Planning and Designing Drinking Water Facilities for Refugee Camps

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Abstract

The Middle East region has been experiencing significant political unrest for the past few years. These conflicts forced thousands of refugees to seek protection in neighbouring countries. The situation in the Syrian Arab Republic escalated in March, 2011 and according to the United Nations High commissioner for Refugees (UNHCR), hundreds of thousands of Syrians were forced to flee to bordering countries. Several camps were developed by the UNHCR and host governments in Lebanon, Turkey, Iraq, and Jordan. As a result of insufficient funding and non-sustainable designs, some of these camps did not meet the standard requirements. This research investigates the possible improvements that can be applied in refugee camps in the region to improve the current situation in the most sustainable and cost effective manner.

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CHAPTER 1
INTRODUCTION

1.1 **BACKGROUND**

The United Nations High Commissioner for Refugees (UNHCR) Handbook on Procedures and Criteria for Determining Refugee Status under the 1951 Convention and the 1967 Protocol relating to the Status of Refugees define a refugee as a person who *"owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion, is outside the country of his nationality, and is unable to or, owing to such fear, is unwilling to avail himself of the protection of that country."* (UNHCR, 1992).

After a violent event, neighbouring countries have to cope with the influx of refugees to their land. Most of the refugees require the basic necessities of survival, thus, these governments have to shelter those in need in what is known as refugee camps. Refugee camps are usually located on marginal lands either for political or safety reasons, these areas usually lack the basic water and health services, therefore a lot of time and resources are required to develop the needed sanitation and water systems.

According to the US committee for refugees and immigrants, the annual world refugee survey showed that at least 33 million people worldwide are currently uprooted from their homes and living as refugees or internally displaced persons (World refugee survey, 2006). In most cases, refugees do not have access to safe drinking water; this calls them to resort to unsafe or contaminated water which can be life-threatening.

There are many examples of poor water and sanitation provisions such as the Rwandan refugee camp in the Democratic Republic of Congo (DRC) in 1994 where 60,000 people died due to water shortage and water related diseases *(*Cronin, 2008). Another example is Dadaab camp in Kenya, known as the largest refugee camp in the world, hosting at least 290,000 refugees, and according to (The guardian, 2011), each refugee gets an average of 13 litres of water per day, which is 35% less than the minimum requirements for survival (15 – 20 litres). This shortage in water provision had a severe impact on the refugees in Dadaab camp, for example, according to the CDC (Centres for disease control and prevention), 75% of mortalities among children are due to malnourishment and water related diseases (CDC, 2011).

These issues usually occur due to lack of funding which is considered to be one of the major problems faced in today's refugee camps. Insufficient funding can have a severe impact on a refugee camp and it imposes a major threat to the health, security and livelihood of refugees, as most vital services such as health, nutrition, sanitation and water provisions will have to scale back or even stop completely, denying the refugees basic needs for survival.

This study aims to find cheap sustainable solutions that suits the local environment conditions of the newly established Zaatari refugee camp in Jordan to manage the water demand in terms of water quality and quantity.

1.2 AIMS AND OBJECTIVES

The aim of the work is to develop a water supply system to provide clean, safe water for refugee camps in the most sustainable and cost-effective way in order to reduce the effect on the host community.

The main objectives of the work are

1- Over-view existing water and sanitation provisions.
2- Assess and analyse the available data on water and sanitation provisions in the case study camp.
3- To assess the quality of water and sanitation services as well as its impacts on the refugees' daily lives.
4- To conduct a water demand/quantity survey
5- To test an experiment to cool water using natural, sustainable heat exchange approach.
6- To prepare a competent assessment of the camp's water supply.
7- To investigate an alternative water supply for the possible future needs.

1.3 STRUCTURE OF THE THESIS

Chapter one: gives a background on today's refugee situation, also mentions the aims and objectives of this research

Chapter two: focuses mainly on the standards followed by relief agencies around the world, the chapter also mentions the previous research done by other researchers in the area of refugee camp design.

Chapter three: mentions the data and the materials used to produce this research. The data include information regarding the case study camp (Zaatari) collected from UNHCR reports and other news agencies. The chapter also explains the hydrology of the host government (Jordan) that is required understand the effect of the camp on the Jordanian water resources. The chapter also mentions the method and steps used to produce the report

Chapter four: shows the water facilities in the case study camp and compares the provisions to the standards while providing alternative methods to solve the problems in the camp.

Chapter five: discusses the solutions that can be applied in the case study camp to improve the facilities and ensures a sustainable, cost-effective design. The chapter also discusses the future plans for the camp.

CHAPTER 2
LITERATURE REVIEW

This chapter will focus primarily on the two most common standards for planning and designing refugee camps, as well as analyse and discuss some of the previous research about this topic.

2.1 DESIGN STANDARDS AND MANUALS

The two most widely used standards that are followed by most relief agencies around the world are the United Nations high commissioner for refugees (UNHCR) standards and the Sphere project standards that set the target or the minimum requirements that must be reached to ensure the needs of the beneficiaries in the camp are met.

UNHCR Handbook for Emergencies serves as a manual for the design of refugee camps around the world and provides guidelines on the protection and humanitarian assistance of refugees. Its primary purpose is to protect the rights and the well-being of refugees and provides a safe environment for the refugees after a disaster (UNHCR, 2007).

The second set of standards is the SPHERE project that sets the minimum requirements in humanitarian assistance to improve the quality of humanitarian response and the accountability of humanitarian actors to their constituents, donors and affected population (Sphere, 1997).

The provision of clean water is of extreme importance in refugee situations, according to the universal declaration of human rights article 25 (1948) that states *"everyone has the right to a standard of living adequate for the health and well-being of himself and his family"*, the provisions of clean water and proper sanitation facilities are important for the refugees to fully exercise their fundamental human rights. Given the vulnerability of the refugees, all refugees should have access to adequate drinking water, as well as proper sanitation facilities including a safe and proper excreta disposal, as well as adequate vector[1] control.

These standards provide assistance, reference and guidance to those in the water and sanitation field who might have to make onsite decisions during emergency situations. The standards also

[1] "Vector is an agent that carries a disease or a pathogen and transmits it to another living organism, Vectors can be human, animal, insects, or micro-organisms.

provides information for prolonged refugee situations in terms of maintenance of water and sanitation provisions to ensure the safety and well-being of the refugees.

The aforementioned standards are considered to be the main guidelines for designing refugee camps water systems and can be summarized in Table 1.

Table 1- Comparison between Sphere standards and UNHCR Standards for water and sanitation Provisions

STANDARD	SPHERE	UNHCR
Minimum water quantity (short term – survival needs)	7 litres/person/day	7 litres/person/day
Minimum water quantity per person per day	15 Litres	20 Litres
Number of People at each water point	250 per tap 300 per hand pump 400 per well	100 per tap 300 per hand pump 300 per well
Maximum distance of water point from households	500 metres	200 metres
Number of latrines	20 persons/latrine	20 persons/latrine
Distance of latrine from households	50 metres	50 metres

The standards present in Table 1 are followed in almost all refugee camps around the world. These standards provide information regarding the minimum requirements for survival in a refugee camp as anything less would deny the refugees their fundamental human rights. However, according to the UNHCR, almost 50% of refugee camps around the world are not able to provide the minimum water requirement for survival, and around 30% of the camps do not provide adequate sanitation facilities nor do they use safe excreta disposal methods.

By investigating Table 1, it can be noted that the UNHCR standards are almost similar to the communally used SPHERE standards if not slightly higher, Coronin (2008) attempted to examine the standards and conduct surveys to document the gaps in water and health provisions where these standards were not being met. Coronin (2008) surveyed more than 250 refugee camps over 3 years (2003 – 2005), and found that 40% of the camps do not provide more than 20 litres per person per day. However, if the SPHERE standards were used instead, the percentage will go down to 32% that accounts to more than 80 refugee camps that cannot provide the minimum water supply of 15 litres per person per day, while over 25% of the camps have an insufficient number of latrines (more than 20 persons/latrine).

Many studies have documented the importance of providing safe drinking water for refugees, however, the debate is still on about whether the quality of the provided water is as important as the quantity. Both UNHCR and SPHERE standards state that the required quantity of (15 – 20 l/p/d) must be reached while considering quality, while other publications state that the quality of provided water is as important as the quantity since it requires less effort and resources to improve water quality and prevent waterborne diseases (Roberts, 2001). Roberts (2001) believed that the water distributed to refugees was usually contaminated by the refugees themselves, primarily due to contact with their hands. Roberts (2001) conducted his experiments in Malawi refugee camp where he gave the refugees improved water containers (with a cover and a spout) that help preventing household and storage contamination and found that there was a 69% reduction in the geometric mean of faecal coliforms levels in household water and 31% less diarrhoeal disease among the groups using the improved buckets.

CHAPTER 3
METHODS AND MATERIALS

3.1 CASE STUDY (ZAATARI CAMP)

The situation in the Syrian Arab Republic escalated in March, 2011 and according to the United Nations High commissioner for Refugees (UNHCR), hundreds of thousands of Syrians were forced to flee to bordering countries. The UNHCR established several camps in the region including the Zaatari camp in Jordan to shelter the refugees.

Jordan is a country with limited water supply where the current water consumption exceeds the renewable supply, putting Jordan in the category of having an absolute water shortage (Hadadin, 2010). This massive influx of refugees has crippled Jordan's water supply since the main water source in the camp is the municipal water supply that is transported by trucks to the camp. This motivated the author to start looking for alternative and more sustainable water supply that will have less impact on the community host to avoid any hostilities or political unrest.

Zaatari camp was established by the UNHCR in July, 2012. The camp was established to host the refugees fleeing from Syria after the political conflicts in the country. The camp is located along the border of Jordan and Syria, about 10 kilometres to the east of Mafraq governorate, 50 kilometres north east of the capital Amman, Plate 1 shows an aerial map of the camp.

