. When accounting for the expected addition of 600,000 refugees in 2014 (total of 1.2 million), the refugees are expected to increase the total water consumption by at least 4.5%.

It is important to note that a limitation for the water budget analysis was being unable to obtain the annual precipitation values, so an estimated value was used from the literature review. If Jordan was experiencing a particularly dry or wet year, it would impact the precipitation volume included in the water budget. Another limitation in the water budget was the lack of data for the amount of surface water and groundwater outflow from Jordan. The current analysis assumes that there is no outflow, but there should be an assumption that some groundwater and surface water flow outside of Jordan's borders and thus are not considered a local resource. The water balance results calculated are liberal estimates due to it not considering outflow values and in reality will be lower.

Water used for agriculture and food for the refugee camp and host communities would have made the water budget more precise.

Additionally, the water budget analysis would be more accurate if it included the most recent water supply and demand data from 2013, however it was not available from the MWI for this thesis.

The groundwater budget analysis was used to determine whether this resource is being used sustainably. The budget showed negative values for both 2009 and 2012 which indicated that the amount of water extracted from the groundwater aquifers is greater than is being replenished (which is indicated by the recharge rate). The negative groundwater values can lead to groundwater levels declining, which supported by the anecdotal data collected.

To measure Jordan's sustainable use of water, the groundwater use and surface water use values should be compared to the total renewable groundwater and total renewable surface water values. The FAO provided the renewable surface water value of 650 MCM and the renewable groundwater value of 540 MCM. The renewable surface water and groundwater amounts were estimated by the FAO and could be considered overestimates since specific values were not given for the particular years of interest to this study. In the water budget analysis section, the renewable groundwater amount for Jordan was calculated, with raw values provided by the MWI, since the FAO did not indicate what is included in the "renewable" value. The calculated renewable groundwater value for 2009 was 422.7 MCM and for 2012 was 484.5 MCM, about 22 percent and 11 percent lower than the values provided by the FAO. The total surface water and groundwater usage was provided by the MWI for 2004, 2009, and 2012 and are listed in Figure 17.

Although Zeitoun et al. (2012) mentioned that Jordan was withdrawing water up to 20 percent about the sustainable capacity level, the FAO data showed that consumption was less than the renewable water amounts (see Figure 17). The FAO suggests that Jordan is using its water resources in a reasonable way. Using other data sources, we were able to recalculate the groundwater budget and show that the FAO could be significantly overestimating the renewable water supply. This suggests that water use is more sustainable than it may be in reality. The lack of consensus between the data sources affects water management planning, because if water planning is conducted using only the FAO data, then water managers would be overestimating the water supply.

The negative groundwater balance calculated in this study is supported by other literature and field interviews. Many sources stated that groundwater overdrafting and the declining water table were major threats to Jordan's water security. High groundwater use, about 59 percent of total water use in the country, exists within Jordan because of low rainfall and surface water availability. The data received from the MWI showed similar trends which are displayed in the groundwater budget.

Figure 17

	Total Renewable Surface Water (MCM)	Total Surface Water Use (MCM)	Total Renewable Groundwater (MCM)	Total Groundwater Use (MCM)
2004	650	289.09	540	520.1
2009	650	340.73	540	484.13
2012	650	340.73	540	494.1

Sources: FAO and MWI

Conclusion

The recommendations in this thesis were provided for water and refugee planners in order to reduce the impact of the influx of refugees on Jordan's water resources. The recommendations focus on macro level solutions for the national governance of water resources and institutional design of integral decision makers in the refugee planning field. They also address the micro management of water resources at the camp level and community level.

Although the water budget and renewable water calculations indicated that Jordan is using its water resources sustainably (the water consumed is less than existing supply), the literature and interviews in Jordan indicated otherwise. The interviews with water and refugee planning experts in Jordan and the UNHCR EIA indicated that there has been a major stress on the water resources with the influx of population in the past few years. Groundwater overdraft, pollution of freshwater sources, and the inability of the existing water infrastructure to cope with an additional 600,000 people were cited as major concerns for Jordan's water sector. The MWI calculated the overall water demand of the Syrian refugees in 2013, and the overall water usage of 600,000 refugees was about 2.3% of the total water consumption in Jordan. This consumption rate can increase by at least 2.2% if the number of refugees increases to the expected 1.2 million for 2014. Moreover, direct short term costs of the refugees on the water sector were calculated to be about 370 million USD, and long term costs were estimated to be 353 million USD. The most updated data about Jordan's water use and supply (especially regarding water outflow and groundwater recharge rate) is needed for a more precise quantitative analysis.