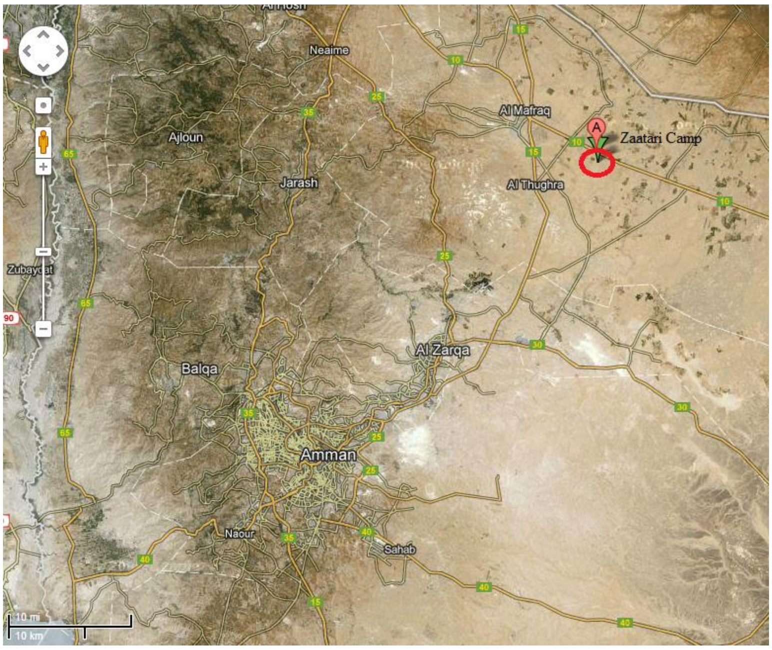

Plate 1 - Zaatari camp Location (Source: google maps

The UNHCR reports published weekly and bi-weekly to report the situation in Zaatari. The data mentioned in the reports included the water and sanitation provisions in the camp, as well as data regarding the problems faced by the UNHCR and its partners while running the camp. From these reports, it can be seen that the camp was designed to host 500 Syrian refugees, however, as of March 2013, the camp was hosting at least 80,000 refugees, which is 160 times more than what it was initially designed for. Table 2 and Table 3 summarise the data collected from UNHCR's weekly reports about the situation in Zaatari camp and the humanitarian response by the UNHCR and other organisations during a 9 month period, starting from the establishment date in July, 2012, until March, 2013.

In order to understand the effect of this refugee camp on the Jordanian water resources, the hydrological review of Jordan's water resources should be discussed, this is done in the next subsection.

Table 2 shows the number of refugees at a given time and the water provisions during the same period

Table 2 - Water provisions in Zaatari camp

Date	***Number of Refugees***	***Water (litre/day)***
23-Jul-12	3,000	150,000 litre/day
08-Aug-12	3,300	150,000 litres/day
16-Aug-12	6,100	375,000 litres/day
23-Aug-12	11,500	400,000 litres/day
30-Aug-12	21,000	600,000 litres/day
06-Sep-12	23,500	600,000 litres/day
13-Sep-12	30,000	600,000 litres/day
27-Sep-12	32,000	1,000,000 litres/day
25-Oct-12	29,145	1,400,000 litres/day
08-Nov-12	48,000	1,400,000 litres/day
07-Dec-12	59,700	1,400,000 litres/day
25-Jan-13	73,000	1,500,000 litres/day
22-Feb-13	79,350	2,350,000 litres/day

Table 3 - Sanitation provisions in Zaatari camp

Date	***Population***	***Latrines***	***Showers***
23-Jul-12	3,000	27	20
8-Aug-12	3,300	80	55
23-Aug-12	11,500	227	200
30-Aug-12	21,000	291	NA
6-Sep-12	23,500	332	NA
8-Nov-12	48,000	450	450
7-Dec-12	59,700	578	576
25-Jan-13	73,000	1,265	1,060
7-Mar-13	79,350	1,366	1266

3.2 SITE SELECTION

SPHERE standards does not mention any specific information regarding site information. In fact, only some vague information regarding the subject were mentioned and it does not provide any guidelines or requirements for selecting a camp site. The information found in the standards indicate that the site should be located away from disease transmitting vectors, allow safe excreta and solid waste disposal, and the selected site should also allow storm water drainage in areas prone to rainfall precipitation. However, UNHCR Standards provide detailed specifications regarding site selection.

According to UNHCR standards, site selection is one of the most important factors to ensure the refugees safety and well-being. However the land for refugee camps is usually decided by the host government and authorities, where in most cases the selected site does not meet the design criteria, in this case, every effort must be made to convince the host authority to change the location.

One of the main factors to be considered in this phase is the availability of resources such as water, food, and other necessities near the site. As well as environmental and climate factors in which the site must be free of environmental health hazards such as swamps, ponds and industrial pollution that can cause major health issues, while climate factors such as flash flooding, and dust prone sites which can cause severe and sometimes fatal respiratory problems.

In terms of water provisions, a water availability is assessed by specialists during the preliminary phase, where the site must not be selected based on assumptions and speculations that water is available or can be made available in that area. According to the UNHCR standards, "*the availability of an adequate amount of water has proved in practice to be the single most important criterion, and the most problematic"* (UNHCR, 1992).

The minimum area for the camp is 30 square metres per person (that includes roads, foot paths, water and sanitation provisions, and other camp facilities) however, even if agricultural activities such as kitchen gardens may not seem as a priority in such situations, it should nevertheless be considered during site planning.

In terms of drainage, the site should be located above flood prone areas, while flat areas must not be considered as a first option for a camp site since it may cause serious drainage problems, however, if no other location can be found, a minimum of 2%-4% slope must be utilized to allow waste water and storm water drainage.

In terms of security, the selected site must be located away from international borders to avoid any hostility, also it must be located at a reasonable distance from other sensitive areas such as military facilities.

In the case study camp (Zaatari camp in Jordan), the location provided by the host government is located around 10 kilometres to the east of Mafraq governorate as mentioned before, which is considered to be the main supply for the camp's resources, and 12 kilometres from the Jordanian - Syrian borders in the eastern Jordanian desert (or Al-Badia desert), although the standards does not specify the minimum required distance from international borders, this location is considered to be satisfactory.

The camp's area according to UNOSAT (United Nations Operational Satellite Application Program) -in 15 November 2012- is 216 hectares which is equal to 21,600,000 m^2. By considering the number of refugees in the camp, this gives around 290 m^2/person. This by far exceeds the minimum area requirements of 30 m^2/person.

However, Water provisions, climate factors, and drainage systems were proven to be unsatisfactory in the camp. Water was provided through trucking which according to (khaleej times, 2012) left Jordanians living in Irbid and Mafraq cities without a single drop of municipal water for at least 2 weeks, Even though both SPHERE standards and UNHCR standards specifically mention that water trucking should only be considered as a last resort. And it should not affect the host community in any way, however, ground water was only considered 3 months after the camp's establishment.

Since SPHERE standards were followed during the camp's planning phase, storm water drainage was not considered at that point, where according to the UNHCR Bi-weekly reports, the camp's area was levelled completely to allow for the establishment of residential tents and other camp's facilities, this did not cause any problems during the summer, however, in last December 2012/Early January 2013, the area experienced heavy rainfall for several days, which flooded the camp completely and lead to the destruction of many residential tents leaving at least 350 refugees without shelter (see Plate 2a, 2b). This incident caused a major riot in the camp which injured around 7 aid workers in the camp.

In the author's opinion, the camp was initially designed as a short-term solution to host the refugees, and was not anticipated to last for a long period of time, however, many refugee camps have turned into thriving cities including a few camps in Jordan such as the Wehdat camp south east of the capital Amman that was established in 1948 to host Palestinian refugees and is now considered a suburb of east Amman. The latter is an example of how temporary refugee situations can turn into a long term or even a permanent situation, therefore, long term planning must always be considered when designing a refugee camp (Fox News, 2013)

Plate 2a ***Plate 2b***

Zaatari camp floods (8, Jan, 2013) – (Source: wordpress, 2013)

In terms of climate conditions, during the period of July – September the camp's area experienced sand storms that caused severe respiratory problems for the refugees in the camp and according to a reporter Aida Alami's twitter page, the sand storm in August 15th 2012 lead to the death of at least 2 toddlers in the camp (see plate 3). This also reflects on the poor site selection. And the poor management of the site since no appropriate measures were taken during that time and only 15% of the camp was equipped with caravans that shelters the refugees from these conditions.

Plate 3 - Sand storm in Zaatari camp (Source: Petra news)

Another problem that was faced in the camp which is also related to site selection was the summer heat and its impact on the water supply, since the camp is located in the middle of the desert, the temperature would sometime rise up to 45 degrees Celsius in the summer (Weatherbase, 2013), this definitely had an impact on the temperature of the water in the camp making it unsuitable for drinking.

Since electricity in refugee situations are never stable or sometimes not even available, the use of standard water coolers would not solve the problem. As a solution, in August 2012, the UNHCR distributed around 5000 clay jars (to 6000 refugees) that would help reducing the water temperature. However, this solution would not only impose unnecessary expenses from the camp's budget, but it would not solve the camp's problem if the influx of refugees would continue.

Due to these circumstances, a more sustainable method to cool down the water was needed, this situation motivated the author to conduct an experiment to cool down the water in a more cost-effective and sustainable manner. As will be seen in section 4.3.4.

3.3 JORDAN: HYDROLOGICAL REVIEW

Internationally, a country that receives less than 1000 cubic metres of water per person per year is considered to be a water scarce country (FAO, 1997). Jordan receives an average of 800 million cubic metres per year in total, while the population in Jordan according to the World Bank is 6.181 million, which means that each person's share of fresh water is less than 150 cubic metres per year, this puts the country on the list of the top 10 water poorest nations in the world.

While the demand of water was around 950 million cubic metres per year in 2008 (Coronin, 2008), this number has increased due to the continuous migration of Iraqis to the kingdom as well as the rapid growth in population which also increased the pressure on the water resources of the country. This shortage is currently managed by rationing where cities are divided into sectors and each sector receives municipal water supply about one day per week (Nortcliff, 2008).

The majority of the fresh water in Jordan comes from surface water (streams, and precipitation flow) and around 30% from groundwater. However, most of the surface water resources in Jordan are mostly from long term flow of rain water. Jordan has three main rivers flowing into its land (River Jordan, Zarqa, and Yarmouk) as well as creeks, wadis, and dam reservoirs which could be of great benefit to the country's water supply, however, these resources contribute very little to the fresh water supply compared to precipitation due to several reasons.

The reasons behind these issues were investigated by many researchers. For example, *Hadadin (2010)* mentioned that the main issue is that the rivers are shared between neighbouring countries, which lead to the creation of diversions and heavy pumping upstream of the river, causing the rivers to shrink significantly. In addition, the buried salt bodies in the area resulted in a significant increase in the water's salinity. Another main factor affecting the quality of the rivers is that the three rivers receive heavy municipal, industrial and agricultural effluent, therefore, the combination of these factors rendered the rivers unsuitable for domestic and irrigation uses.

Another article about the heavy pollution of river Jordan was published in 2010 by *THE GUARDIAN UK* warning visitors from entering the river Jordan –a religious landmark- after several test samples confirmed the presence of high levels of raw sewage (see Plate 4) and chemical pollutants in the river making it unsafe for visitors.

Plate 4 - River Jordan (Source: The guardian, 2010)

Other sources of fresh water in Jordan are wadis, creeks, and dam reservoirs. However, most of them lie downstream from industrial pollutants and waste disposal sites. For example, king Talal dam reservoir receives heavy effluent of chemicals from the factories as well as untreated waste from surrounding waste water treatment plants, thus, reducing the quality of the water below the safety limit. In addition, many other surface water sources in the country located away from urban areas are still unexploited due to financial reasons. This makes rainfall precipitation the most suitable source of fresh water.

In terms of rainfall precipitation, Jordan is categorized as one of the world's ten water poorest countries where the average annual rainfall is around 100mm, a recent study by *Tarawneh, (2002) has* shown that the precipitation varies from zone to zone. By examining Figure 1 that illustrates rainfall precipitation in Jordan, it can be concluded that 80% of the country receives an annual rainfall of more than 100mm, while evaporation ranges from north to south where it is around 2000mm/year in the north and 5000mm/year in the south (JOMDE, 2013). It can also be concluded that the rainfall intensity is at its highest in the west of the country and decreases towards the east where the Zaatari camp is located.

Precipitation drainage in Jordan is governed mainly by topography, water generally flows from the highlands in the west of the country in two flow patterns, first pattern in which water flows from the highlands towards the west through rivers and wadis which then discharge into the dead sea, the second pattern flows through streams towards the east of the country into the desert depressions (Fardous, 2004). However, recent studies indicated that almost 90% of the water from precipitation evaporates leaving only 10% to recharge groundwater.

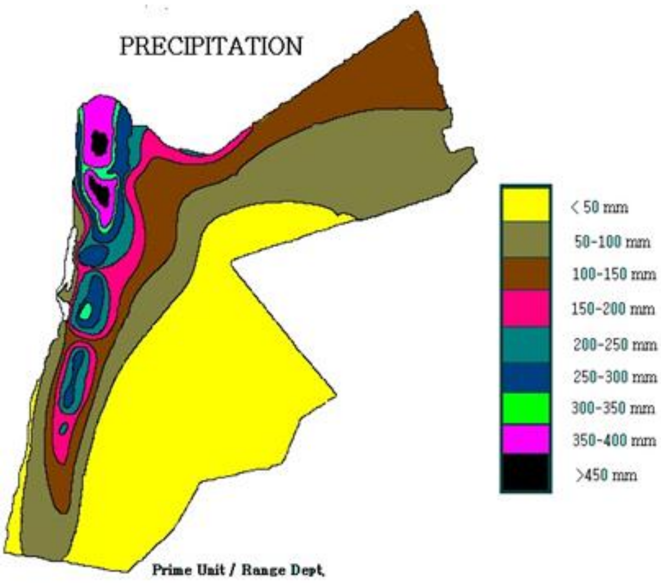

Figure 1 - Rainfall Precipitation in Jordan (Source: Al-Jaloudy, 2001)

In terms of groundwater resources in Jordan, the majority of known reserves are located in the Dead Sea basin, Zarqa basin and Yarmouk basin as shown in Figure 2. However, the groundwater in these basins has been experiencing a major decline in quality, mostly due to over exploitation, where in certain cases such as the Zarqa basin that supplies the capital Amman, the safe yield for pumping was crossed to meet the water demands.

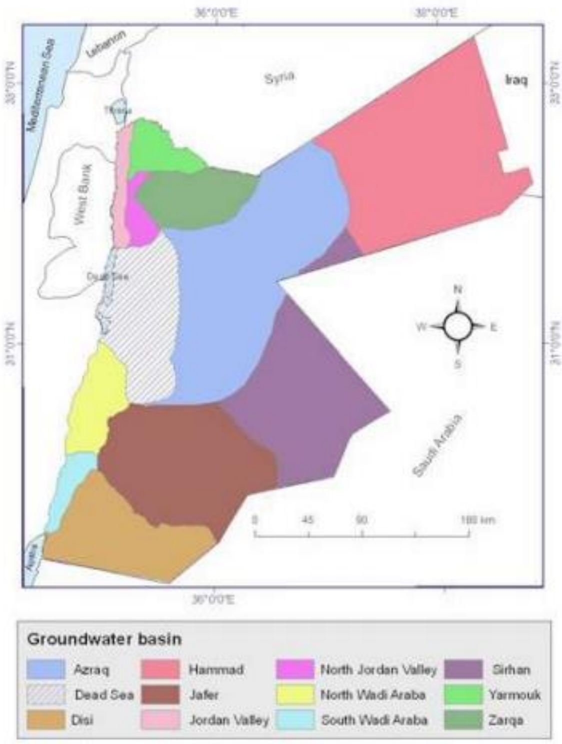

Figure 2 - Groundwater basins in Jordan (Source: Nortcliff, 2008)

3.4 DATA

A quantitative approach was used in this research to get an over view of the current design procedures used in today's refugee camps around the world, this was done by analysing the case study Zaatari camp information by using reports requested from the UNHCR, and comparing them with the main standards that are used for designing refugee camps, SPHERE project standards and UNHCR standards.

UNHCR reports contain information regarding the situation in the UNHCR-Run Zaatari refugee camp in Jordan with a special focus on water and sanitation provisions in the camp such as the quantity of water provided per day and the latrine coverage in the camp. However, a large number of important information are considered to be classified and were not published nor disclosed to the author, the classified information include the camp's water quality, water treatment methods, sanitation facilities and excreta disposal methods. Other technical information were also not disclosed such as borehole pumping tests, and water quality tests that would have aided in the camp's water quality assessment.

In addition to the UNHCR reports, other information regarding the camp's facilities were collected from news reports, interviews, and other information from social networks on the internet from reliable sources such as free-lance reporters and major news corporation channels on YouTube. This type of information aids in comparing the actual situation in the camp to the situation mentioned in the UNHCR reports

In order to assess the camp's water facilities, a background on the host community's water resources was needed. The data were collected from various publications, journals, and websites specialised in weather data. A hydrological review of the host community is of great aid when designing a refugee camp, this is because it must be made sure that the camp's water supply should not affect the host community's water resources.

After the data were gathered and analysed, a standard-based assessment of the camp in terms of site selection, water supply and sanitation provisions, was then carried out to evaluate the camp's facilities and whether or not it was meeting the standards. In such cases where the camp was not meeting the standards, alternative solutions were suggested by the author in the most sustainable and cost effective way as will be seen in chapter 4.

3.5 ZAATARI CAMP'S FACILITIES

While the UNHCR standards provide better living for refugees, the SPHERE project standards are still the most communally-used standards even in UNHCR- Run refugee camps such as the case study camp, Zaatari camp. This Chapter will assess the camp's water supply and water facilities by taking into consideration both SPHERE standards and UNHCR standards as well as the Author's view based on discussions with the camp's operators.

3.5.1 Population

The first step in assessing the water supply for a refugee camp, is to determine the number, age, and sex of the affected population, these numbers are considered to be the core of the analysis and can be used as guidelines while designing service facilities since children and pregnant women will require more attention in terms of latrines and water supply requirements. Table 3 shows the estimated number of refugees in the chosen case study camp (Zaatari Refugee Camp, Jordan).

Table 3- Affected population in Zaatari camp (22-Feb-2013)

	Percentage	***Total***	***Males***	***Females***
Total Population	51.1% males 48.9% females	79,350	40,548	38,802
Children under 18 years of age	53%	42,056	21,448	20,608
Children under 5 years of age	19%	15,077	7,990	7,087
Children 6-23 months old	12%	9,522	4,761	4,761
Pregnant women	2%	15,870	--	15,870

Refugee camps population tend to vary in numbers; some camps may experience a massive influx of refugees in just a few days while others may not experience an increase for months. In the case of Zaatari camp, the number of refugees was increasing non linearly from the establishment date on the 23rd of July until the 27th of January, 2013 (see Figure 3), which made it more difficult for the UNHCR's response team to provide the necessary services. As a result, hundreds of refugees were stranded outside the camp with no food or shelter awaiting registration. However, since the 27th of September 2012, the influx was stabilizing at approximately 1500 refugee per day, as stated in Table 4 which makes it possible to predict the future situation in the camp and prepare water and sanitation facilities accordingly.

According to the UNHCR bi-weekly report dated on March, 8, 2013, the camp was facing a major budget problem since UNHCR Jordan only received 9% of the requested budget of $57 million until June, 2013. This can have a serious impact on the camp facilities, especially on the water and sanitation provisions that are necessary for survival. With the increasing number of refugees in the camp, the situation will definitely deteriorate unless urgent action is taken to find a more sustainable and cost effective ways to keep the camp's facilities functioning to the minimum living standards.

Figure 3 shows the increase in the population of Zaatari camp over an 8 month period (July, 2012 – March. 2013), from which it can be seen that the average number of refugees entering the camp can be easily deduced from the figure which can aid in the design process of the camp.