As stated in the discussion section, a cross-sectoral and integrated approach for water and refugee planning would be needed to comprehensively address the water shortage issues. Policies should prioritize water demand management and water conservation practices. Stakeholder cooperation is needed to implement a majority of these policies. Lastly, it is important for the UNHCR to mandate environmental impact assessments during the pre-planning phase for refugees. This would encourage host governments which are consulting with UNHCR and other aid organizations to implement strategies specific to the existing conditions in the host country. There has to be a fundamental shift in the ideology of emergency planning since it remains primarily in an adaptive form. Although addressing the humanitarian needs of refugees should be the focus of Jordan and the UNHCR, the environmental impacts cannot be forgotten until it is too late, especially in a host country where water resources are so scarce and vulnerable. Every policy and action should be taken with concern towards the water sector, otherwise the consequence could result in the inability to provide water for Jordanians prior to the projected deadline of 2030 (Zeitoun et al., 2012). This would have the possibility of affecting political and social stability and tensions in the overall water stressed region.

RIAM Methodology results for the Zaatari Refugee Camp (Palo, 2014, p.34)

Sector	A1	A2	B1	B2	B3	ES	Description
Water Resources	4	-2	2	2	3	-56	Significant negative impact
Environmental Health	4	-2	2	2	3	-56	Significant negative impact
Wastewater	3	-2	2	2	3	-42	Significant negative impact
Solid Waste	3	-2	2	2	3	-42	Significant negative impact
Energy	3	-2	2	2	2	-36	Significant negative impact
Site	3	-1	3	2	3	-24	Moderate negative impact
Environmental Management	2	-1	2	2	3	-14	Negative impact
Chemicals	1	-1	2	2	2	-6	Slight negative impact

The important assessment criteria fall into two groups;

a) Criteria that are important to the condition, and which can individually change the score obtained.
b) Criteria that are of value to the situation, but individually should not be capable of changing the score obtained.

The scoring system requires multiplication of the scores given to each of the criteria under (a). This ensures that the weight of each score is expressed differently. Scores for the values in group (b) are added together to provide a sum, this ensure that the individual value score cannot influence the overall score but that takes the collective importance of values in (b) into account. The sum of the group (b) multiplied by the result in group (a) gives the final assessment score (ES) for the condition.

Water Demand of Refugees per Governorate 2013

Potential Water Demand of Refugees

	Host Communities Water Consumption (l/c/d)	Host Communities Water Consumption (MCM/year)	Camps: Total Water Consumption (MCM/year)- based on 30 l/p/d	Total (MCM/year)
Ajloun	54	0.21		0.21
Amman	104	6.29		6.29
Aqaba	86	0.59		0.59
Balqa	96	0.64		0.64
Irbid	66	3.16	0.02	3.18
Jerash	54	0.21		0.21
Karak	103	0.41		0.41
Maan	134	0.5		0.5
Madaba	77	0.24		0.24
Mafraq	128	3.64	1.57	5.21
Tafleh	108	0.96		0.96
Zarqa	91	1.75	0.46	2.21
Total	-	18.6	2.05	20.65

The following numbers were calculated through WEAP based on Syrian refugees registered in host communities and in camps at the 24.10.2013 (Source:UNHCR website). For the camp in Azraq, WEAP considered that the first phase is on-going (22700 refugees).

REFERENCES

Allaf, C. (n.d.). Lessons learned from iraqi refugees in jordan. Retrieved from http://www.odihpn. org/the-humanitarian-space/blog/lessons-learned-from-iraqi-refugees-in-jordan

Alamoush, M. Water scarcity in Jordan. Columbia University, MA Sustainability Management.

Al-Bakri, J., Salahat, M., Suleiman, A., Suifan, M., Hamdan, M., Khresat, S., et al. (2013). Impact of climate and land use changes on water and food security in Jordan: Implications for transcending "The tragedy of the commons". Sustainability , 5, 724-748. Retrieved , from http://static.sdu.dk/mediafiles/ F/4/0/%7BF40EA11F-48A8-4EF0-A0AE-2A25EC390AF4%7DNB0512.pdf

Al-Qurashi, A., & Husain, T. (2001). Sustainable water resources development plan for the middle-east countries . Bridging the gap. doi: 10.1061/40569(2001)366

Altz-Stamm, A. (2012, January 1). Jordan's Water Resource Challenges and the Prospects for Sustainability. Retrieved May 7, 2014, from http://www.caee.utexas.edu/prof/maidment/ giswr2012/TermPaper/Altz-Stamm.pdf

Barham, N. (2012). Is good water governance possible in a rentier state? The case of Jordan.Center for Mellemoststudier. Retrieved , from http://static.sdu.dk/mediafiles/F/4/0/%7BF40EA11F-48A8- 4EF0-A0AE-2A25EC390AF4%7DNB0512.pdf

Borton, J. (1993). Recent trends in the international relief system. Disaster. 17(3), 187-201.

Comair, G., Gupta, P., Ingenloff, C., Shin, G., & McKinney, D. (2012). Water resources management in the Jordan River Basin. Water and Environment Journal.