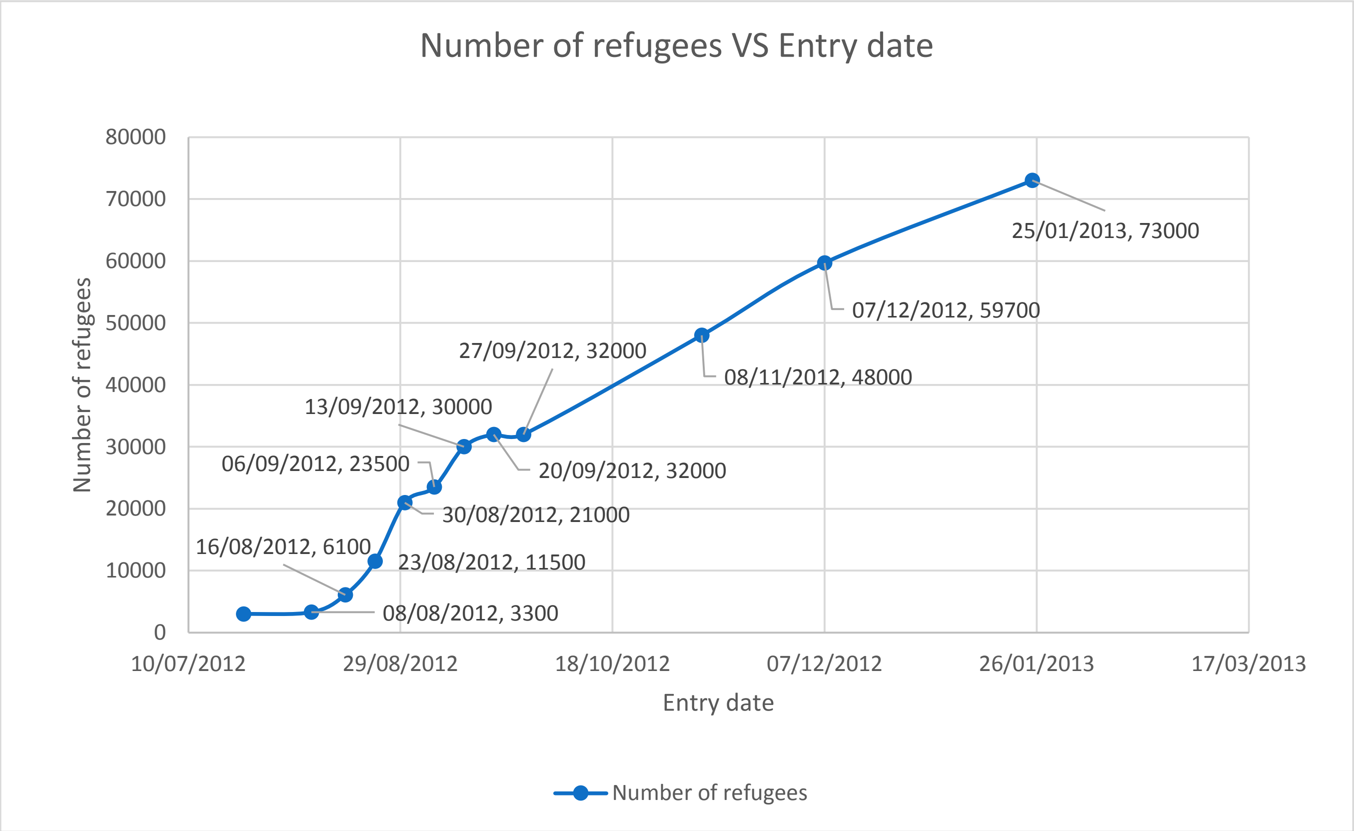

Figure 3 - Number of refugees in zaatari camp VS date of entry

Table 4 - Avarage number of refugees entering Zaatari camp per day

From	To	Average number of refugees per day
23/07/2012	08/08/2012	184
08/08/2012	16/08/2012	763
16/08/2012	23/08/2012	1643
23/08/2012	30/08/2012	3000
30/08/2012	06/09/2012	3358
06/09/2012	13/09/2012	4286
13/09/2012	20/09/2012	4572
20/09/2012	27/09/2012	4572
27/09/2012	08/11/2012	1143
08/11/2012	07/12/2012	2059
07/12/2012	25/01/2013	1490

3.6 HYGIENE PROMOTION

Hygiene promotion plays a major role in the prevention of epidemics in refugee communities, as optimum benefit is only achieved if the community was aware of the relationship between poor hygiene practices, sanitation, contaminated water, and diseases.

According to SPHERE standards, "affected men, women and children of all ages must be aware of key public health risks and are mobilised to adopt measures to prevent the deterioration in hygienic conditions and to use and maintain the facilities provided."(SPHERE 2011).

With this massive number of refugees and the chaotic situation of the camp, it is important to educate people about water-born and sanitation related diseases and their consequences particularly in a place where children form 53% of the population. Since children are more vulnerable to infectious diseases, raising awareness about sanitation and hygiene related diseases is crucial.

As a result, in Zaatari camp, the UNHCR deployed a team of on-site hygiene promoters to conduct daily sessions to educate people on water preservation, personal hygiene and preventive measures to avoid water-borne diseases during sessions conducted every day in the camp. However the hygiene promotion team was unable to reach more than 50% of the refugees in the camp since most refugees consider this issue unimportant as they do not know the severity of the situation.

As a solution, a few arrangements can be adopted to help raise awareness about the matter, either by recruiting and training hygiene promoters from the refugees themselves for a fee. Or by adopting other methods such as: handing out brochures and flyers, making training sessions compulsory to attend, including it in school program, or by making it part of the camp's registration requirements.

CHAPTER 4
ZAATARI CAMP'S WATER SUPPLY

All people must have safe and equitable access to a sufficient quantity of water for drinking, cooking and domestic hygiene. Public water points must be sufficiently close to households to enable use of the minimum water requirement. (SPHERE, 2011)

4.1 WATER RESOURCES

The first step in assessing a camp's water supply is to find an appropriate water source to meet the demands on water by providing a minimum of 15 litres per person per day (SPHERE standards).

"Identify appropriate water sources for the situation, taking into consideration the quantity and environmental impact on the sources" (SPHERE 2011, page 97).

This step should be considered during the site selection phase since most suitable water sources may be located far from the camp which may cause an unnecessary increase in expenditures due to transportation cost. A source is defined as the source that is most reliable (available all year round), capable of providing a sufficient quantity with a reasonable quality, while feasibility must be considered as well. The sustainability and availability of the candidate source must also be taken into account, and whether the new source will need treatment. The effects on the host community must also be measured, including social, political or legal factors concerning the source to avoid any hostility.

In the case of Zaatari camp, the water was taken directly from the host community that is already facing problems with their water supply as mentioned earlier. This process deprived a high number of citizens in northern Governorates from water and the only way for them to get any water was through private water suppliers for at least 5 times its original price.

In terms of location, the camp is located 10 kilometres away from the nearest water source (municipal water supply) in Mafraq city however; the Mafraq water supply cannot meet the camp's demands without over exploiting the source (as per SPHERE standards), which raised the need to a new source of water to supply the camp without over exploiting the host community's water resources. As a result, the Amman-Azraq water source was chosen to compensate for the water deficiency in the Zaatari camp. The Azraq water source is approximately 120 km to the south west of the camp and it is also the main water supply for the capital Amman which places an extraordinary pressure on the source.

Water supplied via trucking is also not the most cost-effective method, since water prices experienced a sudden increase from 4 JD ($5.65 USD) per metre cube to 6 JD ($8.5 USD) after the camp's establishment (GOETHE-Institute, 2013). Table 6 shows the cost of water supplied to the Zaatari camp by trucking.

Table 5 – Estimated trucking supply cost for Zaatari camp

Date	Population	Water supply per day (litres)	Cost per day (USD)	Cost per month (USD)
23-Jul-12	3,000	150,000	1,269	38,070
16-Aug-12	6,100	375,000	3,172.5	95,175
23-Aug-12	11,500	400,000	3,384	101,520
30-Aug-12	21,000	600,000	5,076	152,280
27-Sep-12	32,000	1,000,000	8,460	253,800
25-Oct-12	29,145	1,400,000	11,844	355,320
25-Jan-13	73,000	1,500,000	12,690	380,700
22-Feb-13	79,350	2,350,000	19,881	596,430

Therefore, In December 2012 the Jordanian authorities in collaboration with the UNHCR and its partners, began searching for a new water source within the camp's area, and in February 2013 the digging of two boreholes inside the camp was finished with a capability of supplying 100,000 litres/hour (combined).

Pumping from the boreholes was supposed to start by the end of February, yet, UNHCR report on the 7th of March did not mention any information on whether the pumping started or not, however, these boreholes would only be able to supply 2.4 million litres per day if the pumping continues for 24 hours a day, which would not be sufficient to meet the demands in the camp if the influx of refugees continues, thus, the current supply does not provide enough extra supply for new comers and emergencies.

In order to supply the deficiency in the camp, an alternative water source is required. Since Jordan depends mainly on rainwater as its main water source, the author suggested rainwater harvesting as a supplementary method, however, this method should *NOT* be considered as a main water source for a refugee camp, since it is not continuous nor reliable.

There are many ways that can be used to harvest rainwater, the most effective methods are designed for permanent household solutions that involves high-tech equipment which are not suitable for refugee situations. The most suitable method was developed by a British company called Practical Action that uses a corrugated iron roof system equipped with gutters to harvest rainwater, these gutters lead to a water tank near the building (or the caravan in this case) to store the rainwater (see Plate 5 and Figure 4)

Plate 5 - Example of rainwater harvesting roof system in Rwanda (Source: Practical Action, 2008)

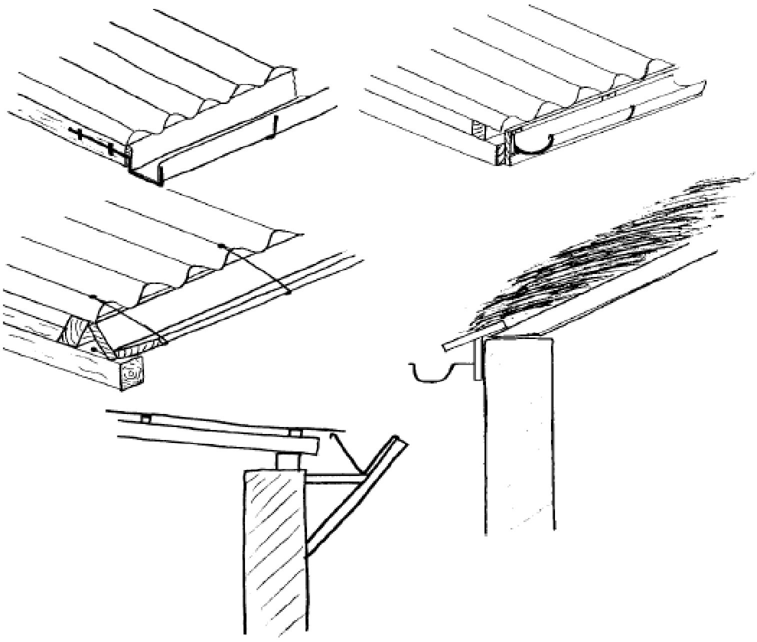

Figure 4 - Sketches of Rainwater harvesting roof system (Source: Practical Action, 2008)

As mentioned before, Zaatari camp is in Mafraq governorate, an area that experiences an average of 155 mm of annual precipitation, although this may sound very little, it can have some contribution to the camp's water supply.

Table 7 below shows the average rainfall precipitation in different areas of the kingdom of Jordan.

Table 6 - Rainfall Precipitation in Jordan (Source: Jordanian ministry of environment)

Station	Elevation (m)	Annual Precipitation (mm)
Amman	772	272
Aqaba	51	31
Azraq	521	60
Irbid	66	473
Maan	1069	42
Madaba	785	352
Mafraq	353	155
Ar Ruwayshid	672	72

The two main factors that determines the amount of harvested rainfall using this system are average annual precipitation, and area of roofing system, see equation below:

$$rainwater\ supply\ per\ year = Area\ of\ Roofing\ \times Annual\ precipitation\ \times runoff\ coefficient$$[2]

There are at least 7,500 caravans in Zaatari camp (as of January 25th, 2013), the UNHCR is planning to phase out the use of tents and transfer all refugees into caravan units, If this system is applied in Zaatari camp, a standard caravan of 15m^2 will supply about 2092 litres per year (excluding evaporation, percolation, etc.). By assuming that the camp's total planned number of caravans is 25,000, the total amount of rainwater that can be harvested is approximately 52 million litres per year. Although this amount may seem very little compared to the demand in the camp, it can still contribute to the water deficiency in terms of extra supply for infants, pregnant women, new comers and other communal needs, as well as reducing the strain on the host community's water resources.

By examining table 7, it is noticed that the camp is located in an area with one of the least amount of rainfall precipitation in the country, which may help in protecting the refugees from

[2] Runoff coefficient for corrugated iron is assumed to be 0.9

extreme climate conditions. Therefore, rainwater harvesting may not seem the most sustainable method in terms of cost, however, it can be more suitable in other areas, for example, if the camp was located in Irbid (north west of the kingdom) with an annual precipitation average of 473mm, the amount of harvested water would reach approximately 159 million litres per year, which can supply Zaatari camp for a minimum of 2 months by using corrugated roof rain water harvesting system.

Even though this method may seem sustainable, there is one disadvantage, the cost of the corrugated roof is approximately $60 USD per square metre, excluding the gutters cost, which may not seem cost-effective. On the other hand, since the caravans in Zaatari have already been equipped with a roofing system of similar materials, therefore, only some minor adjustments are required to deploy this method.

4.2 WATER QUANTITY

According to standards, the required quantity of water may differ according to climate, sanitation provisions, people's customs, like cultural and religious habits, food they cook, clothes they wear. Also, a person's water consumption generally increases the closer the water source is to the person, Since water consumption in Zaatari camp is limited, each person was getting around 20 litres of water per day for drinking, domestic and hygienic uses, which matches exactly the requirements in SPHERE standards for the basic survival water needs (See Table 4).

Table 4 - Minimum water quantity for basic survival needs (Sphere 2011)

Survival needs:	***Demand (L/p/day)***	***Conditions***
water intake (drinking and food)	2.5 - 3	Depends on the climate and individual physiology
basic hygiene practices	2 - 6	depends on social and cultural norms
Basic cooking needs	3 - 6	Depends on food type and social and cultural norms
TOTAL basic water needs	7 - 15	

The new boreholes may not be sufficient to meet the SPHERE requirements if the influx of refugees continues since it is only enough to supply 80,000 (currently 79,350) refugees at 30 litres/person/day, excluding reserves, leaks, spillage and communal supply (clinics, schools, and other emergencies). However, it does relieve the pressure on the host community's water resources, which will be discussed later.

The water in the camp was supplied by private contractors via trucking throughout the period of 8 months (July, 2012 – March, 2013). However, this method placed a remarkable amount of pressure on the water resources in Jordan, which –inevitably- had a heavy impact on the surrounding community.

Table 8 shows the amount of water provided to the camp with the respective date, and method of transportation.

Table 7 - Water provisions in Zaatari camp

Date	Population	Minimum water (l/p/d)	Water provided (l/p/day)	Q (litre/day)	Q (m3/day)	Source
23-Jul-12	3,000	15	50	150,000	150	trucking
08-Aug-12	3,300	15	45.4	150,000	150	trucking
16-Aug-12	6,100	15	61.4	375,000	375	trucking
23-Aug-12	11,500	15	34.7	400,000	400	trucking
30-Aug-12	21,000	15	28.5	600,000	600	trucking
06-Sep-12	23,500	15	25.5	600,000	600	trucking
13-Sep-12	30,000	15	20	600,000	600	trucking
27-Sep-12	32,000	15	31.25	1,000,000	1000	trucking
25-Oct-12	29,145	15	34.3	1,000,000	1000	trucking
08-Nov-12	48,000	15	20.8	1,000,000	1000	trucking
07-Dec-12	59,700	15	20.1	1,200,000[3]	1200	trucking
25-Jan-13	73,000	15	20.5	1,500,000[1]	1500	trucking
22-Feb-13	79,350	15	29.6	2,350,000	2350	trucking

[3] The numbers were estimated by the author (excluding spillage, leaks and emergency supply) in order to meet the standards as they were not disclosed by the UNHCR,

The trucking method that was used to supply the camp with fresh water did not only affect the country’s water resources, it also affected the host community. When the water rationing system was implemented in 1998, most Jordanians started to rely mainly on private water suppliers (known as the water black market in Jordan) to supply them with potable water. However, when the Zaatari camp was established in 2012, the price of water was increased due to unavailability, and long queues were formed by water trucks near the water outlets surrounding the camp.

By inspecting Table 8, it can be determined that the camp’s water supply does not provide enough spare water for emergency cases, nor for a communal supply (clinics and schools). It is also worth noting that the camp’s water supply does not consider pregnant women and infants that make up around 20% of the camp’s total population who require much more water than the supplied minimum amount. However, it was not mentioned in any of the standards therefore, no actions were taken regarding the matter in the camp.

The table also shows that the amount of water provided by the boreholes would have only been sufficient to the camp if the influx of refugees would have stopped by the end of February, 2013, since the boreholes can only provide 2.4 million litres per day (assuming the pumps will function 24 hours/day) which would not be enough to meet the minimum requirements and would not allow for a reserve supply, as a result, in that same month, the UNHCR and its partners worked on improving the water supply in Mafraq governorate to produce a further 2.4 million litres/day than what it was producing before. This action would not only meet the SPHERE requirements by not affecting the host community, but it would also benefit both the surrounding community and the refugees since the deficiency of the water supply in the camp will have to be provided via trucking from the abovementioned source.

As a suggested solution by the author, in order to minimise the impact on the host community, it is possible for the UNHCR to procure water trucks that would supply the camp continuously throughout the day. The number of required water trucks could be determined by considering the information provided in table 5, assuming the capacity of a water truck is 30 cubic metres, and the distance from the camp to the nearest water source to be 10 - 45 kilometres away (Mafraq and Azraq reservoirs), see table 9:

Table 8 - Water truck requirements in Zaatari camp

Date	Population	Truck capacity (m3)	Q (m3/day)	Number of trips required/day	Number of trucks required (factored)
23-Jul-2012	3,000	30	150	5	3
08-aug-2012	3,300	30	150	5	3
16-Aug-2012	6,100	30	375	13	6
23-Aug-2012	11,500	30	400	14	6
30-Aug-2012	21,000	30	600	20	8
06-Sep-2012	23,500	30	600	20	9
13-Sep-2012	30,000	30	600	20	9
27-Sep-2012	32,000	30	1,000	34	14
25-Oct-2012	29,145	30	1,000	34	14
08-Nov-2012	48,000	30	1,000	34	14
07-Dec-2012	59,700	30	1,200	40	16
25-Jan-2013	73,000	30	1,500	50	20
22-Feb-2012	79,350	30	2,350	79	30

4.3 WATER QUALITY

Controlling water quality is crucial to ensure the safety and well-being of the refugees from water-borne diseases which are considered to be the most prominent epidemic that may occur in a refugee camp. According to the world health organization, water related diseases account for 1.8 million deaths annually.

4.3.1 Water Quality in refugee camps

UNHCR stated "Assume all water available during an emergency is contaminated. Immediate action must be taken to stop further pollution and reduce contamination" (UNHCR, 1992).

The main concerns when treating contaminated water are bacteria and micro-organisms, as they are considered to be the major cause of water borne-diseases. Other aspects that must be considered when treating water are: suspended matter, dissolved matter, and the water physical properties (colour, taste odour).

It is worth noting that the treatment process depends on the water source, while some sources may require heavy chemical treatment, other sources may not require any treatment at all, for example, in Zaatari camp, water treatment was not considered during the first 8 months (July

– February) since the water was taken directly from the municipal water supply and did not require further treatment. However, in March 2013, when the boreholes were finished and the camp was depending on groundwater as its main water supply, water treatment became necessary.