Denny, E., Donnelly, K., McKay, R., Ponte, G., & Uetake, T. (2008, April). Sustainable Water Strategies for Jordan. University of Michigan, Gerald R. Ford School of Public Policy , 5, 724-748. Retrieved , from http://static.sdu.dk/mediafiles/F/4/0/%7BF40EA11F-48A8-4EF0-A0AE- 2A25EC390AF4%7DNB0512.pdf

Harper, A. (2008). Iraq's refugees: Ignored and unwanted. International Review of the Red Cross, 90(869), Retrieved from www.icrc.org/eng/assets/files/other/irrc-869_harper.pdf

IRIN. (2013, October 16). Getting it right for syrian refugees the second time round. IRIN Middle East. Retrieved from http://www.irinnews.org/printreport.aspx?reportid=98946

Lei Ravelo, J. (2013, June 20). Mike bailey: Building a camp for syrian refugees in jordan. Retrieved from https://www. devex.com/en/news/mike-bailey-building-a-camp-for-syrian-refugees-in-jordan/ 81276

Madanat, H. (2013, January 29). Impacts of refugees in societies. Retrieved from http://blog. hopesforwomen. org/2013/01/29/impacts-of-refugees-on-societies-by-haya-madanat/

Maden, T. (2013, May 19). Jordan, syrian refugees and water problem. Today's Zaman. Retrieved from http://www. todayszaman.com/news-315834-jordan-syrian-refugees-and-water-problem.html

REFERENCES

Ministry of Water and Irrigation. (2013, April). Cost of hosting syrian refugees on water sector of Jordan. Amman, Jordan.

Ministry of Water and Irrigation. (2009, February). Water for life: Jordan's water strategy 2008-2022. Amman, Jordan. Retrieved from http://www.irinnews.org/pdf/jordan_national_ water_strategy.pdf

MIT. Groundwater (Mission 2012 : Clean Water). Retrieved from http://web.mit.edu/12.000/www /m2012/finalwebsite/problem/groundwater.shtml#recharge

Namrouqa, H. (2013, October 23). Authorities seek to identify pollution sources at zaatari. Jordan Times. Retrieved from http://jordantimes.com/article/authorities-seek-to-identify-pollution -sources-at-zaatari

Namrouqa, H. (2013, July 2). German grant to address increasing demand for water in northern region — ministry. Jordan Times. Retrieved from http://jordantimes.com/german-grant-to-address-increasing- demand-for-water-in-northern-region----ministry

Nielsen, B. (2011, November 29). [Web log message]. Retrieved from http://designforselfreliance. wordpress.com/2011/11/29/the-ideal-design-of-a-refugee-camp/

Palo, T. (2014, January 5). Draft Environmental Impact Assessment, of the Zaatari camp, Jordan: Towards a green response. Prepared for UNHCR, Amman, Jordan. Retrieved from palo@unhcr.org

Raddad (2005).

REACH Survey. (2013, July). Key findings of reach's survey of wash facilities in Zaatari. UNICEF.

Shepherd, G. (1995). The impact of refugees on the environment and appropriate responses. Humanitarian Exchange Magazine,(4), Retrieved from http://www.odihpn.org/humanitarian-exchange-magazine/issue-04/the-impact-of-refugees-on -the-environment-and-appropriate-responses

Todd, D. K. (1959). Ground Water Hydrology. John Wiley and Sons.

Trading Economics. (2010). Average precipitation in depth (mm per year) in Jordan. Retrieved May 9, 2014, from http://www.tradingeconomics.com/jordan/average-precipitation-in-depth-mm- per-year-wb-data.html

UNEP. (2000, March). Environmental impact of refugees in guinea. Report to the Secretary General on Pre Assessment of Environmental Impact of Refugees in Guinea. Retrieved from http://www.grid. unep.ch/guinea/reports/reportfinal3b.pdf

UNESCO. (2013). Promoting water education in the fourth most water scarce country in the world. Retrieved from http://www.unesco.org/new/en/amman/natural-sciences/news/promoting_water_education_in_the_fourth_most_water_scarce_country_in_the_world/

UNHCR. (2014). Syria refugee regional response. Retrieved from http://data.unhcr.org/ syrianrefugees/country.php?id=107

UNHCR. (2014). Environment. UNHCR News. Retrieved May 9, 2014, from http://www.unhcr.org/pages/49c3646c10a.html

REFERENCES

UNHCR. (2002). Refugee operations and environmental management. A handbook of selected lessons from the field, retrieved from http://www.unhcr.org/406c38bd4.html

UNHCR. (2001, January). Refugees and the environment. Retrieved from http://www.unhcr.org/ cgi-bin/texis/vtx/search?page=search&docid=3b039f3c4&query=Refugees%20and%20the%20environment

Zeitoun, M., Allan, T., Al-Aulaqi, N., Jabarin, A., & Laamrani, H. (2011). Water demand management in yemen and jordan: addressing power and interests.The Geographical Journal, 178(1), 54-66. doi: 10.1111/j.1475-4959.2011.00420.x