There are different ways to treat water in refugee camps, depending on the quality of water. The simplest most widely used methods are chlorination, boiling, and purification tablets, yet it is impractical to use such methods for large scale water treatment, since most of these methods are mostly used for disinfection and can contribute very little to treating turbid or cloudy water, especially in emergency cases, as the benefiting population are usually more prone to diseases and health problems.

Even though groundwater is generally assumed to be safe, ground water might pick up dissolved substances on its way up through the ground layers, these substances are usually soluble such as dissolved minerals. Sometimes it might pick up organic waste which can be very dangerous to humans, therefore, the water must be tested regularly if not daily to ensure the health and safety of the refugee population.

4.3.2 Water purification methods in emergency cases

The safest, most common method to treat water in emergency cases is by using mobile water treatment units (Plate - 6), these units can be used to treat both surface water and ground water and is commonly used in the army. However, these units require electricity that may not be stable or even available in emergency situations. Thus, a more sustainable treatment method is required

Plate 6 - mobile water treatment unit (LennTech, 2011)

There are many sustainable water treatment solutions that have been used in emergency situations around the world, most of which are inexpensive, easy to use, and do not require any source of energy which makes them more suitable for refugee camps than the standard mobile treatment unit. Listed below are some of water treatment methods that can be used in Zaatari camp.

Life straw

The life straw is a device shaped like a cigar (see Plate 7) designed to be used in harsh conditions. The device purifies water, reduces turbidity, and removes 99% of pathogens such as cholera, typhoid and other diarrheal diseases without the use of chemicals.

Plate 7 - Life Straw

The Life straw is an ingenious, durable and inexpensive solution, that can be used for any type of water, however, it only provides a solution for drinking water, and does not fully solve the over-all water quality issues.

Ceramic water filters

Ceramic water filters are an effective inexpensive water treatment solution. The device does not use any chemicals and does not require any source of energy, as it depends mainly on the small pores in the ceramic to filter out suspended materials, pathogens and bacteria, and uses gravity to speed up the filtration process. (See Figure 5)

Plate 8 - Ceramic water filter

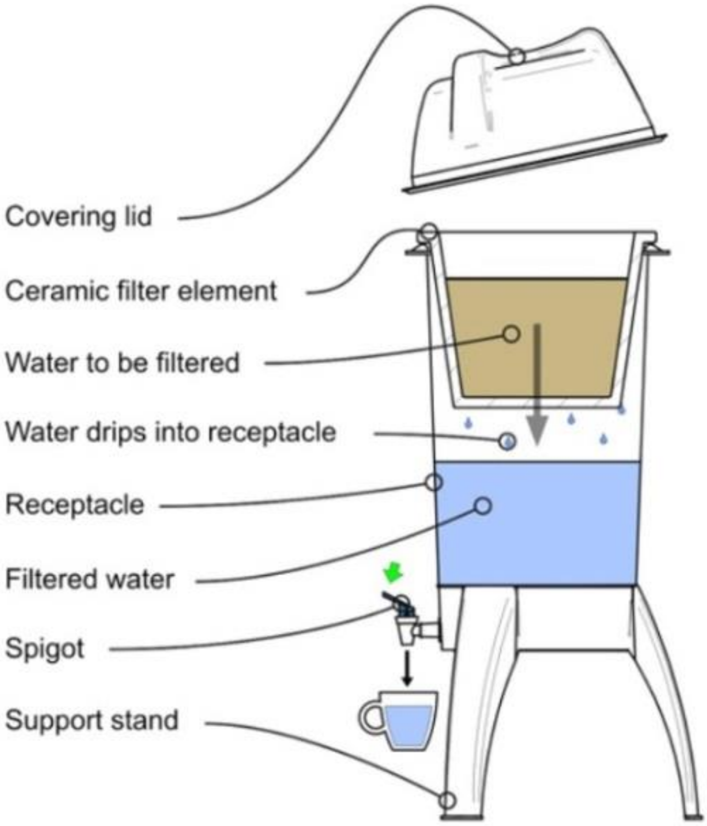

Figure 5 - Ceramic water filter

This device was first used in Cambodia and resulted in 50% reduction in diarrheal diseases. However, there is only one disadvantage, since it depends on gravity, it can only provide 1-3 litres of clean water per hour, which may not be sufficient in some cases.

4.3.2.1.1 Water purifying bicycles

The water treatment system uses the kinetic energy from the bicycle to purify water. This simple yet innovative design can produce 5 litres of clean water per minute. The device was specially designed for rural or disaster areas where electricity is not available.

Plate 9 - Water purifying bicycle

The only action required from the user is to pedal, as the device will utilize the kinetic energy from the bicycle to activate the pumps mounted on the back of the bicycle, the water will be filtered with low pressure through special membranes, to produce safe, clean water.

Life Sack

Life sack is a sack that is embedded with filters to filter out impurities and suspended matter, and uses solar water disinfection by utilising UVA radiation to kill bacteria and other micro-organisms, the sack is also embedded with filters to filter out impurities and suspended matter. The sack can also be used as a food container, where in emergency cases, food can be distributed in life sacks, and can be used as a water treatment system later on.

Plate 10 - Life sack

Pure Water bottle

A bottle that is equipped with 4 filters to filter out any impurities and uses UV rays to kill bacteria and other dangerous micro-organisms, the bottle is capable of producing 0.7 litres of clean water in under 2 minutes.

Plate 11 - Pure water bottle

The modified bottle is not only capable of purifying water, it is also equipped with a freeze stick system where the purified water flows through the stick to produce clean cold water.

Solar Ball

The solar ball simple design uses the heat of the sun to purify water. The ball uses simple evaporation to separate water from contaminates. However, the amount of water the ball provides is limited to only 3 litres/day.

Plate 12 - Solar ball

Bio-Sand Filter

The bio-sand filter was adopted from the communally used slow sand filter, the container is usually made from concrete or plastic with a capacity of 60 – 80 litres per day. The filter consists of two main layers, especially sand and gravel. The layers remove suspended matter from the water while a layer of bacteria that is formed on the top of the sand layer eats pathogens and other harmful micro-organisms. Figure-6 explains the treatment process.

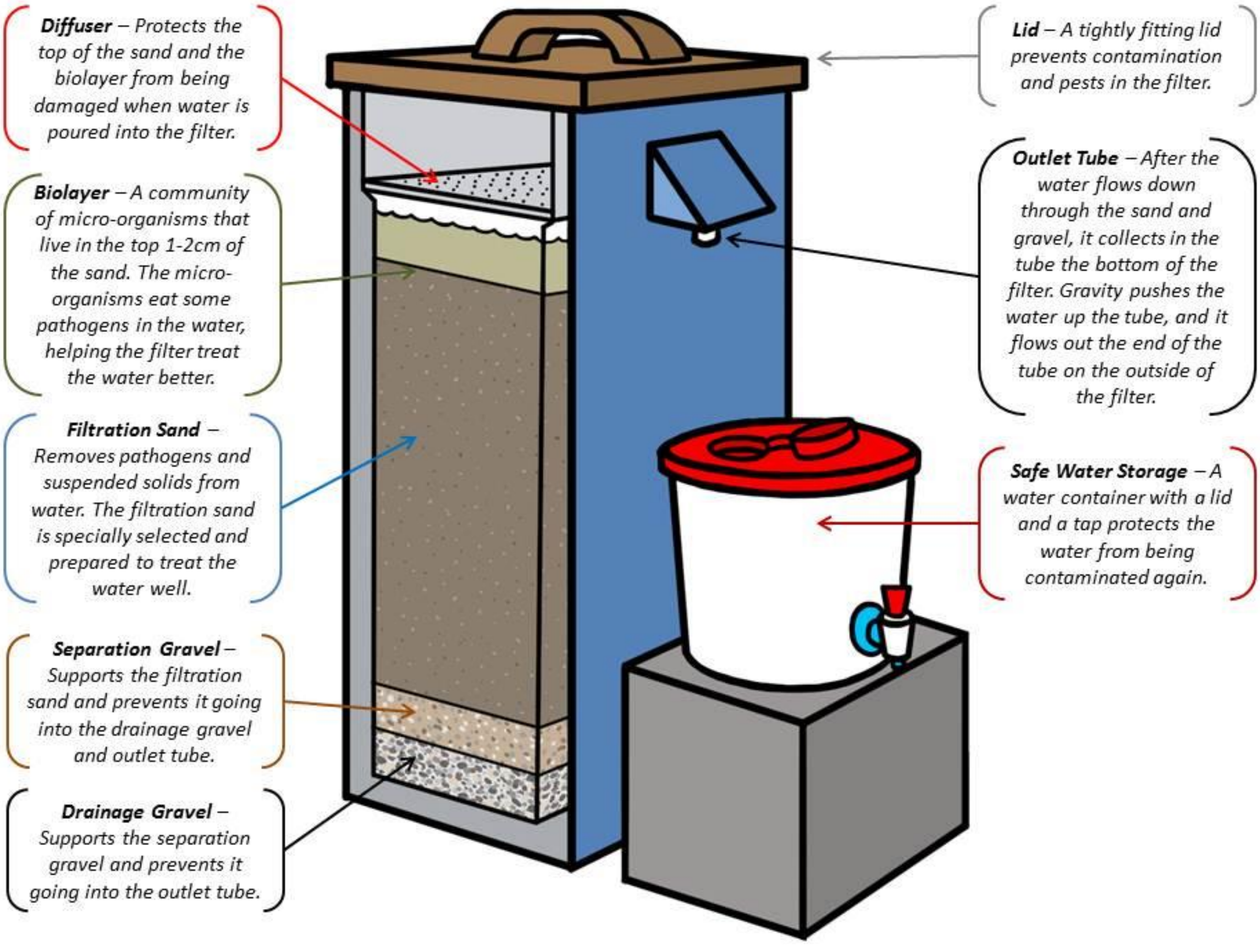

Figure 6 - Bio-sand filter (Source: CAWST)

4.3.3 Water quality in Zaatari camp

The UNHCR and its partners refused to disclose any information regarding the groundwater quality in Zaatari camp; therefore, an accurate water treatment method could not be determined. However, the above mentioned methods were designed to be used in the harshest conditions, and can be used for any water, therefore it would be more than suitable for the water in Zaatari camp. On the other hand, since the main water supply in Zaatari camp comes from groundwater which can be considered relatively clean, the simplest, most inexpensive method can be applied to treat the water in the camp.

In order to determine the most sustainable water treatment method to be used in the camp, the cost and durability of each method must be taken into account. The over-all cost per year can be determined by considering the number of refugees, the cost of each method, as well as its capacity and durability.

Table 9 - Water treatment methods with their respective cost, durability and capacity

Item	Price (USD)[4]	durability (months)	Capacity
Life Straw	25	12 +	1 person
Ceramic water filter	8	12 +	1 Family of 5
water purifying bicycle	3,000	12 +	50 families of 5
Life sack	40	6 to 12	1 person
Pure water bottle	12	4	1 person
Solar ball	20	12 +	1 person
Bio-sand filter	90	12 +	1 family of 5

Even though some methods such as the water purifying bicycle may seem expensive, the capacity of that method must also be considered. When the Life straw and the water purifying bicycle are compared, it can be noticed that the ratio of cost per person is far less than the life straw (see Figure 7)

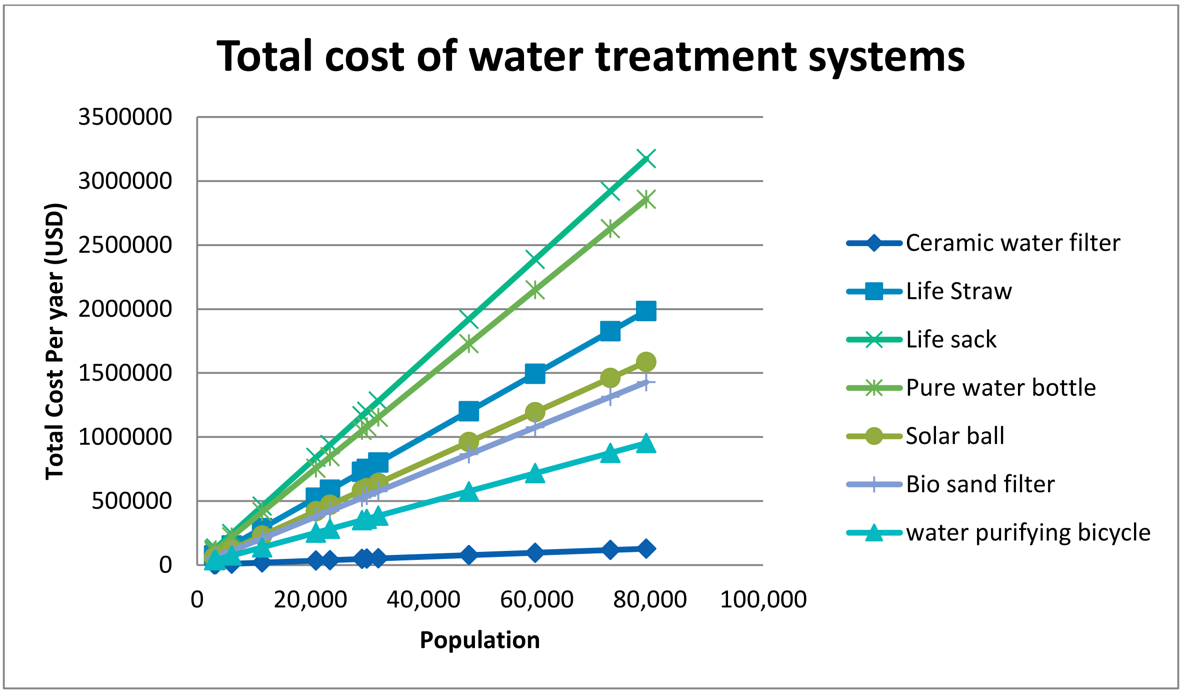

Figure 7 - Comparison of water treatment systems in terms of cost

However, by examining Figure 7, it can be observed that the personal water treatment methods (life sack, life straw, pure water bottle, and solar ball) are far more expensive than the other methods when compared in terms of cost per person. Nevertheless, methods like life straw or

[4] Prices were taken from each method's respective manufacturer's website

solar ball can be much more effective in treating/disinfecting water than others, therefore, depending on the quality of the water in the camp, and the available budget, a proper method can be selected.

In terms of water temperature, an experiment was conducted (subsection 4.3.4) to cool water using natural and sustainable heat exchange approach to minimise the dependence on electricity that may not be stable or even available in emergency situations.

4.3.4 Water cooling Experiment

The experiment was conducted by the author in Amman, Jordan about 50 kilometres south west of Zaatari camp, the aim of the experiment is to determine whether it is practical to cool down the water temperature in a more sustainable and less energy consuming manner, by using natural materials such as porous canvas bags.

Materials:

3 Standard 20 litre water cooler bottles (Plate 13b)
Porous canvas bags (Standard Rice bags) as a cover for the bottles. (Plate 13a)
Digital Thermometer (Plate 13c)

Plate 13a – Canvas Bags

Plate 13b – Water Bottle

Plate 13c – Digital Thermometre

Procedure:

a canvas bag is dipped in water for 1 to 2 minutes (until soaked completely), a water bottle is then covered with the canvas bag and exposed to direct sun light, the evaporation process of the water in the canvas bag will reduce the temperature of the water bottle.

In order to measure the difference in temperature, and to determine the efficiency of the canvas cover, 3 bottles were used in this experiment: (see Plate 14)

Bottle 1: Without cover.

Bottle 2: 1 cm wet cover.

Bottle 3: 1 cm wet cover + 1 cm dry cover.

Plate 14 - Experiment methodology

The experiment started on Sunday 28/10/2012 at 22:00 and continued for 24 hours, the Weather forecast for that day was: 18^0 - 24^0 with 55% Humidity.

Results:

As predicted, the bottle covered in the thick wet canvas bag was not affected by the increase of temperature, instead, the water temperature in the bottle kept decreasing as the outside weather temperature increased.

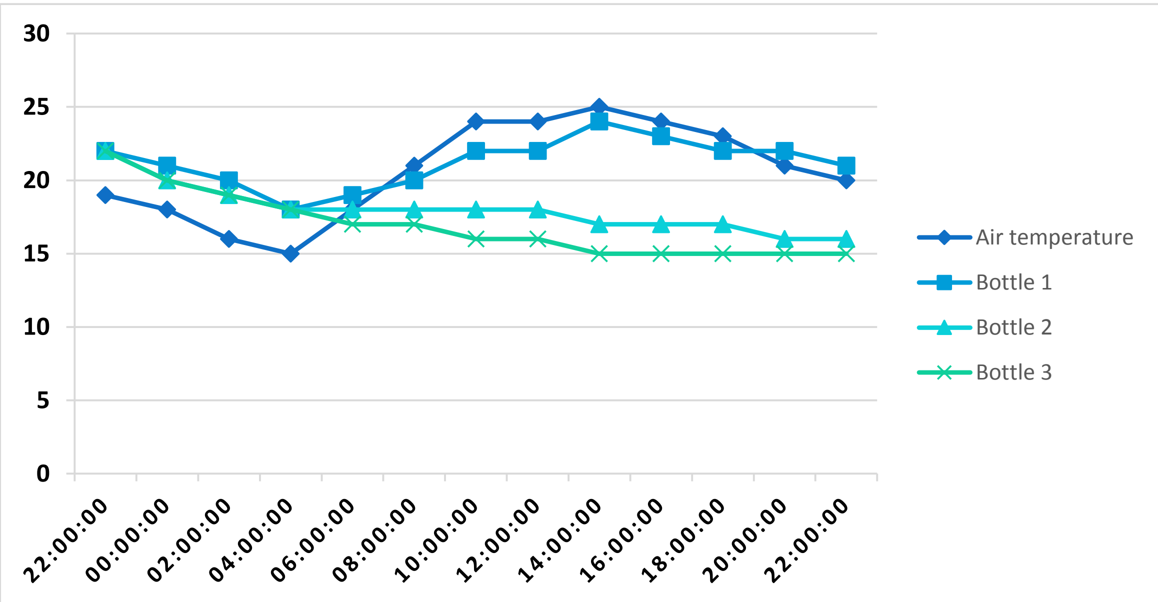

Figure 8 - Difference in temperature of water bottles

Compared with electrical cooling:

The approximate amount of energy required to cool down the same amount of water to the same temperature can be determined by using the equation below:

$$Q = m \times C_v \times \Delta T$$

Where

$Q: energy\ Required\ in\ kJ$

$m: mass\ of\ water$

$C_v: specific\ heat\ capacity\ (approximately = 4.1)$ (

$\Delta T: the\ difference\ in\ temperature$

By simple substitution, the energy required to cool down the same water bottle was found to be around 1000 kilo Joules per 20 litres which can be saved using this natural cooling method.

The camp's total requirements of water (March 2013) is 2.5 million litres per day, the energy required to cool down that amount of water is 125×10^6 kJ. Therefore, the total cost of electricity that would be used can be determined by using Table 5, which is approximately[5] 2,252 USD per day

Table 10 - Jordan Electricity Tariffs (Dynamic energy and water solutions, 2012)[6]

Residential		Non-Residential			
Slab in kWh	Tarrif in Fils/kWh	Type	Peak load in JD/kWh/month	Day Tarrif in fils/kWh	Night Tarrif in Fils/kWh
1 to 160	32	Broadcast and TV	2.98	86	86
161 to 300	71	Commercial	2.98	86	86
301 to 500	85	Small Industries	2.98	49	49
Over 500	113	Medium Industries	3.79	46	36
--	--	Agriculture	3.79	46	36
--	--	Hotels	3.79	81	70
--	--	Mixed	3.79	73	73

[5] Cost was determined by using Agriculture Tarrif (46 Fils/kWh)
[6] 1 Jordanian Dinar = 1000 Fils = 1.4 USD
1 kJ = 0.00027777778 kWh

4.4 WATER SUPPLY SYSTEM (STORAGE AND DISTRIBUTION NETWORK)

A water supply system can be divided into several parts: Intakes, outlets, service points, treatment and storage facilities, and a pipeline network. These parts play a major role in the camp, since without them, life in the camp would perish.

These facilities must always be monitored and regularly checked for leaks or any other contaminates. For example, one leaky pipe may incorporate pollution, since all parts of the system are connected, it may cause a serious disease outbreak in the camp.

The UNHCR reports did not provide any information regarding distribution network in the camp, the water is stored in standard water tanks, and the tanks are connected to water taps distributed around the camp. (See Plate 15)

There wasn't any reported problem regarding the water in Zaatari other than the lack of water during the night as the tanks are only filled once in the morning, which causes major queuing in front of water taps and other water facilities. This causes most children to skip school in order to help their mothers collect water.

Plate 15 - Water tap in Zaatari camp (source: Unicef)

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4.5 SANITATION FACILITIES AND EXCRETA DISPOSAL

Excreta may cause major health problems if disposed inadequately; it may also accelerate the transmission of dangerous diseases such as malaria, yellow fever and diarrhoeal diseases. In these situations, disease transmission may occur in a direct way through direct exposure or in an indirect way through vector and/or polluted groundwater.

SPHERE standards specify that the environment in any refugee camp must be completely free of human faeces contamination particularly around living areas, water sources, communal kitchens and dining areas. While containment measures for lavatories must be considered such as trenches and soak away pits, these containments must be located at least 30 metres away from ground water sources and the bottom of any trench or pit is at least 1.5 metres above the water table.

In the case of Zaatari camp, trucking is used as a method for excreta disposal where the waste is evacuated and sent to the municipal waste water area. While this method may not appear to be the most sustainable in terms of cost, however, it is meeting the requirements for both SPHERE and UNHCR standards.

As an alternative, the Ecological sanitation toilet in Figure 10 (also known as EcoSan) that was specially designed to be used in emergency situations can be used in Zaatari camp.

Figure 9 - EcoSan toilet

The EcoSan toilets carry urine and wash water to a separate pot placed away from the toilet (usually outside the caravan) and can be used for watering kitchen gardens, while solid waste is held in a pot under the toilet that has a concrete base to prevent groundwater contamination, after usage, ash is poured into the pot to prevent insect breeding, and the drop hole is then closed with a lid. The toilet can be used for up to 9 months by a family of 5, afterwards the solid waste pot is closed with a cement layer and left for at least 6 months so it can then be used as compost for farms.

A recent study by Katherine Kinstedt (2012), a masters student in the technical university of Hamburg Germany improved the design of EcoSan toilet by making it more environmental and user friendly (by making it possible to control odours as well as providing initial treatment of excreta). The improved design cost is estimated to be $70 for 1 toilet with a monthly cost of $0.8 per user.

If this solution was to be used in Zaatari camp, assuming that the number of refugees is 80,000, the total cost would be around $1.12 million to procure the EcoSan toilets, with a monthly cost of $64,000 in total. However, since the UNHCR did not disclose any information regarding the cost of latrines in Zaatari camp, it is not possible to determine whether this solution is more cost effective than the current method used in the camp. However, this solution is unquestionably more sustainable and environmental friendly.

In terms of sanitation provisions, the current latrines used in Zaatari camp today are the standard septic tank latrines where a septic tank is built under or near the latrine to collect the excreta which is then evacuated by trucks and taken into the municipal waste disposal area, the current provisions in Zaatari camp are mentioned in table 11.

By examining Table 11, it is obvious that the camp's facilities do not meet neither SPHERE nor UNHCR standards, as the number of users per latrine is much higher than what is set by the standards (20 users per latrine) and this is possibly due to the continuing influx of refugees to the camp. However, if EcoSan system was used, with the predictable/steady influx of refugees, this problem can be easily avoided.

In terms of showers provisions, both SPHERE and UNHCR standards failed to specify the amount of showers needed per person, however, considering the severity of the weather conditions in Zaatari camp, 70 persons per shower will be assumed. Which almost meets the shower provisions in Zaatari camp.

Table 11 - Sanitation provisions in Zaatari camp

Date	***Population***	***Latrines***	***person/latrine***	***Showers***	***person/Shower***
23-Jul-12	3,000	27	112	20	150
08-Aug-12	3,300	80	42	55	60
23-Aug-12	11,500	227	51	200	58
30-Aug-12	21,000	291	73	NA	0
06-Sep-12	23,500	332	71	NA	0
08-Nov-12	48,000	450	107	450	107
07-Dec-12	59,700	578	104	576	104
25-Jan-13	73,000	1,265	58	1,060	69
07-Mar-13	79,350	1,366	59	1266	63

CHAPTER 5
DISCUSSION AND CONCLUSIONS

The aim of this work was to develop a sustainable, cost effective water and sanitation facilities for a refugee camp while monitoring and reducing the impact on the host community as much as possible. This was achieved by conducting a standards-based assessment of the UNHCR's humanitarian response in Zaatari camp. Table 12 summarises the current methods and the suggested methods that can be used to improve the situation in Zaatari camp.

Table 12 - Summary of the research findings

	Current method	***Suggested method***
Hygiene Promotion	- Team of promoters	- Include it on school programs - Include it in camp's registration requirements - Hand out flyers and brochures
Water Sources	- Boreholes - Water trucking	- Rainwater harvesting as a supplementary method. - UNHCR private water trucks.
Water Demand	- 15 litres per day with no extra supply for newcomers and emergencies.	- Rainwater harvesting to supply the deficiency in the camp. - Improved water trucking method.
Water treatment	- Unknown	- Ceramic water filters (depending on the quality of water)
Sanitation	- Standard pit latrines	- Improved EcoSan Toilets

By examining Table 12, it can be noticed that there is no suggestion regarding the site selection. This is because both standards (SPHERE and UNHCR standards) prohibit the relocation of a refugee camp due to excessive cost of such process and its impact on the refugees and the host community.

The site selection is a controversial topic between planners, researchers, and others involved in the design of refugee camps, this because the parameters required to develop a sustainable design of a refugee camp are almost impossible to be present in one location. For example, for a refugee camp to be situated near a water source such as a river or lake, this would be at the cost of another parameter which in this case is vector control. Since these areas are considered to be breeding sites for insects and harmful vectors, additional efforts will have to be made to protect the refugees from such problems.

In terms of water sources, the current available water in the camp is considered to be satisfactory since it meets the requirements for both standards, except for the fact that it does not provide an extra supply for emergency cases. Considering the scarcity of water in the country, it is very unlikely to find a new water source in Jordan without conducting an extensive research in that area. The most effective method that could be used to avoid affecting the host community is to procure a special UNHCR water trucks that can supply the camp with water without affecting the host community in the most cost-effective manner. Another alternative is to import water from neighbouring countries, however, the standards plainly state that water is only to be important in extreme situations due to the high cost of water transportation (piping or trucking).

As a suggested solution by the author, in order to minimise the impact on the host community, it is possible for the UNHCR to procure water trucks that would supply the camp continuously throughout the day. The number of required water trucks was determined to be 30 trucks that would supply the camp with fresh water continuously. This method is cost-effective and helps reducing the effect of Zaatari camp on the host community.

Another solution in this case would be rainwater harvesting. If the camp was to be moved to another location (Irbid Governorate), rainwater harvesting can have a much more effective contribution to the camp's water supply which can supply the camp for at least 60 days per year (159 million litres) which can save around $160,000 USD[7].

The new location also lies in the way of the streams that flow eastwards, as well as streams in valleys and creeks that flow towards the Dead Sea that are recharged by the relatively high rainfall precipitation in that area; these sources can be utilised to contribute to the camp's water supply. The water collected from these sources can then be tested and a treatment method can then be selected to treat the water, thus, making it safe for drinking. In addition, groundwater in the suggested area is heavily recharged due to the relatively high amount of annual rainwater precipitation, which makes it more sustainable when compared to the less recharged

[7] The price of 1 cubic metre of water is considered to be 6 JD ($8.5 USD)

groundwater in the current location of the camp. It is also worth noting that water trucking can also be used in this location (from nearby Irbid city) to supply the deficiency that may occur in the camp's water supply (drought, pumping malfunction, etc.).

In terms of sanitation, the facilities currently available in the camp are satisfactory in terms of availability and efficiency, however, the current waste disposal method (trucking) imposes an unnecessary cost to the camp, and is not considered to be environmental friendly since it is disposed in the rivers without treatment. The suggested location can play a major part in wastewater treatment, by using lagoon treatment system, however, since the camp's location is not likely to be changed, the most sustainable method in this case would be the aforementioned "improved EcoSan system" that is relatively cost-effective (when compared to normal latrines) and does not require continuous waste evacuation.

In terms of water quality and water distribution systems, there were no issues found in the camp except for the water temperature during the summer that causes the water to heat up making it unsuitable for drinking or other uses. To solve this problem the author conducted an experiment to cool down the water temperature using the natural heat exchange that is considered both sustainable and cost effective since only canvas bags were used without the use of any expensive equipment. This method that was tested in Jordan for 24 hours and was able to keep the water temperature stable at 15^{o} Celsius during the day. Since the weather is almost similar in most of countries in that region, this method can be applied to Zaatari camp, as well as all the refugee camps in the surrounding countries to ensure insure a sustainable and cost effective design and to improve the quality of life in refugee camps.

In conclusion, a sustainable design of a refugee camp is heavily dependent on site selection and site location in terms of water resources and sanitation facilities, where an improper location of a refugee camp may require a much larger budget to provide the necessary water and sanitation facilities.

5.1 LIMITATIONS AND FUTURE PLANS

There were many limitations that were faced during the production of this work, the main issue was that a large number of important information were classified and not published, these information include the camp's water quality which is vital to determine the type of water treatment method required in the camp, other technical information were also considered classified such as the borehole pumping tests and the water quality tests that would have aided in the camp's design.

As for future plans, by examining figure – 3 (number of refugees entering the camp) it is noticed that the number of refugees is gradually increasing. Since the water provisions in the camp can only supply up to 80,000 refugees, and it is very difficult to relocate the camp, the author recommends establishing a new camp in Irbid Governorate to host the newcomers. Any of the suggested methods can be applied in the new camp to ensure a sustainable design and better life quality for the refugees, in order to minimise the impact on the municipal water resources as well as the host community.

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